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FAUNA & FLORA INTERNATIONAL'S

# Breaking down ocean polystyrene

An initial investigation into marine uses of foamed polystyrene

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## EXECUTIVE SUMMARY

The scale and extent of plastic pollution, and the threat this poses to marine life, is now well recognised. Foamed polystyrene is amongst the most commonly recorded components of marine litter, and foamed polystyrene used directly in the marine environment poses a direct pollution risk. In recognition of this, Fauna & Flora International undertook an initial investigation to explore how foamed polystyrene is used in marine contexts (with a focus on the UK), how and why it becomes pollution, and what further actions could be taken to tackle this threat to ocean life. This research was supported by a grant from 11<sup>th</sup> Hour Racing, and involved an in-depth literature review, stakeholder mapping and engagement, and an online questionnaire.

Foamed polystyrene is cheap to produce, extremely lightweight, impact resistant, waterproof, a good insulator and buoyant. These properties mean that it is frequently employed in marine activities, such as aquaculture, fisheries and the leisure industry. Unfortunately, these properties also make it vulnerable to a variety of potential problems when used in coastal or marine settings. Foamed polystyrene is easily fragmented and carried off by wind and waves, it becomes brittle when exposed to UV rays in sunlight, and is burrowed into by marine invertebrates that can cause it to break apart, all resulting in pollution to the ocean.

This research found that within the UK context, fish boxes appear to be the marine foamed polystyrene product with the highest turnover. The sheer number used, their low cost, and the fact that reuse is limited means that they perpetuate a linear economy model and present a significant pollution risk. As the case study from Hong Kong (page 27) indicates, foamed polystyrene fish boxes are also widely used outside Europe.

Foamed polystyrene is commonly used for buoys, floats and pontoons. In the UK, large buoys and floats appear to be covered in hard protective plastic in most situations, reducing the risk that they will fragment and cause pollution while in use. However, large uncovered buoys and floats are still used to some extent, and small polystyrene buoys and floats appear to be predominantly uncovered. Outside Europe, uncovered buoys and floats are extensively used in aquaculture and fisheries and cause significant pollution. Pontoons often contain foamed polystyrene, and while they are increasingly covered by a more resilient material in Europe, this does not guarantee protection from damage in all conditions, as seen at Holyhead Marina in Wales in March 2018 (see section 4.2).

Uncovered foamed polystyrene is also used for boat support blocks, which are reportedly sometimes abandoned in boatyards once no longer needed. Other marine uses of foamed polystyrene, such as bodyboards, appear to contribute a steady stream of pollution to the ocean. However, the relative proportion that each product contributes is difficult to assess, due to a paucity of information.

Data specifically on disposal of marine foamed polystyrene items are also limited. Foamed polystyrene from all uses is frequently incinerated. Recycling does occur, although the different definitions of recycling in data sources (for example, sometimes including pyrolysis and plastic to fuel) makes interpretation of the data problematic.

The useful properties of foamed polystyrene, as well as its low cost, can make finding viable reusable alternatives or materials less likely to pollute challenging. However, alternative materials and delivery models for fish boxes are being explored and trialled. Air-filled hard plastic is a readily available option for buoys, floats and pontoons, and covering foamed polystyrene with a hard material can reduce pollution risk; legislation forbidding the use of uncovered polystyrene in the water has been introduced in some jurisdictions. At the international level, two intergovernmental initiatives are focusing on marine pollution from all uses of foamed polystyrene.

Building on this scoping research, a list of recommendations to address pollution from marine uses of foamed polystyrene has been developed (see section 9.2). Recommended interventions aim to reduce the use of foamed polystyrene in the marine environment (although the entire life cycle impacts of any alternatives must be fully assessed), improve product design or in-use care where foamed polystyrene is used, and facilitate responsible end of life disposal. Increasing awareness amongst stakeholders of the impacts of foamed polystyrene pollution, relevant regulations and potential solutions is also recommended, to encourage engagement in addressing the problem and support for solutions.

## TERMINOLOGY

<b>Foamed polystyrene</b>	Refers to expanded and extruded polystyrene.
<b>EPS</b>	Expanded polystyrene, when used refers specifically to this type of foamed polystyrene.
<b>XPS</b>	Extruded polystyrene, when used refers specifically to this type of foamed polystyrene.
<b>Styrofoam™</b>	Refers to the XPS trademarked by The Dow Chemical Company. Elsewhere, it is frequently used erroneously to refer to EPS.
<b>Marine-based foamed polystyrene</b>	Refers to foamed polystyrene used by a coastal or marine industry, including but not limited to fisheries, aquaculture, leisure boating, and marina operations.
<b>Land-based foamed polystyrene</b>	Refers to foamed polystyrene used in terrestrial industry, including but not limited to building construction, packaging and takeaway restaurants.

## 1 INTRODUCTION

The scale and extent of marine plastic pollution is now recognised as never before. Plastic is found everywhere in the ocean, from the surface of the water to the deepest ocean trenches. Images of plastic pollution have become a familiar sight, from remote tropical island ecosystems overwhelmed by incoming plastic waste to arctic waters polluted with fragmented plastic particles.

Worldwide, over 300 million tonnes of virgin plastic are currently produced each year<sup>1</sup>. If unchecked, global plastic production is predicted to increase almost four-fold on 2014 figures by 2050<sup>2</sup>. It is estimated that 4.8 – 12.7 million tonnes of plastic enter the ocean every year<sup>3</sup>. Consultancy Eunomia places this estimate at 12.2 million tonnes, with up to 3.2 million tonnes coming from marine and coastal sources<sup>4</sup>. Without widespread and systemic change the amount of plastic in the ocean looks set to increase even further.

Once in the ocean, plastic has a direct impact on marine life. The most obvious impacts include entanglement of animals such as turtles in large plastic items like bags and fishing nets. Ingestion of plastic is also commonplace, with species from mussels to seabirds to marine mammals known to take in plastic from the water. As well as causing immediate physical damage, ingesting plastic can cause less visible chemical damage that may affect growth, feeding, reproductive behaviour, and ultimately result in impaired ability to survive.

Fauna & Flora International (FFI) started working on marine plastic pollution in 2009, recognising it as a serious threat to the marine biodiversity we seek to protect. We were the first biodiversity conservation organisation to address the emerging threat from microplastics in our oceans, and were instrumental in providing technical evidence to support the ban on microbeads in rinse-off personal care and cosmetics products introduced in the UK in 2018. We are now actively working on addressing pollution from plastic pellets and microplastic fibres.

We also regularly scope other sources of microplastic pollution that have a significant impact on the marine environment, where we see a gap that needs to be addressed. As such, during 2019 – 2020 we conducted an initial investigation into marine uses of foamed polystyrene, with a focus on the UK, and the risk of marine pollution that this presents. Foamed polystyrene is used in the fishing, aquaculture and boating sectors, and while land-based foamed polystyrene has received significant attention, the scale and impact of marine uses has been less in the spotlight to date.

This report summarises the results of this initial qualitative research, and identifies some potential solutions and areas for further work.

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<sup>1</sup> Ellen MacArthur Foundation, 2016

<sup>2</sup> *Ibid.*

<sup>3</sup> Jambeck *et al.*, 2015

<sup>4</sup> Sherrington, 2016





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## 1.1 Foamed polystyrene<sup>5</sup>

Polystyrene is a plastic polymer made of styrene monomers, which are made from benzene and ethylene, by-products of oil refining<sup>6</sup>. Polystyrene is often foamed to create rigid, lightweight materials: expanded polystyrene (EPS) or extruded polystyrene (XPS). Expanded polystyrene is made by expanding spherical beads in a mould and then applying heat and pressure to bind beads together, while extruded polystyrene involves continuous extrusion to produce a homogenous closed-cell matrix. One of the key differences in the two materials is density, with EPS being less dense than XPS.

Polystyrene and foamed polystyrene make up a small but significant component of plastic production, which globally exceeds 300 million tonnes per year<sup>7</sup>. In 2018, global production of polystyrene was estimated at 9.4 million tonnes<sup>8</sup>. According to PlasticsEurope, in 2018 approximately 3.3 million tonnes of polystyrene and EPS (foamed polystyrene) was used to make plastic products in Europe (6.4% of all plastic used by European plastics converters). In the HELCOM countries<sup>9</sup> (excluding Russia), an estimated 599,000 tonnes of polystyrene is consumed per year for manufacture of foamed polystyrene.

