Market and Regulatory Research to Support Prohibition of Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) in the Marine Environment

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Disclaimer

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Executive Summary

This report delves into the intricate regulatory landscape and challenges associated with Expanded Polystyrene (EPS) marine infrastructures, focusing on mitigating their environmental impact and promoting sustainable alternatives. Divided into three sections, the report scrutinizes EPS infrastructure activities, relevant regulations, and jurisdictional scans to provide an analysis and comprehensive recommendations for a targeted EPS ban campaign.

The first section illuminates EPS marine infrastructures, highlighting their various applications and potential environmental ramifications. The market research conducted to explore potential alternatives to EPS in marine infrastructures has revealed a range of promising options. These alternatives offer varying degrees of environmental sustainability and feasibility while aiming to address the ecological consequences of EPS pollution. However, each alternative has its own challenges and considerations, including durability, cost-effectiveness, and manufacturing feasibility. The transition away from EPS towards these alternatives necessitates a comprehensive approach that involves regulatory measures, stakeholder collaboration, and innovative material solutions to ensure a more sustainable future for marine environments.

The second section, "Regulatory Review," navigates through essential regulations and policies governing EPS marine infrastructures. It highlights key areas of focus, including fisheries, aquaculture, private docks, and XPS/EPS management. An examination of the Canadian Environmental Protection Act (CEPA) and the Environmental Enforcement Act (EEA) underscores their pivotal roles in preventing pollution and strengthening enforcement. The report also explores CEPA amendments through Bill S-5, which presents potential implications for the regulation of toxic substances in EPS. To effectively regulate toxic substances, the report emphasizes the significance of clear definitions and a potential federal ban on EPS and Extruded Polystyrene (XPS) based on the Supreme Court's interpretation of CEPA's jurisdiction.

The third section, "Jurisdictional Scan," offers a comparative analysis of international and provincial regulatory efforts. Case studies from Ontario, the US, Taiwan, and Europe provide valuable insights into encapsulation policies, stakeholder collaboration, and the challenges faced in managing EPS pollution. Notable initiatives include Ontario's Bill 228, the US Army Corps of Engineers' experiences, and the European Commission's strategies for a circular economy.

Informed by these insights, the report offers comprehensive recommendations for a targeted EPS ban campaign. The recommendations encompass various domains, including eco-labeling processes, promotion of sustainable practices, data collection, long-term monitoring, public awareness, stakeholder engagement, regulatory advocacy, innovative solutions, collaboration with businesses, local cleanup efforts, media campaigns, and cross-border collaboration. These recommendations, when collectively implemented, hold the potential to raise public awareness, drive policy changes, foster

innovation, and encourage international collaboration in the endeavor to combat EPS pollution.

Ultimately, the report underscores the urgency of addressing EPS pollution within marine ecosystems. By understanding the regulatory landscape, embracing sustainable alternatives, and collaboratively implementing impactful strategies, stakeholders can pave the way for a cleaner, more sustainable future, safeguarding our oceans and marine life for generations to come

Market Research

A. The EPS and XPS problem

Expanded Polystyrene(EPS)and Extruded Polystyrene(XPS) are common sources of global marine pollution. EPS and XPS materials account for 50-70% of marine pollution debris collected by coastal clean-up groups(Surfrider Foundations Canada, n.d). As the most common forms of garbage found in Canadian coastal shorelines, EPS and XPS debris create serious economic and environmental problems. To start with, the clean-up cost for EPS is up to 2000$ for each eter of coastline(BC Styro Pollution, n.d). In addition, EPS and XPS materials continue to break down to microbeads, which makes the cleaning process significantly more challenging, if not practically impossible. Although recycling programs and facilities are available, only 9% of Canadian plastic waste is recycled (CCME,2020). Furthermore, microplastics that enter the marine environments threaten the well-being of fisheries and mammals by posing the risk of ingestion (BC Styro Pollution, n.d). Thus, the mitigation of EPS and XPS implications should focus on reducing their usage, advocating for alternatives, as well as promoting recycling programs for EPS and XPS.

B. EPS and XPS use

Marine pollution stemming from plastics has garnered considerable attention from scientists, media, and public spheres in recent years. Numerous studies have delved into various facets of plastic pollution, encompassing sampling techniques, sources, distribution patterns, environmental and wildlife impacts, as well as pollutant absorption. While studies often categorize plastics and microplastics as a unified entity, distinct characteristics necessitate a reevaluation of this classification, particularly when considering foamed plastics. In this context, foamed polystyrene (PS) emerges as a distinctive player due to its unique attributes. As opposed to its unfoamed counterparts, the remarkably lower density and distinct behavior of foamed plastics merit their independent classification within the plastic pollution discourse (Turner,2020). Given the environmental, economic and wildlife impacts, it is important to understand the distinctive behavior of foamed plastics (PS) within marine environments, including elucidating its origins, pathways of distribution, degradation processes, contamination accrual, animal ingestion, and ensuing ecological ramifications, particularly concerning chemical additive mobilization.

Foamed PS Structure & Production

Polystyrene (PS) stands as a rigid, amorphous thermoplastic synthesized via radical vinyl polymerization of styrene monomers. Its molecular configuration can be depicted as [CH2CH(C6H5)]n, wherein the pendant phenyl group (C6H5) introduces restricted rotation, thereby contributing significant physical and mechanical attributes to the polymer. Two key iterations of PS, Expanded PS (EPS) and Extruded PS (XPS), share a common characteristic of over 95% air content(Gausepohl,& Nießner,2001). Notably, EPS is created by expanding pelletized raw material using steam, forming bead-like cellular structures. These beads are subsequently fused and molded, with discernible 2–5 mm diameter beads in the final product. The air within these beads accounts for EPS's insulation prowess, though inter-bead voids render it somewhat susceptible to limited water absorption. In contrast, XPS involves extruding PS crystals, additives, and blowing agents at high temperatures, yielding a foamy liquid that takes shape in a die during cooling and expansion. XPS's closely packed cells exhibit a closed structure devoid of gaps or voids, curbing water absorption and resulting in a smoother surface and higher density compared to EPS. It's noteworthy that while "Styrofoam" is often used interchangeably with foamed PS, it specifically denotes Dow Chemical's trademarked XPS variation tailored for construction insulation purposes(Turner,2020).

Foamed PS Chemical Contaminants and Influences

Hexabromocyclododecane Hexabromocyclododecane (HBCD) is a key flame-retardant employed in EPS and XPS. It's added at concentrations of about 0.7 to 2.5% by weight in foamed PS for construction, with XPS having more than EPS(Alaee et al.,2003). HBCD's adverse health and environmental effects led to its inclusion in the Stockholm Convention's persistent organic pollutants list, effectively prohibiting its use in building PS foams. The EU also imposed concentration limits for certain brominated compounds, including HBCD(ECR, 2004).

PART 3

(Sections 1 and 2 and subsections 4(1) and (3) and 4.1(2))

Prohibited Products

	Column 1	Column 2
Item	Toxic Substance	Product Containing the Toxic Substance
1	Hexabromocyclododecane, which has the molecular formula $C_{12}H_{18}Br_6$	Expanded and extruded polystyrene foams and their intermediary products for a building or construction application

Influence of Foamed PS on Marine Organisms:

1. Ingestion and Impact:

    Foamed PS affects marine organisms through ingestion and interaction. It's ingested directly or mistaken for food, observed in various marine animals. Ingestion leads to blockage, injuries, and reduced fitness(Coffin et al.,2019). Effects might be milder than harder plastics due to foamed PS's properties.