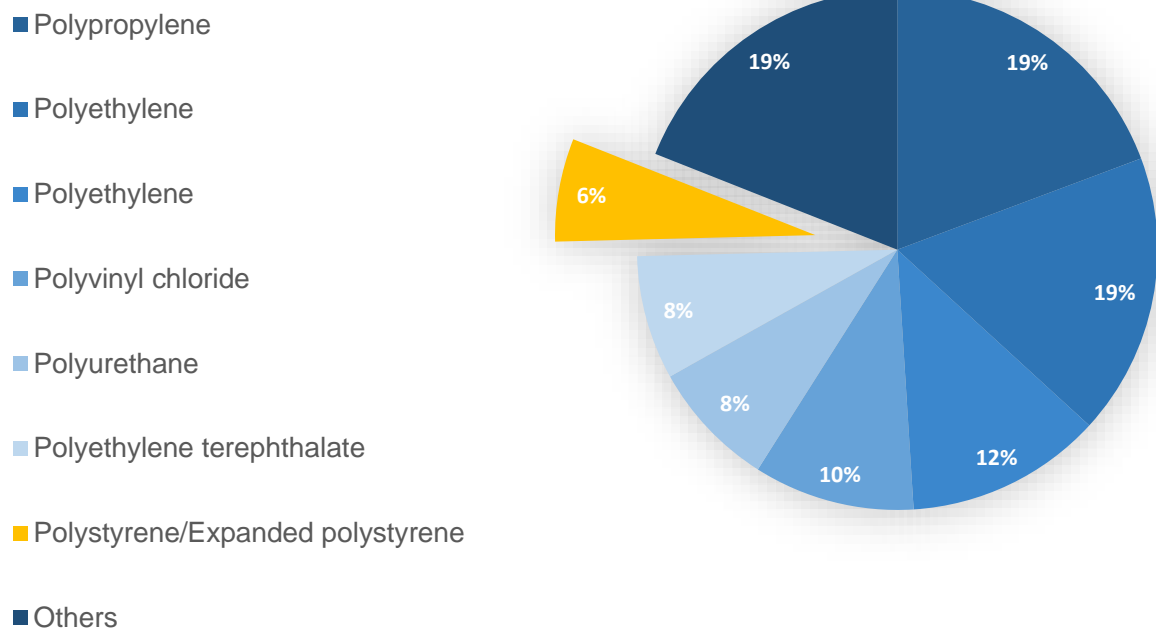
<sup>5</sup> Foamed polystyrene is often referred to as Styrofoam (trademarked brand of extruded polystyrene owned by Dow Chemical Company) or recently Airpop (expanded polystyrene registered trademark in Europe). Use of the term foamed polystyrene throughout this report comprises both expanded and extruded polystyrene.

<sup>6</sup> Fish Boxes, 2020

<sup>7</sup> Ellen MacArthur Foundation, 2016

<sup>8</sup> HDIN Research, 2019

<sup>9</sup> Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden



**Figure 1. Plastics use by converter companies in Europe in 2018<sup>10</sup>**

In the UK, EPS production for packaging is approximately 18,000 tonnes per year, with an additional 10,000 tonnes arriving in the UK as packaged goods. An estimated 24,000 tonnes of foamed polystyrene packaging waste is produced per year in the UK. There are no available data for XPS production in the UK, likely because the quantity is very small; it is mostly used for construction<sup>11</sup>.

## 1.2 Properties and uses of foamed polystyrene

Foamed polystyrene is cheap to produce, extremely lightweight, impact resistant, waterproof, a good insulator and buoyant. As a result, it is a popular choice for building insulation, takeaway food containers, and protective packaging for delicate products, amongst others. According to the European Manufacturers Association of Expanded Polystyrene, of all EPS and XPS produced in Europe, 70% is used for construction, 25% is used for packaging and 5% goes to “other” uses<sup>12</sup>.

While land-based uses of foamed polystyrene are clearly the most common in Europe, foamed polystyrene’s qualities mean that it is frequently employed in marine or aquatic activities, such as aquaculture, fisheries and boating, for products such as fish boxes, buoys, floats and pontoons. Here, it currently plays an important role, such as keeping fisheries products cool during storage and transit and providing walkways that can rise and fall with tides.

The following is a non-exhaustive list of marine uses of foamed polystyrene, starting with some of the more common applications.

<sup>10</sup> PlasticsEurope, 2019

<sup>11</sup> Personal communications

<sup>12</sup> Lassen *et al.*, 2019



## FISH BOXES



Fish boxes can be used on vessels, in storage and in transport, for protecting catch and keeping it cool.

## BUOYS



Buoys are used as floating markers or moorings in a variety of contexts, such as to guide vessels around dangerous rocks, demark safe swimming zones, float ropes attached to lobster pots, and outline yacht racing courses. Buoys can be made of hard plastic filled with air, uncovered foamed polystyrene, or hard plastic filled with foamed polystyrene. It may not be immediately clear whether or not a buoy contains foamed polystyrene.

## FLOATS



Like buoys, floats can serve as floating markers and suspension devices, such as for suspending fishing nets (e.g. purse-seine nets and gill nets) and in aquaculture.

## PONTOONS



Foamed polystyrene is commonly used for pontoons in docks, harbours and marinas although it is usually covered in concrete or rigid plastic in the UK and wider Europe.

### VESSEL INSULATION



Foamed polystyrene is used within the hulls of some vessels, such as sailing boats for racing<sup>13</sup>.

### VESSEL SUPPORT BLOCKS



If boats are removed from the water, such as over winter, they are propped up on a stand. Foamed polystyrene blocks are sometimes used to stand boats<sup>14</sup>, likely because they will not damage the hulls of vessels<sup>15</sup>.

### PERSONAL FLOTATION DEVICES



Foamed polystyrene can be used to fill or make a number of personal flotation devices for leisure and safety, including surfboards, bodyboards, swimming aids and life buoys.

Other foams can also be used for certain applications, including expanded polypropylene (EPP), ethylene-vinyl acetate foam (EVA foam), expanded polyethylene<sup>16</sup> (EPE) and polyurethane foam (PU foam). It is possible that these other foamed plastics would be confused for foamed polystyrene during beach and ocean surveys of marine plastic pollution.

While most marine uses of foamed polystyrene, such as floats and buoys, fall under “other uses” in market data, fish boxes fall under packaging and account for a significant proportion

<sup>13</sup> Personal communications

<sup>14</sup> Universal Foam Products, 2020

<sup>15</sup> Personal communications

<sup>16</sup> JPW Marine, 2020

of foamed polystyrene packaging consumed. For example, in Germany 25% of foamed polystyrene packaging supply is for fish boxes<sup>17</sup>.

### **A note on additional foamed polystyrene uses**

While not a marine use of foamed polystyrene, Biostyrene™ spheres are made of foamed polystyrene and are used in Biostyr™ wastewater treatment to remove organic, nitrogenous and particulate compound pollution<sup>18</sup>. Other media, such as biobeads, used to treat wastewater regularly escape treatment facilities and enter the marine environment in large volumes. For example, NGO Rame Peninsula Beach Care records removing an estimated five million biobeads from a 100m stretch of Cornish coastline during seven beach cleans in one year<sup>19</sup>. There would be a similar concern regarding the use of Biostyrene™, and we encourage very careful consideration of applying microplastics and small plastics to situations where they may easily escape to the environment and become pollution. Particularly relevant to this report is the use of filters similar to biobeads, such as for filtering water in fish farms and hatchers<sup>20</sup>.

## **2 METHODS AND SCOPE**

### **2.1 Methods**

This study was conducted through a combination of literature and grey literature review and direct engagement with relevant stakeholders. It should be noted that the information presented from the stakeholder engagement is largely qualitative and based on the opinion or experience of the individual involved.

The main steps involved were:

- Literature review of studies, reports and surveys documenting uses and pollution of foamed polystyrene in the marine environment, the regulatory frameworks relevant to the use and disposal of foamed polystyrene, and potential alternatives or initiatives that have been, or are being, explored.
- Stakeholder mapping to determine which other organisations are working on foamed polystyrene pollution from maritime sources.
- Stakeholder engagement through contacting key stakeholder groups that use foamed polystyrene in the marine environment, as identified in the literature review, and to organisations working on foamed polystyrene, as identified in the stakeholder mapping. This included direct engagement with 20 people active in relevant sectors (including aquaculture, sailing, packaging, research, policy, marine NGOs), and an online questionnaire, which was completed by 23 individuals (see Annex 1).

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<sup>17</sup> Lassen *et al.*, 2019

<sup>18</sup> Veolia, 2020

<sup>19</sup> Cornish Plastic Pollution Coalition, 2018

<sup>20</sup> *Ibid.*



## 2.2 Scope

**Foamed polystyrene:** This study only considers foamed polystyrene (expanded and extruded), due to its frequent use directly on the ocean and its propensity to rapidly break down into microplastic pollution in this context.

**Maritime uses:** This study only considers marine uses and pollution of foamed polystyrene, including associated coastal or sectoral uses. For example, when researching foamed polystyrene use in fisheries, fish boxes used for storage and distribution of fish products are included within the scope.

**Geographic scope:** The research and stakeholder engagement focused largely on the UK. However, UK information is grounded in the European and international context where possible. Where UK data were not available, European and/or international data are used instead. Findings and proposed interventions have relevance for marine uses of foamed polystyrene beyond the UK. Three case studies on pages 22, 27 and 33 explore the use of and pollution from marine uses of foamed polystyrene in North America and East Asia, as well as proposed and trialled solutions.

## 3 MARINE USES OF FOAMED POLYSTYRENE

### Fish boxes

Foamed polystyrene fish boxes are widely used for transport and storage of fish and seafood. In Europe, this tends to be once the catch is landed, rather than on board fishing vessels. On board, rigid plastic, such as high density polyethylene (HDPE), is commonly employed instead<sup>21</sup>. While fish boxes may not be used on vessels in Europe, they are often stored outside at ports, presenting a pollution risk to nearby waterways<sup>22</sup>. Elsewhere in the world, fish boxes are still used on board to keep catch cool, particularly on small fishing vessels with lower cooling capacities<sup>23</sup>.



### UK FISH BOXES

The UK uses 22 million fish boxes every year for seafood storage and transport<sup>24</sup>, protecting UK fish worth 900 million GBP<sup>25</sup>. Year on year use appears to be growing in line with the growth in UK fish consumption, which is predicted to increase from 8 million kg to 9.23 million kg of fish by 2030<sup>26</sup>.

<sup>21</sup> Lassen *et al.*, 2019

<sup>22</sup> BiPRO, 2013

<sup>23</sup> Lassen *et al.*, 2019

<sup>24</sup> BPF EPS Group, 2020a

<sup>25</sup> BPF EPS Group, 2013

<sup>26</sup> BPF EPS Group, 2020b

The significant number of foamed polystyrene boxes used in the UK was confirmed by conversations with stakeholders and the polystyrene survey (see Annex 1), with fish boxes being the most commonly highlighted use by survey respondents. One fisheries and fish processing business contacted estimated that they used 1–2 articulated vans (77.76m<sup>2</sup> standard capacity) full of foamed polystyrene boxes per week for chilled dispatches, adding that most fish and shellfish businesses use foamed polystyrene fish boxes because they are cheap and provide excellent thermal qualities required for delicate products<sup>27</sup>. The business owner was aware of the environmental consequences of foamed polystyrene fish boxes and was also trialling cardboard fish boxes, discussed in more detail in section 8.1. A small aquaculture business contacted estimated that they use 100 foamed polystyrene fish boxes per month, each filled with 2–10kg of produce, which is sometimes only equivalent to one or two fish<sup>28</sup>.

Some shortcomings of foamed polystyrene fish boxes were identified by stakeholders. For live transport, it was noted that the hard, serrated shells and pincers of shellfish often cause significant damage to the interior of the boxes. Furthermore, the boxes cannot be flatpacked, and therefore take up a lot of room in storage, delivery and in sending to end-of-life processing. Despite these shortcomings, foamed polystyrene boxes were felt to be preferable to alternative boxes because of their thermal insulation properties.

Foamed polystyrene fish boxes are relatively cheap to buy, as highlighted in the comparison below.

**Table 1. Cost of fish boxes made of four different materials from sample UK suppliers**

Material	Volume (L)	Cost for single unit (GBP)	Unit cost in bulk order (GBP)
Foamed polystyrene <sup>29</sup>	52	6.83	6.42 each for 24 or more boxes
High density polyethylene <sup>30</sup>	60	22.99	N/A
Waxed cardboard <sup>31</sup>	34	4.78	2.27 each for 324 or more boxes
Expanded polypropylene <sup>32</sup>	50	51.91	48 each for 21 or more boxes

The low cost is likely to encourage a single or limited use culture, with boxes being regarded as disposable items, treated with little care, and regularly replaced.

Discussions with the stakeholders contacted suggested that many foamed polystyrene fish boxes are currently landfilled, incinerated or openly burned, with very few being recycled. For example, one consultee observed that some smokehouses and other supply chain actors burn

<sup>27</sup> Personal communications

<sup>28</sup> Personal communications

<sup>29</sup> JB Packaging, 2020a

<sup>30</sup> Gael Force Marine, 2020a

<sup>31</sup> JB Packaging, 2020b

<sup>32</sup> JB Packaging, 2020c

the polystyrene boxes they receive on their facilities. It was also noted that courier companies and delivery services do not always handle the boxes appropriately, leading to damage to the boxes<sup>33</sup>.

Frustration at the absence of practical alternatives with a lower environmental footprint was also expressed. Barriers to using alternatives that are currently available included cost and confusion regarding whether or not they are actually better for the environment.

Discussions also revealed that small-scale aquaculture that delivers straight to nearby customers may be able to get customers to return the boxes or bags that they use to supply products<sup>34</sup>. However, this is not the case for dispatches further afield, in part because of the cost of returning the boxes. According to the fisheries business mentioned above, customers are responsible for the disposal of the fish boxes in which their products are delivered. All stakeholders asked said that for international shipping it would not be economically viable for customers to return the fish boxes. It is expected that customers returning boxes would be difficult for a large part of the fisheries and aquaculture sectors.

### **Buoys and floats**

Uncovered foamed polystyrene floats (sometimes coated in paint) are used in fishing in the UK and elsewhere, for example on purse-seine nets and gill nets, and have been seen discarded along with nets at harbours in the UK. Use and discard of nets with uncovered foamed polystyrene was also reported to be common practice in Canada<sup>35</sup>. Uncovered foamed polystyrene floats are reportedly preferred over other materials, such as hard plastic air-filled floats, because when submerged they do not crack and lose their buoyancy. A survey respondent involved in purse-seine fishing noted that some floats are lost at sea, but in their experience these incidences are rare and their floats last several years before being discarded in regular rubbish bins (likely then landfilled or incinerated). If coated in hard plastic, some floats are estimated to last 10–15 years, as they work even if degraded<sup>36</sup>.

Buoys for a variety of purposes are also made from foamed polystyrene. Discussions indicate that hard plastic buoys filled with polystyrene appear to be a popular choice in the UK, as the hard cover protects the buoy (thereby requiring less maintenance or replacement). As touched on above, some of these products can be made of a hard plastic shell filled with air, but it was reported that a foamed polystyrene interior provides more buoyancy than air. Foamed polystyrene-filled buoys also remain buoyant if the hard plastic cracks.

Uncovered buoys are still used to some extent in the UK, however. One stakeholder reported that most fishing pots for crab and lobster have a big hard plastic-covered buoy, often accompanied by several small uncovered foamed polystyrene buoys on either side<sup>37</sup>. Lobster pot buoys were mentioned repeatedly as a source of exposed foamed polystyrene in the UK during discussions with individuals from the sailing, fisheries and aquaculture sectors. Sailing race markers are sometimes exposed foamed polystyrene, although this is discouraged and they are predominantly covered in hard plastic.

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<sup>33</sup> Personal communications

<sup>34</sup> Personal communications

<sup>35</sup> Personal communications

<sup>36</sup> Lassen *et al.*, 2019

<sup>37</sup> Personal communications



Similarly, hard plastic-covered foamed polystyrene floats and uncovered foamed polystyrene floats both appear to be used for shellfish and fish farming<sup>38</sup>. Discussions with the Scottish aquaculture industry indicate that they use foamed polystyrene floats, predominantly covered in hard plastic, with examples including fish, seaweed and mussel farming. These floats were estimated to last approximately 40 years for fish farming, although it was noted that the hard exterior is easily cracked, for example if rammed by a boat. Additionally, the steel bridle rubs on the interior, wearing away foamed polystyrene over time.

Salmon farming pens in the UK used to employ wooden boxes, uncovered foamed polystyrene floats and metal joining brackets<sup>39</sup>. However, the widespread use of these materials was abandoned 10–20 years ago, and has largely been replaced by HDPE equipment and air flotation systems. This shift in materials appears to be driven by the greater durability of HDPE and other hard plastic equipment, which is far more resilient to biotic and abiotic factors that quickly break down exposed foamed polystyrene, such as waves and crustaceans. Furthermore, one business owner described how concerns over fisheries waste and antibiotic build up in Scottish sea lochs have led to salmon farming moving further offshore, where sea conditions are more turbulent and require hardier materials that are easily and cheaply maintained, such as HDPE.