2. Chemical Exposure and Bioaccumulation:

Foamed PS's breakdown into nanoparticles(density~1.1 g cm−3) raises concerns for marine life. Ingested foamed PS exposes organisms to manufacturing or environmental chemicals. Notably, more sensitive HPLC analysis reveals that HBCD in EPS buoys, kept in dark seawater, is slowly mobilized from the plastic. This highlights the potential release of the brominated flame-retardant under harsh digestive conditions of sea birds and other animals. HBCD's bioaccumulation in marine organisms, particularly mussels, underscores the necessity to comprehend the broader ecological implications of these interactions(Botterell et al.,2019).

3. Abiotic Interaction and Littoral Zone Influence:

Foamed PS serves as a substrate for bacterial colonization, mussels, polychaete worms, and isopods due to its floating instability. Interactions encompass dunal plants that perforate EPS, showcasing how foamed PS interacts with terrestrial vegetation within the littoral zone. This phenomenon signifies the broader implications of foamed PS's unique attributes, suggesting potential widespread ecological interactions at the interface of land and sea(Poeta et al.,2017).

C. EPS and XPS Application, Pathways and the Marine Environment

EPS Employment Across Different Industries

It is extensively integrated into home and appliance insulation, safeguarding packaging, automobile components, embankment filling, lightweight concrete as an aggregate, and food packaging. When considering construction, extruded polystyrene (XPS) gains preference over EPS in situations demanding stability and enhanced resistance to pressure and humidity. EPS finds widespread application in various industries and building structures, offering sustainability benefits, improved energy efficiency, durability, and enhanced indoor environmental quality. It serves diverse purposes:

In terms of applications, EPS is used for home and appliance insulation, providing effective thermal protection. It also acts as protective packaging for fragile items during transportation, owing to its lightweight and cushioning properties. Moreover, EPS plays a role in automotive manufacturing by being incorporated into components to contribute to lightweight design and impact absorption. In construction projects, EPS is employed for embankment filling due to its lightweight characteristics, and it is also utilized as a lightweight aggregate in concrete, enhancing structural properties while reducing overall weight. Additionally, EPS serves the purpose of insulating and protecting food packaging, helping to extend the shelf life of various products.

Industries that extensively use EPS include construction, where it is thermal insulation and lightweight features make it an invaluable material. EPS is a popular choice for packaging due to its ability to provide protection and cost-effectiveness.

Furthermore, EPS is integrated into the automotive sector, contributing to improved fuel efficiency and safety measures. In aquaculture, EPS is utilized for its buoyant properties in floatation devices, offering an efficient solution for various applications (Grand View Research, n.d).

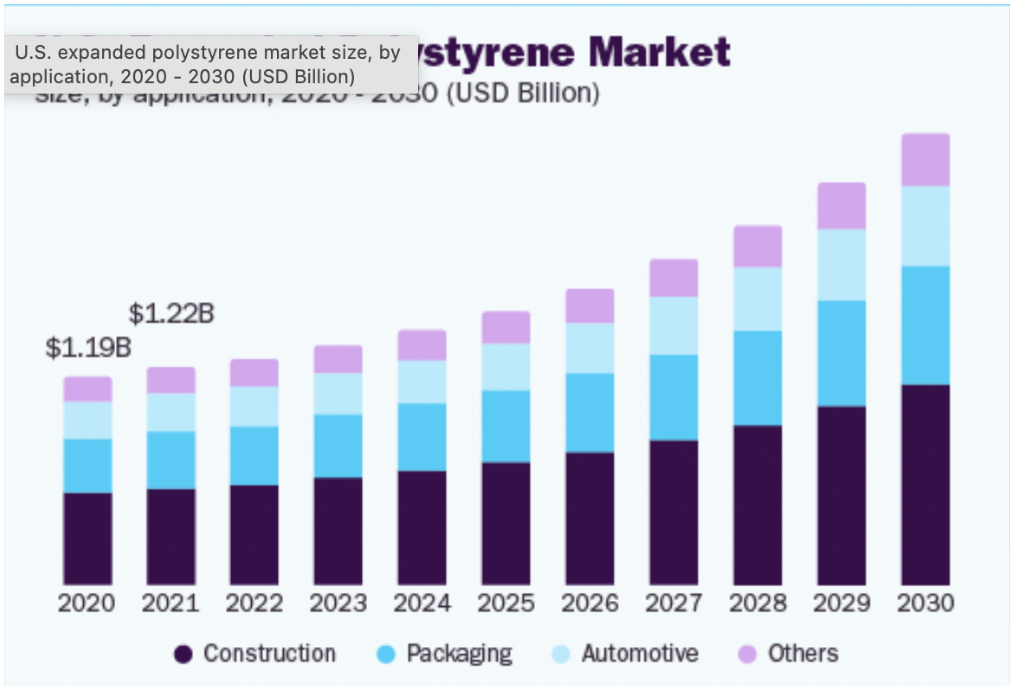

Figure 1. Projected EPS Market Growth from 2020 to 2030, by Sector

The **inherent durability, low density, and insulating capabilities** of foamed PS have led to its incorporation within the maritime sector. In the marine environment, EPS (less frequently, XPS) finds application in an array of contexts, including fish boxes, buoys, pontoons, floating docks, net floats, life jackets, surfboards, and boat stands(Jang et al., 2020). In particular, EPS is widely applied in aquaculture buoys. A notable occurrence involves the prevalent presence of stranded foamed plastic debris, which often results from the inappropriate use of uncovered floats for securing mooring buoys, subsequently undergoing deterioration (Fujieda & Sasaki, 2005). To extend the lifespan of EPS flotation devices, a viable approach is encapsulating them within resilient materials like rigid plastic or cement, potentially enhancing their endurance (Turner, 2020).

EPS Properties such as density, permeability, water absorption, pore values, and tensile strength all contribute to their behavior in the marine environment (Turner, 2020). In comparison, XPS is far worse characterized in literature, which explains why XPS products are omitted from many market regulations on plastic products(Troya et al.,2022).

Table 1. Properties of Foamed PS of Relevance to the EPS behaviors and fate in the marine environment. Note that data is based on a single, or unspecific brands of EPS, thus variation make occur across different types of EPS products(Source: Turner, 2020).

property	mean ±1 sd or range
Physical	
density	0.01 to 0.19 g cm^{-3}
permeability	0.5 to 3.5
water absorption	0.03 to 9.0%
pore volume	0.02 ± 0.005 cm^3 g^{-1}
average pore diameter	39.3 ± 0.5 nm
Mechanical	
tensile strength, ultimate	0.08 to 0.91 MPa
compressive yield strength	0.069 to 10.9 MPa
tear strength	1.05 to 5.29 kN m^{-1}
Surface	
BET specific surface area	2.03 ± 0.04 m^2 g^{-1}
point of zero charge	4.7 ± 0.2

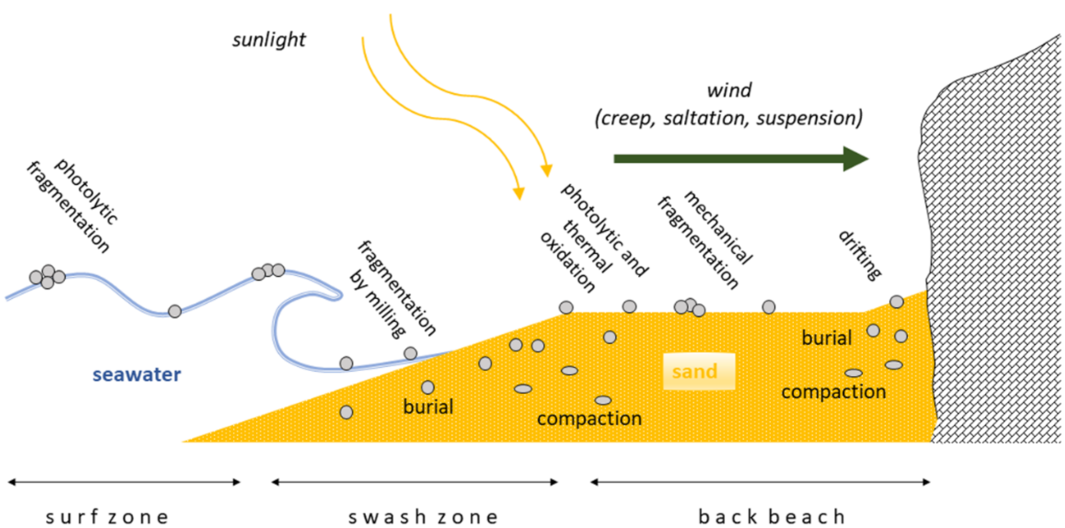

Figure 2. Conceptual representation of the effects and forcing mechanisms acting on foamed PS fragments in the sandy littoral zone(Source: Turner, 2020).