There do continue to be a few instances of exposed foamed polystyrene in small-scale salmon farming in Scotland. This includes wooden pens kept afloat with exposed foamed polystyrene floats, which have been observed to break down quickly, releasing foamed polystyrene beads into the ocean. The exposed foamed polystyrene has also been observed to be pecked by gulls, causing further deterioration<sup>40</sup>. Additionally, it was noted that some finfish aquaculture employs foamed polystyrene inside the plastic piping more commonly used for flotation<sup>41</sup>.

In HELCOM countries, it is reported that floats are typically air-filled hard plastic, such as polypropylene or polyvinyl chloride, with EPS being more common 20 years ago<sup>42</sup>. Outside Europe, foamed polystyrene floats are frequently used for aquaculture, particularly to suspend oyster rafts and mussel-growing structures<sup>43</sup> in East and Southeast Asia (see section 4.1).

As with fish boxes, foamed polystyrene buoys and floats are relatively cheap to buy. For example, small (76.2mm length) foamed polystyrene gill net floats are available from one equipment supplier in the UK for £0.64 each<sup>44</sup>. This does not encourage careful stewardship of the products, which can be readily replaced.

## Pontoons

Foamed polystyrene is often used for pontoons. In Europe it appears these are mostly covered in concrete or other hard protective casings.

One survey respondent from a small boatyard on the southern English coast reported using old polystyrene pontoons in steel frames. The respondent indicated they hope to replace these

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<sup>38</sup> Personal communications

<sup>39</sup> Personal communications

<sup>40</sup> Personal communications

<sup>41</sup> Personal communications

<sup>42</sup> Lassen *et al.*, 2019

<sup>43</sup> Moore, 2014

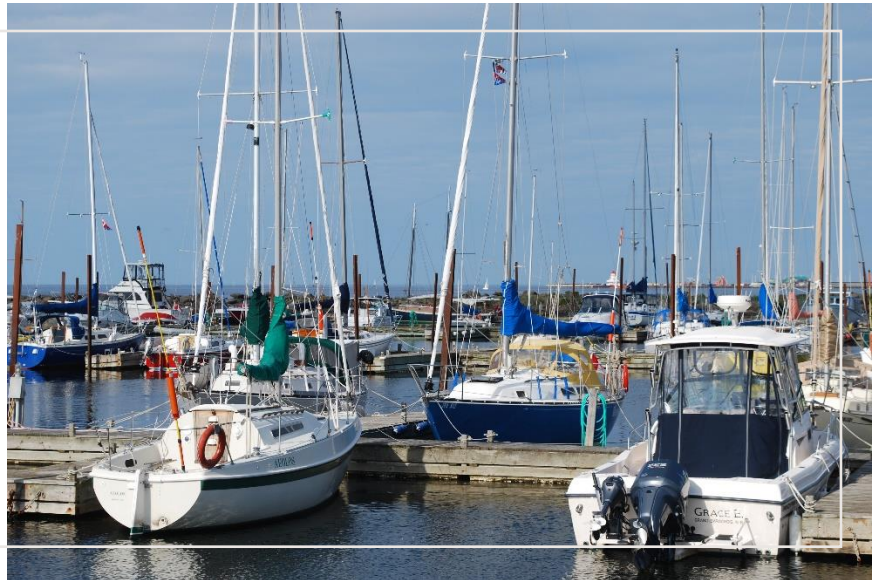
<sup>44</sup> Gael Force Marine, 2020b

with a better alternative, but that the cost of replacement is high, and the availability of recycling options for the existing pontoons limited: *“landfill, not ideal but all we can do.”*

Another respondent indicated that a marina in Scotland has a policy of replacing old pontoon floats with a new variety encased in concrete, and that retired pontoon floats are removed by a waste disposal service to a licensed site at end of life.

## MARINA

Pontoons, dock floats and other floating platforms at marinas are commonly filled with foamed polystyrene, which keeps them buoyant. Storms can damage these platforms (see 4.2).



© Stephen Downes/Flickr

## Hull insulation, boat fenders and crash bags

Recreational boats will occasionally have foamed polystyrene fenders, although these are usually rubberised. Leisure boats may have foamed polystyrene insulation in their hulls, which can be exposed if the hull is damaged during a storm or from scraping along rocks.

When carbon fibre racing boats are being moved, crash bags filled with polystyrene (similar to large bean bags) are sometimes used to protect the boat in case it falls<sup>45</sup>.

## Vessel support blocks

Foamed polystyrene can be used to support overwintering boats. From personal communications, it appears that this is not commonplace in Scotland, where wooden chocks and sleepers are used for supporting boats out of the water. However, in the southern UK where there is largescale leisure boating (e.g. near Plymouth), polystyrene blocks have been observed as supports for racing boats<sup>46</sup>, potentially because they are less likely to damage the fibreglass hulls<sup>47</sup>.

## Personal flotation devices

Cheap, uncovered foamed polystyrene bodyboards are sold widely across UK beaches. These bodyboards break easily and holidaymakers that buy them may not always bother to take the bodyboard home, promoting rapid use and discard<sup>48</sup>. Neil Hembrow, manager of the BeachCare South West project, is quoted on Keep Britain Tidy’s website, *“Every summer a*

<sup>45</sup> Personal communications

<sup>46</sup> Personal communications

<sup>47</sup> Personal communications

<sup>48</sup> Keep Britain Tidy, 2019

*deluge of these boards hit our shores. They are created from cheap materials that are only two inches thick and they don't last five minutes in our powerful Atlantic waves. We find hundreds of boards on the beaches we clean, but there are thousands more dumped every summer."*

## 4 FOAMED POLYSTYRENE POLLUTION

### 4.1 Foamed polystyrene as a component of marine litter

Foamed polystyrene (from all sources) has been widely recorded as a common component of marine litter, including pieces that have found their way to the Arctic Ocean<sup>49</sup>. Polystyrene spherules polluting the ocean were recorded in scientific literature as early as 1972, with Carpenter et al. (1972) noting that they were abundant in coastal waters of southern New England. The study notes that the spherules had a number of pollutants on their surface and that the spherules were selectively eaten by eight of the 14 species of fish examined<sup>50</sup>.

It should be noted that due to foamed polystyrene's very low density, it is more likely to float than other plastics, until biotic and abiotic factors, such as biofouling and wave action, increase its density and it sinks. As such, polystyrene's presence in water surface or beach surveys may not be representative of the proportion of plastic pollution that it forms, although its presence in 50 year-old studies points to a long growing problem.

It is also worth noting that figures on foamed polystyrene pollution from specific products only take into account products that can still be identified, and not those that have broken down into fragments.

Finally, studies and surveys often aggregate foamed polystyrene data with other plastic types, which can make it difficult to extract data that are specific to foamed polystyrene.



#### ANONYMOUS POLLUTION

Due to foamed polystyrene's propensity to fragment, it is often difficult to determine its original use. Blocks of foamed polystyrene pollution such as this one could be from construction, marinas, boat yards, or other sources that can be impossible to determine.

<sup>49</sup> Doward, 2017

<sup>50</sup> Carpenter et al., 1972

Nonetheless, foamed polystyrene (from all sources) was reported as the most frequently observed macroplastic in visual surveys of ocean gyres, accounting for 1,116 of 4,921 (~22.7%) items observed<sup>51</sup>. The inter-organisational OceanWise project (see section 8.3.2) reports that foamed polystyrene is amongst the top ten types of marine litter found in European beach litter surveys<sup>52</sup>. Meanwhile, it has been estimated that 10–30% of total EPS used in the HELCOM<sup>53</sup> catchment area (on land and at sea) is released to the Baltic Sea<sup>54</sup>. Beach litter monitoring for the HELCOM catchment area suggests that foamed polystyrene accounts for 10% of all plastic pollution, although beach-specific percentages are very variable<sup>55</sup>. A consultancy report for the European Commission detailing the top 15 beach litter items for the Baltic Sea found the average amount of “foam sponge” on beaches to be 40 items per km, equal to 3% of all items found<sup>56</sup>. In the UK, EPS represented 10% of anthropogenic litter across all beaches surveyed, with the North Sea containing the highest proportion of EPS (14%)<sup>57</sup>.

Derelict fishing buoys were recorded in one published study to account for 58.3% of total macroplastic weight in ocean gyres, but it is not reported whether these buoys were made from hard plastic, foamed polystyrene, or a combination of the two, or whether additional materials such as metal fittings may have contributed to this weight. Foamed polystyrene is very light, making it seem unlikely that buoys solely made of this material would account for over half of macroplastic pollution weight<sup>58</sup>. In contrast, during surveys of European beaches, fish boxes were estimated to account for 0.02% of marine litter counted, and 0.11% of marine litter associated with fishing activities<sup>59</sup>, while foam buoys accounted for 0.02% of marine litter associated with fishing gear<sup>60</sup>. It should be noted, however, that these figures only include products that can still be identified, and not those that have broken down into fragments. The disparity between these figures may arise from the fact that few studies have reported figures for foamed polystyrene pollution separately. As discussed above, the ability of studies to do so is compounded by the fact that foamed polystyrene quickly fragments into pieces that are too small for some studies to collect and that cannot be attributed to a specific product.

In a polystyrene survey conducted as part of the research for this report (see Annex 1), 22 of the 23 respondents reported seeing marine foamed polystyrene pollution, predominantly along the coast and at sea. Fragmented pieces were reported as the most frequently sighted type of foamed polystyrene pollution, and fish boxes and pontoon floats as the most regular types of identifiable debris.

Outside Europe, levels of polystyrene pollution have been closely linked to fisheries and aquaculture activities, as described overleaf.

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<sup>51</sup> Eriksen *et al.*, 2014

<sup>52</sup> OceanWise, 2019

<sup>53</sup> Helsinki Commission, an intergovernmental organisation that governs the Convention on the Protection of the Marine Environment of the Baltic Sea Area

<sup>54</sup> Lassen *et al.*, 2019

<sup>55</sup> *Ibid.*

<sup>56</sup> De Vrees, 2012

<sup>57</sup> Nelms *et al.*, 2017

<sup>58</sup> Eriksen *et al.*, 2014

<sup>59</sup> Addamo *et al.*, 2017

<sup>60</sup> *Ibid.*

<b>CHILE</b>	<p>At-sea surveys conducted in order to determine whether marine litter was land- or marine-based found 80% of floating marine debris was a combination of EPS, plastic bags and plastic fragments. EPS is used intensively as a flotation device in mussel farming in Chile<sup>61</sup>. EPS pollution was abundant in the north and scarce in the south, and it is reported that 85% of Chilean mussel and salmon farming occurs in the north. The distribution of plastic bags was uniform throughout the study area, reinforcing the likelihood that the presence of foamed polystyrene near aquaculture facilities is due to pollution from these facilities rather than other sources.</p>
<b>JAPAN</b>	<p>EPS is used abundantly for flotation devices in oyster farming. Oysters are cultured in Hiroshima Bay, where 99.5% of the marine litter found in a study along the 50km shoreline was foamed polystyrene, which was predominantly fragmented to &lt;10mm<sup>62</sup>. The study notes that uncovered floats are unsuitable for use in this context.</p>
<b>SOUTH KOREA</b>	<p>A study by Lee et al. (2015) identifies commercial fisheries and aquaculture as the main source of marine litter nationwide, with uncovered foamed polystyrene buoys from aquaculture being the most abundant type of beach litter<sup>63</sup>. Small buoys (40–80 litres) are used in long-line hanging culture systems for oysters, mussels, scallops, sea squirts and seaweed. An estimated 1,000 60 litre foamed polystyrene buoys are used per hectare in hanging culture of oysters and mussels<sup>64</sup>. Large buoys (&gt;200 litres) are used for mooring submerged fish cages and fish nets, and as flotation devices for docks and barges<sup>65</sup>.</p> <p>According to the South Korean Ministry of Environment, South Korea deploys approximately 2 million foamed polystyrene buoys every year, with an estimated 28% of them retrieved by the government for recycling<sup>66</sup>. Conversely, it is also reported that 90% of buoys are intentionally discarded at sea after use and that 1,800,000 buoys become ocean pollution annually, although this has not been scientifically validated<sup>67</sup>.</p>

<sup>61</sup> Hinojosa & Thiel, 2009

<sup>62</sup> Fujieda & Sasaki, 2005

<sup>63</sup> Lee et al., 2015

<sup>64</sup> *Ibid.*

<sup>65</sup> Hong et al., 2014

<sup>66</sup> Jang et al., 2017

<sup>67</sup> Lee et al., 2015



## TAIWAN

Taiwan's first-ever island-wide marine debris survey (conducted by the Society of Wilderness and Greenpeace in 2018) found that foamed polystyrene buoys used in oyster aquaculture are among the most pervasive types of pollution along the coast<sup>68</sup>. The uncovered foamed polystyrene buoys are used in shallow-water oyster farming to keep rafts afloat<sup>69</sup>. Here, they are easily broken up by waves during use and are also reportedly discarded on site<sup>70</sup>. It is estimated that 120,000–200,000 polystyrene buoys are used every year by approximately 200 farmers across approximately 1,400 acres for oyster farming that is worth an estimated 630 million NTD (17 million GBP). This is based on the fact that 8–10 buoys are needed initially per raft, increasing to 12–15 buoys per raft as oysters grow. See Taiwan case study on page 33 for further information on Taiwan.

## VIETNAM

A rapid survey conducted by the International Union for the Conservation of Nature (IUCN) and Au Co Cruises in Cat Ba Archipelago estimated that approximately 54,582 foamed polystyrene floats are in use at any one time for the estimated 500 floating aquaculture farms<sup>71</sup>. Mollusc culture requires beams of rafts carrying 20–30kg baskets of sand and spat, and so highly buoyant material is needed to keep them afloat. The same study found that 50% of total marine litter collected was polystyrene. Covering foamed polystyrene with hard plastic would help to reduce loss of foamed polystyrene fragments during use. However, this is considered very expensive.

Floating restaurants in Vietnam also make use of EPS floats to remain buoyant<sup>72</sup>.

<sup>68</sup> Ning, 2018

<sup>69</sup> Chen *et al.*, 2018

<sup>70</sup> Liu *et al.*, 2015

<sup>71</sup> IUCN & Au Co Cruises, 2016

<sup>72</sup> *Ibid.*



## 4.2 Routes to pollution for maritime foamed polystyrene

Foamed polystyrene can become pollution through accidental loss of, or damage to, items and through intentional discarding or littering.

**Accidental loss or damage:** When exposed to ultraviolet (UV) radiation in the presence of air, polystyrene rapidly yellows and becomes brittle<sup>73</sup>. Combined with biofouling and wave action, this weathering means that foamed polystyrene quickly fragments in the marine environment and often cannot be traced back to its original source.

Marine isopods have also been reported to burrow into foamed polystyrene floats, making them weaker and hollower<sup>74</sup>, likely exacerbating the possible damage caused by abiotic factors. For example, dense colonies of isopods are capable of expelling millions of polystyrene microplastic particles into aquaculture facilities and docks. This has been recorded at aquaculture facilities in Yaquina Bay, USA and Tainan, Taiwan. A tugboat terminal in Coos Bay, USA had to be abandoned due to severe burrowing rendering it unusable<sup>75</sup>.

**Intentional pollution:** Like other plastic products and fishing gear, foamed polystyrene can be intentionally discarded into the marine environment. This may be exacerbated because of the amount of space that foamed polystyrene takes up, making it more difficult to transport for appropriate waste disposal, with limited space on vessels and vehicles.

### Fish boxes

Fish boxes and their lids are frequently observed as beach litter and floating at sea. They may be accidentally lost from vessels that use them to store catch at sea, or blown away when inappropriately stored outdoors. Damage during inappropriate handling or storage can also create fragments that are then more likely to be carried by wind or rain to sea.

In conducting research for this report, there were no accounts of intentional discarding of fish boxes from vessels. However, given the frequency of fishing gear discard, it is likely that damaged fish boxes, or those that are no longer needed, would also be discarded at sea.

### Buoys and floats

Buoys and floats are also frequently observed in marine litter. Uncovered foamed polystyrene buoys and floats are particularly vulnerable to fragmentation by waves, through pecking by birds or burrowing by marine animals. Entire buoys and floats can come adrift during bad weather and be lost.

Buoys and floats may also be discarded at sea when no longer needed, to avoid having to transport them back to land for processing. It is noted that there is sometimes a fee associated with landing unwanted gear or waste at ports. The intentional discarding into the sea of buoys used in aquaculture is reported in many countries, including South Korea and Taiwan as described in section 4.1 above.

There were reports from stakeholder engagement from the south of the UK and Scotland of boat yards and aquaculture operators leaving large blocks of foamed polystyrene and old

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<sup>73</sup> Yousif & Haddad, 2013

<sup>74</sup> *Ibid.*

<sup>75</sup> *Ibid.*

buoys degrading in the open, where UV light and gulls readily fragment small pieces off that can then enter the marine environment<sup>76</sup>.

## Pontoons

Foamed polystyrene pontoons, including those covered with other materials such as concrete, may be broken or damaged during storms. Storm Emma, which hit the UK in early March 2018, destroyed Holyhead Marina in Wales, releasing an estimated 30 tonnes<sup>77</sup> of foamed polystyrene into the marine environment.