In the context of marine environments, windage significantly impacts floating stability due to buoyancy. Wind pressure and drag forces influence PS movement, causing changes in position and orientation. Theoretical calculations indicate that foamed PS moves faster than polyethylene under specific wind and current conditions. Increased sunlight exposure at the sea surface accelerates PS degradation through chain scission, leading to embrittlement and fragmentation. UV radiation prompts the degradation of foamed PS, breaking it into micro fragments. Evidence suggests shorter EPS lifetimes compared to polyethylene due to degradation differences (Yousif & Haddad,2013).

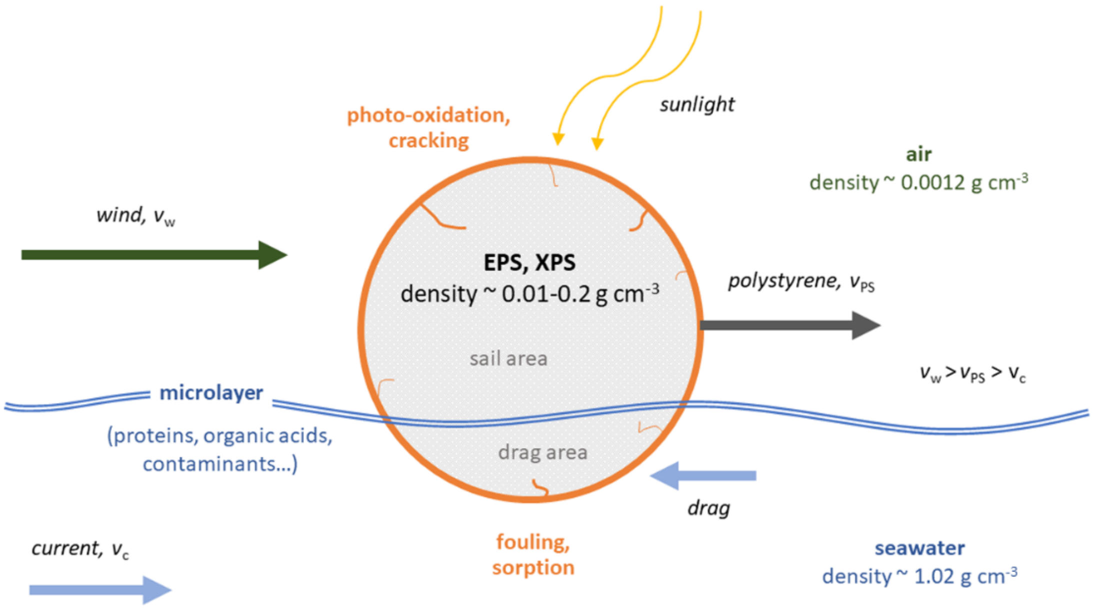

Figure 3. Conceptual representation of the effects and forcing mechanisms acting on a foamed PS sphere in the ocean (Source: Turner,2020).

Foamed PS debris, both ocean-sourced and land-originated, predominantly accumulates in littoral zones like mangroves, beaches, and rocky shores. Sandy shores intensify photolytic and thermal foamed PS degradation due to higher temperatures, and wind-driven forces result in fragile material's mechanical fragmentation. UV exposure and sand agitation lead EPS beads to break down significantly, with the majority reducing to sizes smaller than 1 µm—too minuscule to detect(Song et al.,2017). Swash zone processes further weaken litter, while experiments show sand interactions smooth, tear, and fragment material. Fragmented particles often become attached to or trapped within sediment due to their low density(Turner, 2020).

D. Densities of EPS

Different EPS products are employed in marine environments with varying densities, each serving specific purposes:

Floating Docks and Marinas: EPS foam, with densities of about 10-20 kg/m³ and 15 kg/m³, is utilized in the construction of floating docks and marinas. These structures offer buoyancy, but they can break apart due to weather or other factors, releasing EPS foam into the water.

Fish Farming Equipment: In aquaculture, EPS with densities ranging from 15 to 25 kg/m³ is used in floating cages and fish pens. Over time, deterioration of these structures can lead to EPS foam entering the surrounding water.

Buoyancy Aids and Navigation Markers: Buoys and navigation markers, typically with densities around 15 to 25 kg/m³, incorporate EPS foam. These structures aid in marking shipping channels, hazards, and guiding boats. Storms or collisions can damage them, releasing EPS foam into the ocean.

Surfboards and Watercraft: EPS foam cores, with densities ranging from 20 to 50 kg/m³, are integral to the construction of surfboards, stand-up paddleboards, and watercraft. Lost or damaged items can result in EPS foam ending up in the ocean.

Packaging Materials: EPS foam, commonly used for protecting fragile items during shipping, can enter water bodies including the ocean. Accidental loss or improper disposal of EPS packaging contributes to this issue(Material Property Data,2015).

E. Alternatives for EPS

As the environmental concerns surrounding expanded polystyrene (EPS) and extruded polystyrene (XPS) grow, innovative alternatives are being sought after to minimize their impact. These alternatives offer numerous advantages, including longer product life, enhanced durability, resistance to weather conditions, reduced maintenance requirements, and a decrease in pollution.

Air-Filled Flotation Devices:

Air-filled flotation devices have emerged as a viable substitute for EPS, offering benefits that extend beyond ecological considerations. Although upgrading to air-filled devices incurs an annual cost of approximately $1000, roughly four times the cost of EPS, the associated advantages are compelling(Turner, 2020). These benefits include:

- **Longer Product Life:** Air-filled devices boast a longer lifespan compared to EPS, providing extended utility and reducing the frequency of replacements.
- **Enhanced Robustness:** These flotation devices are designed to be more robust, better withstanding the rigors of the marine environment and potential impacts.
- **Weather Resistance:** Air-filled alternatives are more resistant to varying weather conditions, ensuring consistent performance over time.
- **Reduced Repairs:** With improved durability, air-filled devices require fewer ongoing repairs, resulting in lower maintenance costs.

- **Fewer Repeat Installation Fees:** The extended product life of air-filled flotation devices reduces the need for frequent installations, saving both time and resources.
- **Less Pollution:** By opting for alternatives, such as air-filled flotation devices, the risk of pollution associated with EPS is mitigated, contributing to cleaner marine ecosystems.

High-Density Polyethylene (HDPE) Floats: HDPE floats have gained prominence as a suitable substitute for EPS in aquaculture. Their durable and UV-resistant properties contribute to a longer lifespan compared to EPS. Additionally, HDPE floats are less susceptible to environmental degradation, mitigating the risk of microplastic pollution(Shen&Worrell,2014).

Concrete or Steel Structures: Concrete or steel structures are emerging as potential replacements for EPS in aquaculture infrastructure, such as fish cages. While they offer exceptional durability and strength, these alternatives may necessitate higher investment and specialized construction expertise.