Personal communications also indicate that foamed polystyrene-filled pontoons may be left on site when no longer needed, degrading and potentially becoming pollution. One individual from a sailing organisation noted that this occurs frequently along the River Thames in London.

### HOLYHEAD MARINA

Hard casings around foamed polystyrene can help to minimise the likelihood of pollution. However, as seen with Storm Emma and severe weather events, the hard protective casing can break, releasing vast amounts of foamed polystyrene directly into the marine environment.



© Hafin Owen/Flickr

## Vessel insulation, support blocks and crash bags

Foamed polystyrene used in vessel insulation can be released if the vessel hull breaks during a crash or storm, and/or during repair on the water. One individual from a sailing organisation estimated that 10–15 damaged boats per year wash up after storms in the UK<sup>78</sup>. Cracks in the hulls of sailing boats (from collisions during a race, for example) are sometimes repaired directly on the water because of the cost of lifting the boat out of the water. When this takes place, foamed polystyrene insulation in the hull may be lost to the ocean<sup>79</sup>.

Support blocks may occasionally be neglected in boat yards, where they degrade or are pecked (e.g. by gulls) over time and can release fragments to the sea.

One individual involved in sailing noted that they had observed crash bags used for moving sailing boats splitting when a boat fell, releasing the foamed polystyrene balls from within.

<sup>76</sup> Personal communications

<sup>77</sup> BBC, 2019

<sup>78</sup> Personal communications

<sup>79</sup> Personal communications

### **Personal flotation devices**

Items such as body boards and personal flotation devices may be abandoned on beaches or lost when in use at sea. Publicly available disposal facilities at the seaside are often not designed for bulky products, which may promote abandonment of bodyboards and similar cheap foamed polystyrene personal flotation devices on the beach where they can be blown or washed into the ocean. Personal flotation devices may also be accidentally lost while in use swimming in the sea. According to the NGO Keep Britain Tidy, an estimated 16,000 bodyboards are found in UK waters every year, and they collected 600 from Cornish beaches in just one day<sup>80</sup>. In the summer of 2019, 480 snapped bodyboards were recovered from two beaches<sup>81</sup>.

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<sup>80</sup> Telegraph, 2019

<sup>81</sup> Keep Britain Tidy, 2019

## Canada Case Study

Polystyrene pollution is a serious problem in Canada. An estimated 80% of foamed polystyrene waste in Canada ends up in landfills and environment<sup>82</sup>. Furthermore, foamed polystyrene and microplastic pollution are the two most common types of beach litter found during the Great Canadian Shoreline clean-ups<sup>83</sup>.

On Lasqueti Island, north of Vancouver in British Columbia, foamed polystyrene is such an omnipresent problem that residents have held an annual Styrofoam Day four years running. In 2019, approximately 70 volunteers collected two tonnes of plastic waste, the majority of which was foamed polystyrene. Given how light foamed polystyrene is (98% air), this is a colossal amount, and in some places volunteers reported sinking knee-deep into foamed polystyrene fragments<sup>84</sup>. Associate Professor of Economic Ethics at University of Montreal and part-time Lasqueti resident, Dr Peter Dietsch is quoted in Canadian Broadcasting Corporation (CBC) News, *"We're finding relatively few of the consumer items that are dominating news headlines when it comes to marine pollution. There are plastic bottles, but when you put them next to the Styrofoam, the ratio is 3,000 to one"*<sup>85</sup>.

Much of this foamed polystyrene is believed to come from floats used by the aquaculture industry and marina pontoons or dock floats. While Lasqueti's pollution receives high volumes of pollution coming up the Strait of Georgia, nearby Denman Island has aquaculture facilities and also sees high volumes of foamed polystyrene pollution that likely originate from these<sup>86</sup>.

Sheila Malcolmson, British Columbia's Parliamentary Secretary for Environment travelled across British Columbia to hold meetings with representatives from government, industry, environmental NGOs, citizen groups and boater groups to inform the report *What We Heard on Marine Debris in B.C.* All participant groups raised foamed polystyrene as a problem<sup>87</sup>. Malcolmson is quoted in the Vancouver Sun news noting that *"we heard more about [foam] than any other marine debris. We saw photos of people shovelling so much broken up ... foam it looks like they were in snowdrifts."*<sup>88</sup> Concerns have been raised about the local wildlife, such as Canada geese and otters, which have been observed to eat fragments of foamed polystyrene<sup>89</sup>.

The meetings revealed that there has been a shift from steel pilings to foamed polystyrene floats in aquaculture, without an appropriate containment plan in place for the rapid fragmentation of foamed polystyrene. As such, a proposal for a ban on the use of foamed polystyrene in the aquaculture industry in British Columbia is currently being considered. A lack of appropriate disposal and recycling facilities was also cited by meeting participants as a leading cause for foamed polystyrene pollution. As well as exacerbating foamed polystyrene pollution, this can promote other inappropriate disposal practices, as shared by one fisher who disposes of foamed polystyrene by covering it in gasoline and burning it on the shore<sup>90</sup>.

<sup>82</sup> Wallis, 2018

<sup>83</sup> Malcolmson, 2020

<sup>84</sup> Larsen, 2019

<sup>85</sup> *Ibid.*

<sup>86</sup> Personal communications

<sup>87</sup> Malcolmson, 2020

<sup>88</sup> Crawford, 2020

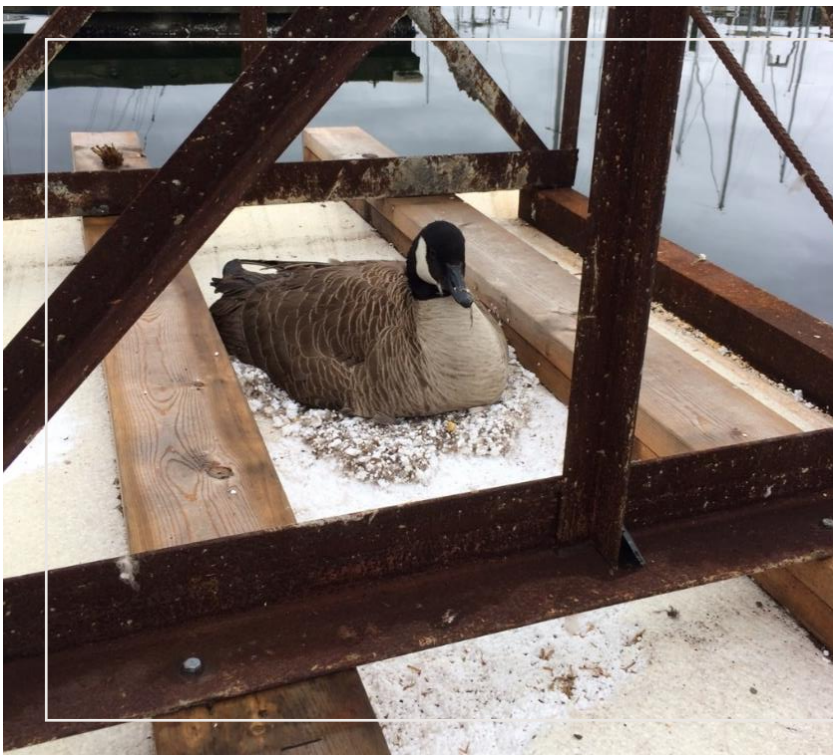
<sup>89</sup> *Ibid.*

<sup>90</sup> Personal communications



Unsurprisingly, this problem isn't unique to British Columbia – 5,851km east in Tracadie Bay, Prince Edward Island, Sarah Wheatley from the Winter River Tracadie Bay Watershed Association collected two tonnes of pollution from the bay with volunteers, with foamed polystyrene buoys being the most common item, as reported by CBC News<sup>91</sup>. Tracadie Bay Watershed Association has suggested an “eco levy” on foamed polystyrene buoys, with the aim of disincentivising their purchase and funding clean-ups. Prince Edward Island Aquaculture Alliance has an environmental code of practice that promotes buying durable, reusable and/or recyclable products in order to reduce the potential of the products becoming pollution. Although some mussel growers on the island have reportedly shifted towards buying hard plastic buoys, they remain unclear on what to do with their old foamed polystyrene buoys. Oyster aquaculture company Atlantic Shellfish Products is also now using hard plastic buoys instead of foamed polystyrene buoys, and has reverted to using wooden and hard plastic boxes instead of foamed polystyrene and wax-lined cardboard boxes for oyster dispatches<sup>92</sup>. However, it is unclear what is used to insulate these alternative boxes, given their lower thermal capabilities compared to foamed polystyrene.

The abundance of foamed polystyrene pollution amassing in Canada's waters and shorelines is likely the driver behind the Canadian Liberal Party's proposal to the Ministries of Fisheries and Environment to ban un-encapsulated foamed polystyrene destined for use in freshwater, estuarine or marine environments, establish an effective standard for foamed polystyrene encapsulation, require timely transition to encapsulated foamed polystyrene and require recycling or disposal of foamed polystyrene and encapsulation materials (see section 7.2)<sup>93</sup>. While such encapsulation can be broken and whole buoys, floats and other such products can be lost to the sea where they become pollution, the proposal would address the immediate threat posed by exposed foamed polystyrene.



### FOAMED POLYSTYRENE NEST

Canada goose nesting on foamed polystyrene dock floats in British Columbia, Canada. Aside from being pecked and burrowed into, this kind of exposed polystyrene is vulnerable to being rapidly broken up in storms. The fragments are difficult to extract once in the water, and many will inevitably be lost out to sea.

<sup>91</sup> Russell, 2019

<sup>92</sup> *Ibid.*

<sup>93</sup> Liberal Party of Canada, 2017

## 5 EFFECT ON MARINE SPECIES

Once in the marine environment, foamed polystyrene fragments can persist for decades, if not hundreds of years, where they present a chemical and physical risk to marine species<sup>94</sup>. Foamed polystyrene also rapidly fragments into microplastic pollution, as discussed above. Although representing only a relatively small proportion by weight of the total amount of plastic entering the environment, microplastics are a disproportionately serious problem because of their ability to be eaten by almost all marine species and their high surface area to volume ratio, enabling them to collect high amounts of toxic chemicals.



### 5.1 Chemical impacts

#### 5.1.1 Inherent

When EPS is produced, incomplete polymerisation of styrene monomers into polystyrene results in the continued presence of unreacted raw materials, such as the styrene monomer, which are classified as endocrine-disrupting chemicals<sup>95</sup>. Compared to the five most common plastic polymers, polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE) and polypropylene (PP), polystyrene leaves the factory with approximately 8–200 times more parent Polycyclic Aromatic Hydrocarbons (PAHs)<sup>96</sup>. PAHs are pollutants that have been linked to cancer, liver damage and kidney damage in humans<sup>97</sup>.

A number of laboratory studies have observed the effects of polystyrene (not foamed) microspheres on study species, with implications for the effects of foamed polystyrene. Results include ingested polystyrene leading to: interference with energy uptake and allocation, reproduction and offspring performance in oysters<sup>98</sup>; significantly reduced feeding

<sup>94</sup> Martinelli, 2018

<sup>95</sup> Lithner *et al.*, 2011

<sup>96</sup> Rochman *et al.*, 2013

<sup>97</sup> Kim *et al.*, 2013

<sup>98</sup> Sussarellu *et al.*, 2016



capacity and reduced reproductive output and energy in marine copepods<sup>99</sup>; and severe effects on feeding and shoaling behaviour, and metabolism in crucian carp<sup>100</sup>.

### 5.1.2 Adsorption of pollutants

Furthermore, while all plastics can sorb contaminants from the water column, the porous, hydrophobic surface of EPS and the volatility of the styrene monomer make it more effective at sorbing PAHs than other common plastics such as PP (19.3% of European plastic demand in 2018<sup>101</sup>), PET (7.7%) and PVC (10%)<sup>102</sup>. Fluoranthene, one of the US Environmental Protection Agency's 16 priority pollutant PAHs, has been shown to have a high affinity for polystyrene microplastics<sup>103</sup>, meaning it is likely to attach to polystyrene's surface.

### 5.1.3 Additives

Additives such as antimicrobials, flame retardants and ultraviolet stabilisers give plastics many of their unique properties.

Of particular relevance is the use of flame retardant hexabromocyclododecane (HBCD) in EPS in some countries, predominantly for construction materials and electrical housings<sup>104</sup>. This additive has serious implications for the marine environment, particularly because of its toxicity, environmental persistence and propensity to bioaccumulate<sup>105</sup>. HBCD is not covalently bonded, and therefore is easily released from EPS and other plastic products in which it is an additive. HBCD has been associated with endocrine disrupting effects, teratogenicity (abnormality in fetal development), liver toxicity and kidney toxicity. As a result, it has been listed in Annex A of the Stockholm Convention (a legally binding United Nations environmental treaty) as a Persistent Organic Pollutant (POP)<sup>106</sup> since 2013, and under European Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation as a Substance of Very High Concern<sup>107</sup>. Its use as a flame retardant has been banned in the EU since 2016. There are 152 signatory countries to the Stockholm Convention, who would be legally bound to eliminate HBCD from use and production, although specific exemptions can be sought for use of EPS and XPS in buildings and for production<sup>108</sup>. There are currently only three specific exemptions granted to two countries (production and use in China, and use in South Korea)<sup>109</sup>. Countries that are not signatories to the Stockholm Convention may still be using HBCD.

HBCD has been widely detected in EPS buoy debris and EPS microplastics found along South Korean (a Stockholm Convention signatory) coasts<sup>110</sup>. Jang et al. (2017) suggest that this could be as a result of recycling HBCD-containing EPS, such as from construction, to make buoys. It has also been detected in higher concentrations in marine sediments near aquaculture areas in South Korea with high numbers of EPS buoys in use<sup>111</sup>. A study comparing growth of mussels on different substrates found that mussels grown on EPS marine

<sup>99</sup> Cole *et al.*, 2015

<sup>100</sup> Mattsson *et al.*, 2015

<sup>101</sup> PlasticsEurope, 2019

<sup>102</sup> Rochman *et al.*, 2013

<sup>103</sup> Paul-Pont *et al.*, 2016

<sup>104</sup> Rani *et al.*, 2015

<sup>105</sup> Jang *et al.*, 2017

<sup>106</sup> Lusher *et al.*, 2017

<sup>107</sup> Lassen *et al.*, 2019

<sup>108</sup> United Nations Environment Programme, 2020a

<sup>109</sup> United Nations Environment Programme, 2020b

<sup>110</sup> Jang *et al.*, 2017

<sup>111</sup> Al-Odaini *et al.*, 2015

debris accumulated HBCD to a higher degree than those growing on HDPE, metal or rock, and were also found to contain EPS microplastics thought to originate from the substrate<sup>112</sup>.

## 5.2 Physical impacts

The inherent, adsorbed and additive toxic properties of polystyrene are of concern for marine species that may ingest it. As noted by Dr Rochman *“The mixture of the [polystyrene] monomer itself, chemicals from the manufacturing process and those sorbed from the environment may act as a multiple stressor to several species that ingest [polystyrene] debris.”*<sup>113</sup>

A review of available literature on sea turtles ingesting plastics reported that 15 studies had identified foamed polystyrene in sea turtle stomachs, making foamed polystyrene the joint-third most prevalent plastic category reported along with rope, after “Plastic (general)” (30 studies) and “Soft plastic” (19 studies)<sup>114</sup>. Seabirds that feed by skimming food off the water’s surface, such as northern fulmars, shearwaters and albatrosses, have also been found to have foamed polystyrene in their stomachs<sup>115,116,117</sup>.

Physical impacts of plastic ingestion are known to include a false feeling of fullness (pseudo-satiation)<sup>118</sup>, with a broad range of knock-on impacts. These include reduced energy stores, which may account for reduced growth<sup>119</sup>, reduced fertility<sup>120</sup>, reproductive impairment<sup>121</sup>, and weakened immune systems. The physical presence of plastic in the gastrointestinal tract can also result in mechanical obstruction of the gut and accompanying inflammatory responses<sup>122</sup>. Plastic can also impair feeding ability and result in reduced uptake of necessary food<sup>123</sup>.