Natural Fiber Composites: Researchers are investigating natural fiber composites derived from materials like bamboo, jute, or flax as alternatives to EPS. These composites can be utilized to create buoyant structures, boasting biodegradability and renewability as key advantages.

Recycled Plastic Alternatives: Several companies are actively developing buoyancy solutions for aquaculture using recycled plastics. By utilizing recycled materials, these alternatives contribute to reducing new plastic production and associated environmental impacts.

Other Material Substitutes: A range of alternative materials are under consideration:

- Mineral and glass wools, phenolic foams, natural fibers, perlite, and wood fiberboards offer more eco-friendly insulation options.
- Corrugated cardboard, lined with polyethylene or polyethylene terephthalate for water resistance, serves as an alternative for single-use products.
- Expanded polypropylene, a sturdier foamed plastic, is used for multi-use packaging, while higher density EPS enhances abrasion resistance（Thaysen et al.,2018）.

Prominent Companies Driving Alternatives in Canada:

As the need for more environmentally friendly alternatives intensifies, these companies are leading the charge to develop solutions that can help reduce the impact of EPS and XPS in the marine sector:

Cascadia Packaging Group: As a provider of sustainable packaging solutions, Cascadia Packaging Group specializes in alternatives to EPS foam. They work with materials like molded pulp and corrugated cardboard to offer eco-friendly choices.

CPI Equipment Inc. (Parksville, BC): This company custom designs HDPE docks and floats for both private homeowners and large commercial marine use. High-density polyethylene ensures buoyancy and superior strength in their products.

*Although there are alternatives for EPS application, many of these potential options remain theoretical, while large-scale, realistic application deployment is lacking.

F. EPS Recycling Program

Efforts to address the environmental impact of expanded polystyrene (EPS) have led to the establishment of recycling programs across Canada. These programs aim to divert EPS waste from landfills, promote sustainability, and contribute to the circular economy. While progress has been made, challenges and opportunities remain in enhancing EPS recycling initiatives.

Recycling Sources and Progress:

The sources of recycled foam polystyrene (Foam PS) in Canada encompass commercial generators, depot operations (both municipal and private), and curbside collection programs. In 2018, approximately 0.7 million kilograms of Foam PS were reported as recycled, marking a modest increase compared to 2017(Polyform, 2020). The majority of the recycled material consisted of foam polystyrene, primarily originating from protective packaging applications and construction waste, where expanded polystyrene (EPS) is commonly used(Polyform, 2020).

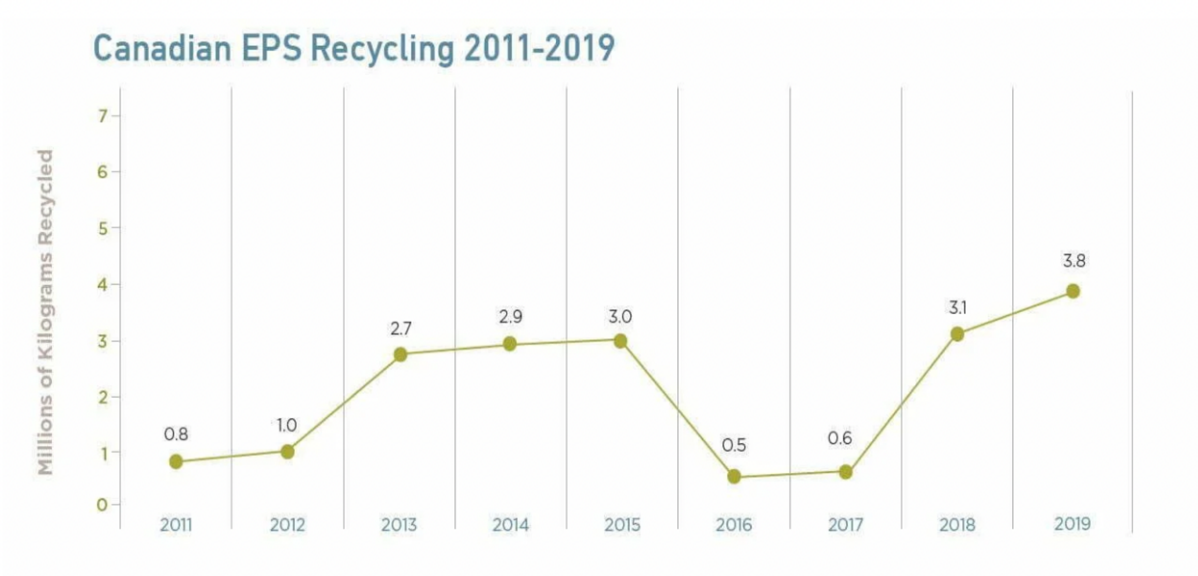

Figure 4. EPS Recycling in Canada. From 2011 through 2017 reference data from the Canadian Plastics Industry Association's (CPIA) annual Post-Consumer Plastics Recycling in Canada Report. The 2018 & 2019 Canadian EPS Recycling Reports were conducted by the EPS Industry Alliance (EPS-IA) & reflect both post-use and post-industrial expanded polystyrene recycling(Source: Polyform, 2020).

Recycling Process Example: British Columbia's EPS Recycling Process:

One notable example of EPS recycling in Canada is the program implemented in British Columbia. In partnership with organizations such as Airfoam Industries, the province has established an EPS recycling process in Surrey, BC. This process is designed to make EPS recycling accessible and effective. Key features of this program include:

- **Acceptable Materials:** EPS foam that is suitable for recycling is accepted free of charge. This includes foam polystyrene waste that meets specific criteria.
- **Quality Requirements:** The EPS waste must be clean, dry, and free of any other materials that could hinder the recycling process.
- **Packaging Guidelines:** To facilitate efficient recycling, EPS waste is either packed in clear bags or palletized according to the guidelines provided.

Recycling Challenges and Limitations:

Despite these efforts, it is important to note that there are still instances where companies do not participate in recycling surveys, potentially leading to underreporting of the total amount of EPS recycled. This indicates that the reported figures may not fully represent the extent of EPS recycling in Canada. In addition, the recycling process may be hindered by contaminated recycle products, meaning that unacceptable materials may contaminate potentially recyclable foam.

Advancing EPS Recycling

While EPS recycling initiatives are making strides in Canada, ongoing efforts are required to improve participation rates, accuracy of reporting, and the efficiency of recycling processes. Collaboration between industries, municipalities, and government entities is crucial to establishing comprehensive EPS recycling systems that reduce the environmental impact of EPS waste and contribute to a more sustainable future.

Regulatory Research

EPS infrastructure activities relevant regulations

Activity	Who is responsible	Link to regulation/policy	Specific language that applies to EPS/XPS/What is used for floating structures

Fisheries	DFO	Inshore regulations(Fisheries Act)	BC Fisheries officers to issue tickets under the federal Contraventions Act, • beneficial for minor convictions • more time-consuming
Aquaculture	Provincial Government Three regimes, BC, PEI, and other territories)	• Wild Aquatic Resources as it Applies to Aquaculture. • Aquaculture Policy Framework. • Gulf Region Molluscan Spat Collection Operational Policy • National Code on Introductions and Transfers of Aquatic Organisms • Prince Edward Island Leasing Policy	• BC, where the province issues the lease and Fisheries and Oceans Canada (DFO) issues the license and monitors license conditions • PEI: where a management board with members from DFO, the province, and industry issues a lease which has a license attached; and • other places: where provincial authorities issue both the lease and the licence • Provincial responsibility • Collaboration of various stakeholders
Private docks	**Ministry of Forest, Lands, Natural Resource Operations and Rural Development**	• **dock application**	provide flexibility to allow regional and site specific issues and conditions to be considered and addressed; • provide dock owners with best management practices and requirements; and,

			• provide for different forms of allocation, with a range of rights, interests and obligations to meet a variety of circumstances and proponent needs.
XPS and EPS management	**Federal and provincial**	Federal partner: Canadian and Environment Assessment Agency	• Prevention of toxic substance • Pollution Prevention Plan

*Regulations do not specify how that infrastructure is developed

Environmental Regulations: Canadian Environment Protection Act

The Canadian Environmental Protection Act, 1999 (CEPA) serves as pivotal legislation designed to uphold sustainable development by preventing pollution. Under its purview, CEPA holds responsibility for numerous federal environmental and health protection initiatives. This encompasses activities such as evaluating and mitigating risks posed by chemicals, polymers, and living organisms, as well as overseeing programs addressing air and water pollution, hazardous waste, air pollutants, and greenhouse gas emissions. CEPA also governs matters concerning ocean disposal and manages responses to environmental emergencies. In essence, CEPA plays a central role in safeguarding Canada's ocean health and overall environmental well-being through comprehensive regulations and actions.

Promising Enforcement: Environmental Enforcement Act

The Environmental Enforcement Act (EEA) serves as a powerful tool for reinforcing the enforcement of legislation aimed at protecting the environment. By bolstering the fine framework under various acts, the EEA provides a more effective means to deter non-compliance. Tailored fine ranges for different offender categories, along with the imposition of minimum and elevated maximum fines for severe infractions, create a more equitable and impactful penalty system.

Moreover, the EEA introduces a cohesive and robust set of sentencing principles that foster consistency in addressing environmental violations. This unified approach ensures that enforcement actions are proportionate and equitable across different cases. The EEA's provisions also empower enforcement officers by expanding their toolkits. This includes the broader utilization of compliance orders, which facilitate rapid remediation and compliance with environmental regulations.

CEPA Amendment Pathway:

The process of revising CEPA was initiated in 2016. In 2017, the environment committee of the House of Commons unanimously recognized the need for reform in CEPA. However, the bills for amendments lapsed due to federal elections being called in both 2019 and 2021. Bill S-5 introduces a novel approach by incorporating a new subsection 77(8). This subsection mandates the Ministers of Environment and Health to provide written explanations for delays exceeding two years, aiming to expedite the review process.

Bill S-5 introduces noteworthy amendments to CEPA with potential implications for the regulation of toxic substances. The bill responds to industry concerns by removing the term "List of Toxic Substances" from Schedule 1. The criteria for listing substances under Schedule 1 have been broadened to encompass various potential harms, including carcinogenic, mutagenic, and reproductive toxicity.

Of particular significance, Bill S-5 divides Schedule 1 into two distinct Parts:

- Part 1 is dedicated to substances of the highest risk, aiming for their complete prohibition. This part includes 19 substances, such as the toxic pesticide DDT.
- Part 2 covers substances of lower risk, with regulations focusing on pollution prevention rather than outright eradication. Notably, Part 2 includes 132 substances, among them asbestos, lead, petroleum, and even single-use plastics.

This division and categorization of substances within the bill raise the possibility of reviewing substances like HBCD and plastics to determine if they qualify as toxins under the new criteria(King et al.,2023).

Toxic substances:

Several potentially toxic substances found in EPS warrant evaluation due to their potential health impacts, although most studies have focused on exposure during manufacturing rather than through end products. Given their potential health and environmental implications, a thorough evaluation of these substances within EPS is essential to ensure proper regulation and protection. Noteworthy substances include:

Benzene: This chemical, extracted from coal and found in gasoline, can lead to severe health issues with long-term exposure. Effects may include skin scaling, leukemia, plastic anemia, and even death.

Styrene: Derived from petroleum and also naturally present in various foods, such as strawberries and beef, styrene poses risks with prolonged exposure. Health consequences might involve trouble with balance, learning impairments, fetal damage, reduced female fertility, and the development of lung cancer.

Ethylene: While commonly present in plants, ethylene can be flammable in larger amounts. Studies on benzene suggest that acute toxicity to freshwater aquatic life can occur at concentrations as low as 5,300 ug/l(Marcy&Johnson, 2019).

Clear Definition of Toxic Substance can promote provincial and Federal Ban:

The precedent set by the Supreme Court of Canada's ruling in R. v. Hydro Quebec in 1997 provides a significant basis for advocating a federal ban on Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) that would apply uniformly across both federal and provincial jurisdictions. In this case, the Supreme Court upheld the applicability of the toxic substance provisions within the Canadian Environmental Protection Act (CEPA) even in provincial domains. The ruling pertained to Hydro Quebec's disposal of PCBs into a river, contravening an order under CEPA. The Court's decision affirmed that CEPA's regulations on toxic substances extend beyond federal territory, allowing for the enforcement of such regulations within provincial boundaries. This landmark case showcases the potential for a federal ban on EPS and XPS, aligning with the Supreme Court's interpretation of CEPA's authority to regulate toxic substances across jurisdictions. As such, a ban on EPS and XPS under CEPA would likely have the capacity to be effectively implemented both at the federal and provincial levels, fostering consistent protection of the environment and human health(Fasken, 2023).

While considerable strides have been made in addressing plastic waste and its environmental impact, certain areas of concern persist within the regulatory landscape. Despite the explicit restrictions aimed at achieving zero plastic waste, there remains a notable lack of clarity surrounding policies and regulations pertaining to EPS marine infrastructures. As we move forward in our regulatory review endeavors, it becomes imperative to not only enhance our efforts in curbing plastic waste but also to ensure that comprehensive and effective measures are in place to manage the specific challenges posed by EPS marine infrastructures. By addressing these uncertainties and refining our regulatory framework, we can collectively work towards a more sustainable and resilient future for our oceans and ecosystems.

Zero Plastic Waste

Summary of the proposed waste prevention regulation

Material/Action	Regulatory Tool	Proposed Items	Alternatives Available for Use
To be phased out in 2023			
Checkout bags	Ban (plastic checkout bags); Fee (paper bags); Reusable bags	Plastic checkout bags include all plastic film, including compostable plastics. Paper bags must include a minimum of 40% recycled content. Reusable bags must be designed and manufactured to be used and machine washed at least 100 times.	Durable reusable bags; paper bags (for a fee).
Disposable foodservice accessories	By-request	All single-use straws, cutlery and stir sticks. Ketchup, soy sauce and other condiment sachets, napkins, cold cup lids, cup sleeves, food or beverage trays.	Durable reusable items, including cutlery, and refillable or bulk options for condiments.
To be phased out in 2024			
Problematic plastic foodservice packaging	Ban	Containers, bowls, plates, trays, cartons, film wrap, and cups made from polystyrene foam, PVC or compostable plastic.	Durable reusable containers; PET, PP, HDPE and LDPE plastics; aluminum; glass; and fibre-based containers.
Oxo-degradable plastic	Ban	All packaging made from oxo-degradable plastic, including oxo-degradable bin liners, dog waste bags and clothing packaging.	Other conventional plastic, non-plastic or reusable alternatives.

Canada has developed a thorough timeline to phase out plastic products as a mean to reduce plastic waste packaging and daily consumption. However, EPS and XPS infrastructures in the marine environment remains untreated in this part of the framework. A comprehensive strategy toward achieving zero plastic waste and realizing a circular economy for plastics necessitates multifaceted actions that span various domains. With the vision of a sustainable future in mind, ten priority result areas have been identified to guide actions and shape collaborative efforts toward this goal. Canada's extensive marine and freshwater resources, encompassing the world's longest coastline, emphasize the significance of addressing plastic pollution not only from land but also from sea-based sources. Marine plastic litter, particularly associated with fishing activities, has a notable impact on ocean health, with approximately 70% of floating macro plastic debris in the open ocean originating from fishing-related sources. Lost fishing gear contributes to entanglements and ghost fishing, causing harm to marine life and leading to the tragic deaths of around 100,000 mammals annually due to marine litter-related causes (CCME, 2018).

To combat these challenges, it is imperative to focus on key sectors such as fisheries, aquaculture, commercial shipping, recreational water users, offshore industries, research platforms, and tourism, including cruise ships. Implementing improved practices and solutions within these sectors will play a pivotal role in preventing both sea-based and freshwater plastic pollution. Enhancing knowledge about the impacts of plastic pollution, fostering behavior change, and bolstering regulations and policies are vital aspects of these efforts. Initiatives such as the development and dissemination of best practices, the expansion of regulations, and the incorporation of plastic spill preparedness in prevention and response frameworks are essential steps. Innovative solutions and accessible waste diversion and disposal systems are equally crucial to mitigate impacts and curb the dumping of plastics at sea. This entails actions like proper disposal and recycling facilities at port reception sites, environmentally sound retrieval of abandoned vessels, and addressing abandoned, lost, and discarded fishing gear. By collectively pursuing these strategies, we can not only protect our marine ecosystems but also propel our journey toward a future marked by sustainable plastic management and reduced plastic waste.

Jurisdictional Scan

Conducting a jurisdictional scan is a vital step in understanding the regulatory landscape surrounding the use of Expanded Polystyrene (EPS) in the marine environment. By examining the actions taken by other countries, provinces, and jurisdictions, we gain insights into various approaches and measures employed to address EPS pollution. This scan aims to answer critical questions such as the existence of EPS prohibitions, the adoption of alternatives, the implementation and enforcement of regulations, and the availability of voluntary programs aimed at reducing EPS pollution. By delving into these aspects, we can discern best practices, assess the effectiveness of different strategies, and ultimately inform our own decisions and policies concerning EPS usage in the marine environment.

Ontario Case Study: Bill 228

"The Bill requires persons who sell, offer to sell or construct floating docks, floating platforms or buoys to ensure that any expanded or extruded polystyrene in the dock, platform or buoy is fully encapsulated."

-- Keeping Polystyrene Out of Ontario's Lakes and Rivers Act, 2021

Bill 228, brought forward by MPP Mr. Norman Miller(Riding Representation: Parry Sound–Muskoka), signifies a stride towards safeguarding aquatic ecosystems and promoting clean waters. This legislative proposal endeavors to curb the menace of microplastic pollution by mandating the encapsulation of new dock floats and buoys constructed from expanded or extruded polystyrene, commonly known as Styrofoam. The aim is to prevent the disintegration of foam and its subsequent entry into waterway ecosystems, a development that poses threats to both wildlife and human health. This bill is particularly pronounced in regions characterized by floating docks, notably the **Great Lakes and Georgian Bay,** where such structures comprise a substantial portion of the maritime landscape.

Factors Contributing to the Success of Bill 228:

The foundation of Bill 228 is rooted in extensive support and awareness generated through various channels. In addition to the support of environmental organizations such as the Georgian Land Bay Trust and environmental scientists, an online petition garnered the endorsement of 490 individuals as vested stakeholders and **cottage owners** also contributed to the bill's success. Notably, the Federation of Ontario Cottagers' Associations has thrown its weight behind this initiative, underscoring its potential positive impact. The backing of eminent scientists, including Dr. Norman Yan, who possesses comprehensive knowledge in the field, fortifies the legitimacy of this bill. Ministry of the Environment, Conservation and Parks. Members also delivered precedent cases where EPS restrictions had been applied in various places in the US, including Washington, Arkansas, and Oregon. Volunteer programs also highlighted significant quantities of foam that end up on the coastline: m**ore than 5000 pieces of foam** were collected along the shorelines of Georgian Bay in 2019.

The efficacy of Bill 228 is underscored not only by substantial public and expert support but also by economic analyses conducted in other jurisdictions. The Connecticut River Conservancy in the United States has undertaken a comprehensive cost analysis to advocate for the transition away from unencapsulated polystyrene foam in dock construction. Their evaluation revealed that while traditional unencapsulated foam might cost $270 for a four-foot by ten-foot dock, it needs replacement approximately every 10 years. In contrast, encapsulated dock foam, despite its initial cost of $400, boasts an extended lifespan of around 35 years. Barrels, another alternative, present a cost-effective choice at $215 new or $50 used, with longevity ranging from 30 to 40 years. Moreover, the regulatory stance of the **US Army Corps of Engineers bolsters the case for transitioning away from unencapsulated polystyrene foam**. For over a decade, the Corps has prohibited the use of such foam in dock billets, a testament to the growing acknowledgment of its adverse environmental impact.

Bill 228 addresses relevant questions and is complementary to the Made-in-Ontario Environment Plan. In response to a pivotal question posed by the government regarding the timeliness of the proposed policy, Why now? It is emphasized that the initiative addresses a unique concern distinct from the ban on single-use plastics. The rationale behind its necessity is underlined, illustrating that this step holds substantial benefits. The solution is portrayed as relatively uncomplicated, with viable alternatives readily accessible. Furthermore, the perspective emphasizes the importance of avoiding the utilization of docks that can lead to environmental degradation, harm to wildlife, and the eventual incorporation of harmful substances into the human food chain.

Current Status: Norm Miller, who brought forward the act is no longer working as an MPP. The riding representation, Parry Sound–Muskoka, did not respond to the question of how many docks had been encapsulated since the bill became effective. The timeline for Bill 228 was carried forward in November 2020 and the final reading was carried forward in May 2021.

2. Case studies in the US

2.1 Oregon

The Oregon Foam Encapsulation Policy, outlined in OAR 250-010-0700 to 250-010-0715, introduces regulations to address the disintegration of polystyrene foam flotation materials in water bodies. Defined terms, including "bonded," "dock," "float," and others, provide clarity within the context of the policy. The essence of the policy lies in ensuring that submersible polystyrene devices installed on docks, buoys, or floats on state waters are encapsulated with protective coverings or designs to prevent disintegration. Various approved methods of encapsulation are detailed, encompassing materials such as concrete, galvanized steel, liquid coatings, plastics, fiberglass, wood, and more. Exemptions exist for certain constructions, maintenance activities, existing structures, and specific regulations for buoys and other floating devices. The policy represents Oregon's proactive approach to mitigating EPS-related water pollution and underscores the importance of ensuring environmentally responsible practices in aquatic environments.

2.2 U.S. Army Corps of Engineers (USACE):

Complementary to a referral from Bill 228 debate. US Army Corps of Engineers realizes that encapsulation is not the silver bullet for mitigating EPS impact. While the effort aimed to address the concern of foam disintegration and the release of microplastics into aquatic ecosystems, certain challenges still persist, necessitating broader considerations in policy implementation.

- **Rodent Attraction**: Enclosed and darker docks may be inviting to rodents. Design docks with openings to allow daylight under and through the sides, discouraging rodent habitation.
- **Leaks and Condensation:** Threaded plugs or "weep holes" in float perimeters can cause leaks due to condensation buildup. Opt for factory-sealed float compartments to prevent water ingress and potential leaks.
- **Punctures from Lake Bottom**: Flotation contacting the lake bottom can lead to punctures. Install "legs" on floats, raising them a few inches above the lake bottom, tailored to the lake's contour to prevent damage(Marcy & Johnson, 2009).

Following its initial enaction in 1992, the USACE conducted a survey in 2007 to gauge compliance across its 45 Districts. However, only 15 Districts had fully embraced policies that mandated encapsulated docks, underscoring the challenges in enforcing a consistent approach. The initial ambiguity of the 1992 policy, subject to varied interpretations, hindered its wide-scale adoption. Despite these obstacles, the survey revealed a positive trend as 91,780 out of the reported 181,272 slips demonstrated the adoption of encapsulated flotation(Marcy & Johnson, 2009). This progress signifies a growing recognition of the environmental benefits of encapsulation.

This case study offers valuable insights for policy implementation. The USACE's experiences highlight the importance of clear and precise policies, which can address ambiguities and promote uniform adoption across Districts. Incorporating a phased-out timeline for existing docks with unencapsulated flotation could facilitate a smoother transition, thereby enhancing overall policy effectiveness. Learning from these challenges and progress, policymakers can leverage the USACE's experience to craft more robust policies that not only combat EPS pollution but also contribute to ecological preservation.

2.3 Washington

The Washington Senate Bill 5546, pertains to the use of flotation devices on state-owned aquatic lands and in state waters. The legislation seeks to address the environmental impact of polystyrene foam, commonly known as "styrofoam," used in construction of docks, buoys, and other flotation devices in the marine environment. Polystyrene foam's lightweight nature and flotation capacity have led to its popularity, but its non-biodegradable nature has resulted in fragmentation and leaching of toxins into water bodies, posing risks to aquatic life and human consumption.

The bill introduces new sections to existing chapters of Washington's Revised Code of Washington (RCW) to enforce encapsulation of polystyrene foam. The definitions section includes terms like "encapsulated" and "polystyrene foam" to provide clarity. The legislation prohibits the installation of non-encapsulated polystyrene foam on docks, buoys, floats, and other flotation devices. Additionally, existing installations of non-encapsulated foam must be removed or replaced by a specified date. The use of polystyrene foam on state-owned aquatic lands, including docks and floatation devices, is prohibited unless encapsulated. Existing uses of exposed or uncontained foam are assessed by the department and must be removed by the tenant within a defined timeframe.Furthermore, the department is empowered to condition permits issued after the enactment of the legislation, mandating encapsulation of polystyrene foam in the construction or operation of structures or devices covered by the permit.

A Case study in Taiwan

The study conducted in Taiwan focused on addressing the environmental challenge posed by Styrofoam buoy marine debris generated from oyster farming activities. Despite efforts by authorities to tackle this issue, the trial was only partially successful due to the persisting environmental externality with long-neglected associated costs. To enhance the management of Styrofoam buoy marine debris, the research employed document analysis, participative workshops, and interviews to identify concerns related to current management practices and propose potential solutions. Key findings of the study highlighted several major areas of concern, including the lack of enforced buoy recovery measures, the unavoidable loss of buoys, and the absence of competitive and eco-friendly alternative buoy options(Chen et al.,2018).

Figure 5(a)(b). a. The floating raft method using Styrofoam buoys to support rafts. b.Beached derelict Styrofoam buoys and fragments.

In addressing the issue of Styrofoam buoy marine debris, several measures were implemented in Taiwan, each with specific numerical outcomes:

- Rafts without the required marks were declared illegal, leading to imposed penalties. Over time, this measure's effectiveness became evident, as the discrepancy between the reported and deployed rafts decreased. For instance, the difference reduced from 1,200 in 2010 to 1,147 in 2011, further dropping to 83 in 2014 and 75 in 2015. This progression highlights the success of this strategy
- A requirement mandates the recovery of at least 80% of the rafts over two consecutive years; failing this results in a restriction on the number of rafts permitted for the next farming season. This 80% recovery rate considers the allowance for a reasonable proportion of rafts accidentally lost. The relationship between recovery rate and the permissible number of rafts has led to a continuous improvement in recovery efforts. The recovery rate increased from 80.9% in 2012 to an impressive 97.4% in 2016

- An incentive program rewarded farmers for recovering buoys, resulting in the retrieval of about 20–33% of discarded buoys(Chen et al.,2018).

Case Study on the West Coast

In response to pervasive foamed polystyrene pollution around Lasqueti Island in British Columbia, an annual event called Styrofoam Day has been initiated. Approximately 70 volunteers collect plastic waste, primarily foamed polystyrene, resulting in an estimated two tonnes of plastic waste collected. Residents reported knee-deep accumulations of foamed polystyrene fragments during the cleanup.British Columbia’s Parliamentary Secretary for Environment, Sheila Malcolmson, engaged stakeholders to address the issue. Meetings involving government, industry, NGOs, and citizen groups highlighted concerns about foamed polystyrene pollution, emphasizing its impact on local wildlife. A significant pollution source is the use of foamed polystyrene floats in the aquaculture industry without effective containment plans, prompting a proposal to ban its use in the industry. The problem extends to Prince Edward Island's Tracadie Bay, where volunteers collected two tonnes of pollution, mainly foamed polystyrene buoys. An "eco levy" on such buoys has been suggested to discourage their use and fund cleanups(Larsen, 2019).

To tackle the issue, the Canadian Liberal Party proposed banning un-encapsulated foamed polystyrene for marine use. The proposal aims to establish encapsulation standards, transition to encapsulated foamed polystyrene, and mandate proper recycling or disposal. This approach addresses immediate dangers posed by exposed foamed polystyrene, acknowledging the urgency of combating mounting pollution in Canada's waters and along shorelines(Malcolmson, 2020).

European Initiatives

In the realm of intergovernmental efforts to combat foamed polystyrene (EPS) pollution, several initiatives are noteworthy:

Baltic Marine Environment Protection Commission (HELCOM): HELCOM, responsible for the Convention on the Protection of the Marine Environment of the Baltic Sea Area, seeks to address EPS pollution. Led by Denmark, it collaborates with OSPAR Convention and the OceanWise project. The goal is to develop recommendations for alternative solutions through engagement with industry, involving changes in product design and handling practices. Finland is making strides by exploring wood-based materials to replace EPS fish boxes used for fish transportation and storage(HELCOM, 2015).

OceanWise: Driven by the EU Marine Strategy Framework Directive and OSPAR Convention, OceanWise is a collaborative initiative led by Portugal, with support from Ireland and partners. Its objectives include investigating the impact of EPS in the marine environment, suggesting alternative materials, and promoting best practices in manufacturing, recycling, and usage of foamed polystyrene. This initiative engages in multi-stakeholder Dialogue Labs, Living Labs of Eco-Innovation, and Knowledge

Hubs. Key industries prioritized for intervention include fisheries, aquaculture, seafood, food distribution, supermarkets, and outdoor events(OceanWise, 2019).

British-Irish Council (BIC): The BIC committed to collaborative efforts with industries to devise solutions for recycling end-of-life fishing gear from main fishing ports, as stated in their 2019 symposium communiqué(ESMA, 2020).

European Commission: The European Strategy for Plastics in a Circular Economy, published in 2018, proposes a Directive on Port Reception Facilities. The directive aims to safeguard the marine environment by reducing waste discharges from ships and improving efficiency in maritime operations. This involves alignment with the MARPOL Convention and measures to address marine litter from ships, including waste from the fishing sector(Flora and Fauna Internationa, n.d).

These initiatives signify concerted efforts to combat EPS pollution through comprehensive research, policy development, and engagement with various stakeholders, industries, and regions.

Recommendations

This section provides recommendations for for a Targeted EPS BanCampaign.

- **Promoting a Eco-labling process**
    - Develop a recognition for sustainable aquaculture that employes EPS and XPS alternatives as floatation devises
    - Promote voluntary movements towards sustainable fishing practices and transitions
- **Data Collection and Analysis:**
    - Collaborate with scientific institutions and research organizations to collect comprehensive data on EPS pollution, its sources, distribution, and impact on marine ecosystems.
    - Use data-driven insights to tailor campaigns, prioritize action areas, and demonstrate the urgency of addressing the EPS issue.
    - The information on the detrimental effects should be confirmed with someone with a scientific background and also have the some extent of political influence
- **Long-term Monitoring and Reporting:**
    - Establish a system for continuous monitoring of EPS pollution levels in marine and freshwater environments, allowing for the assessment of campaign effectiveness over time.
    - Regularly report campaign outcomes, progress, and milestones to keep stakeholders informed and maintain public interest and support.
- **Public Awareness and Education:**
    - Launch an extensive public awareness campaign to educate citizens about the environmental impact of EPS and its contributions to marine pollution.
    - Collaborate with educational institutions to integrate environmental education modules into curricula, promoting responsible plastic use and disposal practices from an early age.
    - Utilize various communication channels such as social media such as instagram stories, documentaries, and community workshops to raise awareness and encourage behavior change.
- **Engagement of Stakeholders:**
    - Engage industry stakeholders, including manufacturers, distributors, and retailers of EPS products, to encourage product redesign, innovation, and sustainable alternatives.

    - Foster partnerships with environmental NGOs, local communities, and indigenous groups to collectively address the EPS pollution issue through coordinated efforts and campaigns.
- **Regulatory Advocacy:**
    - Advocate for the introduction of stringent regulations on EPS production, distribution, and disposal, while aligning with existing waste management and circular economy policies.
    - Collaborate with lawmakers to draft legislation that addresses EPS usage, promotes sustainable alternatives, and enforces penalties for non-compliance.
- **Innovative Solutions:**
    - Support research and development initiatives focused on creating biodegradable or easily recyclable alternatives to EPS products.
    - Encourage the adoption of innovative technologies that can efficiently capture and recycle EPS waste, mitigating its impact on the environment.
- **Collaboration with Businesses:**
    - Work with the business sector to encourage the adoption of sustainable practices, such as offering incentives for businesses that implement EPS-free packaging or engage in recycling initiatives.
    - Recognize and promote businesses that take proactive steps to reduce their EPS footprint.
- **Local Cleanup and Restoration Efforts:**
    - Surfrider consistent efforts: Organize regular community cleanups to remove EPS waste from coastal areas, rivers, and lakes, raising awareness about the issue and involving citizens in hands-on solutions.
    - Partner with local authorities and waste management organizations to ensure proper disposal and recycling of collected EPS waste.
- **Media and Advocacy Campaigns:**
    - Launch targeted media campaigns that showcase the harmful effects of EPS pollution, featuring real-life stories, data, and expert opinions to garner public and political support.
    - Mobilize advocacy groups and influencers to amplify the message, engaging a broader audience and driving demand for change.
- **Cross-border and International Collaboration:**
    - Collaborate with neighboring countries, international organizations, and intergovernmental bodies to address the transboundary nature of marine pollution caused by EPS.

- Share best practices, strategies, and success stories to create a global momentum toward reducing EPS pollution.

By implementing these recommendations, a targeted EPS campaign can effectively raise awareness, drive policy change, foster innovation, and engage communities in a collective effort to combat EPS pollution and work towards a cleaner, more sustainable environment.

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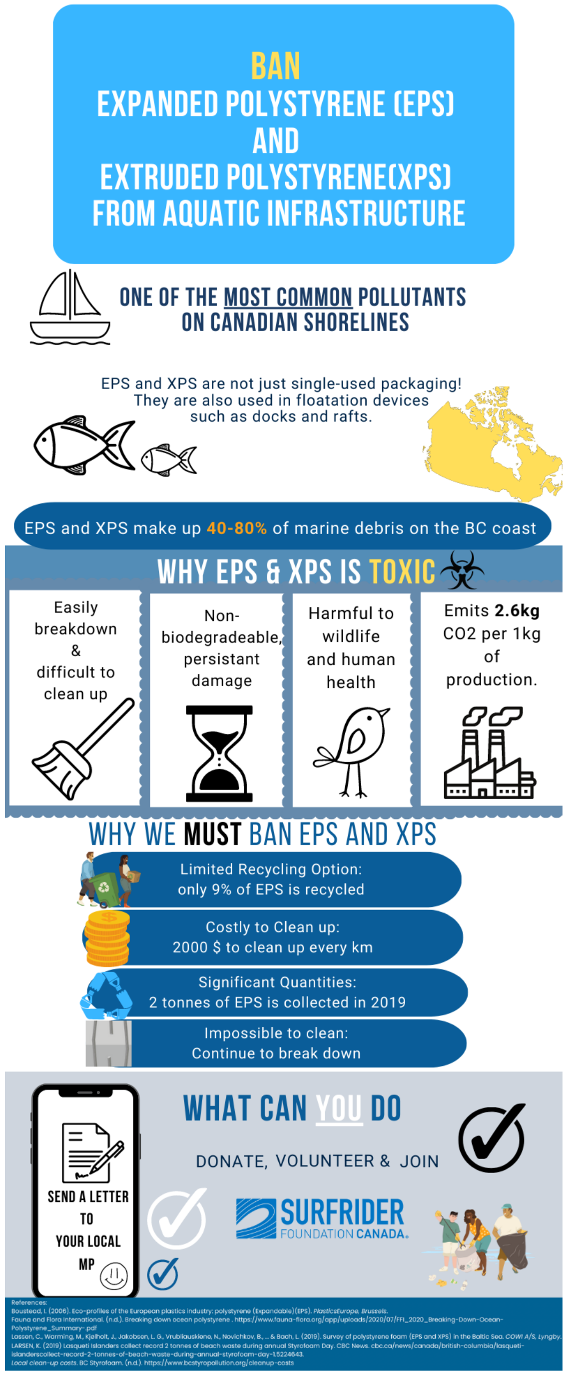
Appendix

I. Communication features to highlight the importance to ban EPS



II. Potential Contact

1. Fisheries and Oceans Canada - Aquatic Ecosystem Fund

- contributing to strategic planning and responding to restoration priorities
- supporting restoration and rehabilitation of aquatic habitats and their long-term sustainability
- educating the public on the impacts of human behavior on aquatic habitats
- supporting co-benefits of aquatic restoration activities (e.g., nature-based solutions to climate change)
- encouraging and building local community capacity

National Headquarters:
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inshore regulations for fishing habitats

- fisheries act in 2019
- fish and fish habitat protection and prevention plan
- " The Governor in Council may make regulations for carrying out the purposes and provisions of this Act and in particular, but without restricting the generality of the foregoing, may make regulations"
    - regarding fisheries management
    - rebuilding fishing stocks
    - protection and conservation of fish
    - respecting the use of fishing gear and equipment

2. Fisheries and Oceans Canada - Aquatic Resources Division
General Enquiries

Telephone:709-327-7004 (St. John's)

3. Fisheries and Oceans Canada - Arctic Aquatic Research Division
https://dfo-mpo.gc.ca/science/coe-cde/ncaare-cneraa/index-eng.html
Telephone: 204-983-5000 (Winnipeg)

- vessel and infrastructure resources
- marine/freshwater research priority planning
- leveraging national and international partnerships

4. Fisheries and Oceans Canada - Ecosystems Science Division
Pacific Biological Station 250-756-7000 (Nanaimo) - NO INFORMATION
MARINE POLLUTION

5. Fisheries and Oceans Canada - Environmental Sciences - Atlantic Waters
General Enquiries: 1-800-782-3058

6. Ministry of environment, conservation and parks to follow up bill 228
Telephone: 4163254000
1800 268 6060 ACT OF BILL

- An Act to prohibit unencapsulated expanded or extruded polystyrene in floating docks, floating platforms and buoys
- Keeping Polystyrene Out of Ontario’s Lakes and Rivers Act, 2021

- assembly of legislative assembly : no dedicated line
- 4163255300 the ones who published ones on the website
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- Mr. Yurek contact

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