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<sup>112</sup> Jang *et al.*, 2016

<sup>113</sup> Rochman *et al.*, 2013

<sup>114</sup> Schuyler *et al.*, 2014

<sup>115</sup> Moser & Lee, 1992

<sup>116</sup> van Franeker *et al.*, 2009

<sup>117</sup> Tennyson, 2019

<sup>118</sup> Cole *et al.*, 2011

<sup>119</sup> Watts *et al.*, 2015

<sup>120</sup> Galloway & Lewis, 2016

<sup>121</sup> Sussarellu *et al.*, 2016

<sup>122</sup> Von Moos *et al.*, 2012

<sup>123</sup> GESAMP, 2015

## Hong Kong Case Study

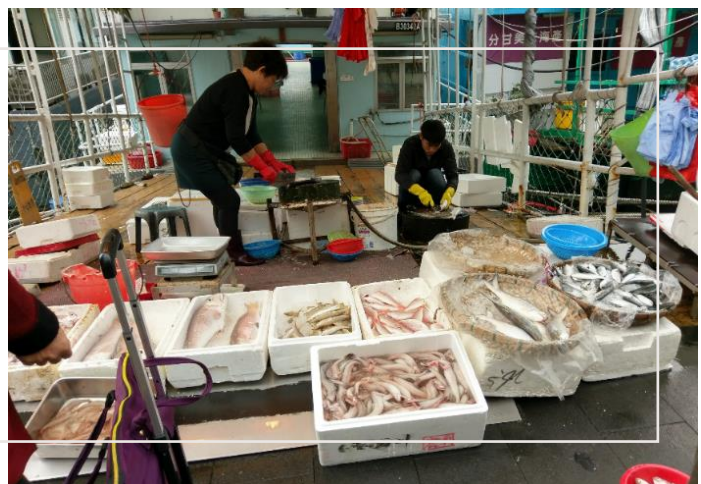
In Hong Kong, foamed polystyrene makes up a significant proportion of coastal pollution and beach litter: according to a 2015 report, foamed plastic represented 21% of floating debris<sup>124</sup>. One of the most common sources of this foamed polystyrene is fish boxes used by Hong Kong's fishing community. Despite the fact that good quality foamed polystyrene boxes are used around eight times before they are discarded<sup>125</sup>, Aberdeen fish market records around 300 foamed polystyrene fish boxes being discarded every day<sup>126</sup>. Fisheries representatives blame the lack of on-site recycling facilities for the amount of refuse ending up in the sea, as fish boxes are dumped at Aberdeen harbour or the fish market, where they are easily broken up, washed into drains, or blown into the harbour<sup>127</sup>.

In previous years, Hong Kong sent foamed polystyrene waste to China for processing, however, since Beijing introduced a comprehensive ban on plastic waste imports in 2017, Hong Kong can no longer export any contaminated plastic waste to the mainland, including used fish boxes or recovered marine debris<sup>128</sup>.

The Hong Kong legislature has introduced a plastic bag levy and bans on single-use takeaway cups, but has not proposed any legislation specifically targeting foamed polystyrene, despite efforts by NGOs to draw attention to the problem<sup>129</sup>. In the absence of any policy intervention, the World Wildlife Fund (WWF) has been working with the Hong Kong fishing community to trial alternative fish boxes made of cheap, lightweight corrugated polypropylene<sup>130,131,132</sup>, though cheaper foamed polystyrene is still commonly used. The Aberdeen Fish Market Organisation has installed a compactor to shred and compress foamed polystyrene waste into solid bricks, which are then sent for recycling through a local scheme, though this is currently an expensive, small-scale pilot project and the Agriculture, Fisheries and Conservation Department has yet to decide whether to expand the initiative to other markets in the region<sup>133</sup>.

### FISH BOXES

Foamed polystyrene fish boxes at Aberdeen Harbour, Hong Kong. The harbour's compactor will reduce the volume that these boxes take up, making it easier for them to be transported to recycling facilities.



© Annkathrin Sharp/FFI

<sup>124</sup> Clean Shorelines, 2019

<sup>125</sup> Bekemans, 2017

<sup>126</sup> Oriental Daily, 2018

<sup>127</sup> Kao, 2016

<sup>128</sup> Murray, 2018

<sup>129</sup> Policy Address, 2018

<sup>130</sup> Kao, 2017

<sup>131</sup> WWF Hong Kong, 2017

<sup>132</sup> Colombie, 2017

<sup>133</sup> Oriental Daily, 2018

## 6 DISPOSAL AND RECYCLING OF FOAMED POLYSTYRENE

Europe is estimated to generate 570,000 tonnes of foamed polystyrene waste per year<sup>134</sup>. According to HELCOM's *Survey of polystyrene foam (EPS and XPS) in the Baltic Sea*, in Europe in 2017, end of life EPS from packaging and construction was predominantly sent to energy recovery (50% and 81% respectively)<sup>135</sup>. However, the British Plastics Federation Expanded Polystyrene Group (BPF EPS Group) state that 54% of all EPS packaging in the UK is currently recycled<sup>136</sup>. It is worth noting that this figure may include chemical recycling (see below), a large proportion is likely to be packaging material that is not heavily contaminated (e.g. EPS used to package electronics and white goods), and the material may be predominantly compacted in the UK before being exported for recycling elsewhere<sup>137</sup>. The impact of recent bans on the export of waste from the UK to non-OECD countries on these figures is unknown. A breakdown of how much of this packaging is foamed polystyrene fish boxes, or figures for recycling of other foamed polystyrene products used by marine industries, is not available.

### 6.1 Recycling

As with other types of plastic, foamed polystyrene can be recycled in two ways – mechanical and chemical:

#### 1. Mechanical recycling

- a. Clean foamed polystyrene can be shredded or ground for land-based uses, such as cavity wall insulation or floor levelling<sup>138</sup>.
- b. Clean foamed polystyrene can be granulated back to individual spherules, which can then be put back into the polystyrene production stream along with virgin foamed polystyrene to produce foamed polystyrene products with recycled content<sup>139</sup>. However, mechanical recycling cannot necessarily remove HBCD and other contaminants.

#### 2. Chemical recycling

The term chemical recycling does not have a universally acknowledged definition, but can include a suite of chemical engineering technologies, including solvent-based chemical recycling as described below, as well as pyrolysis and gasification<sup>140</sup>.

- a. Chemical recycling can involve dissolving foamed polystyrene in a solvent, then separating the resulting polymer solution from impurities and additives (e.g. HBCD). The resulting polystyrene should theoretically be the same as virgin polystyrene. However, as the name suggests, chemical recycling requires chemical solvents. It is unclear whether this type of recycling is feasible at scale.
- b. Instead of conversion back to polystyrene, chemical recycling has also been used to convert plastic to fuel<sup>141</sup>.

Chemical recycling often requires high heat, remains energy intensive and results in a net energy loss. While less energy intensive, mechanical recycling also requires a significant

<sup>134</sup> Lassen *et al.*, 2019

<sup>135</sup> *Ibid.*

<sup>136</sup> BPF EPS Group, 2020b

<sup>137</sup> Personal communications

<sup>138</sup> Lassen *et al.*, 2019

<sup>139</sup> JB Packaging, 2020d

<sup>140</sup> Rollinson & Oladejo, 2020

<sup>141</sup> Bassil *et al.*, 2018

energy input<sup>142</sup>. Mechanical and chemical recycling options almost invariably result in a product of lower quality than the original. As such, recycling indefinitely at scale is not currently feasible.

The potential inclusion of these varying types of recycling in different data sources makes interpretation of the data problematic. For the purposes of this report, where recycling is mentioned hereafter it will refer to both mechanical recycling and solvent-based chemical recycling, and will not include pyrolysis or gasification, nor will it include plastic to fuel.

There are 28 recycling sites belonging to 24 companies across the UK recorded on BPF EPS Group's website<sup>143</sup>, although it is understood that some of these are no longer operational<sup>144</sup>. Generally, recycling of foamed polystyrene is considered difficult to make economically viable, due to the cost of treating, compacting and transporting the material. According to Bernard Merckx, Honorary President of Plastics Recyclers Europe, quoted in China Dialogue in 2017, *"It's not that polystyrene is not recyclable. It's that it has so little value. The weight and limited applicability just don't make it worth the while."*<sup>145</sup>

Fish boxes have been considered to pose a particular challenge in considering reuse or recycling, because of contamination with fish residues and fluids, and one estimate puts the percentage of fish boxes in Europe that end up in landfill at 45 – 50%<sup>146</sup>.

That being said, fish boxes are recycled in a number of contexts across Europe<sup>147</sup>, including the following:

1. In Poland all fish boxes carrying imported seafood are collected, compacted, extruded and turned into polystyrene pellets, which are then sent to a recycler or foamed polystyrene manufacturer in Finland.
2. A recycling plant for fish boxes in Denmark imports fish boxes from across Europe and has a capacity of 4,500 tonnes per year.
3. The Fischer Group, a large recycling company in Germany, recycles fish boxes.
4. The Netherlands reports fish box recycling rates of over 90%.

All of the above appear to be mechanical recycling.

## 6.2 Incineration

Foamed polystyrene is frequently disposed of by industrial incineration; as stated above, this has been estimated at 50% of EPS packaging and 81% of EPS from construction in Europe in 2017<sup>119</sup>. Small-scale burning of fish boxes on site was also reported during this research.

Foamed polystyrene has a high calorific value, which means that there may be a perverse incentive to process it through incineration and waste to energy, to maintain high temperatures and therefore the incineration plant's efficiency.

<sup>142</sup> Levidow & Raman, 2019

<sup>143</sup> BPF EPS Group, 2020b

<sup>144</sup> Personal communications

<sup>145</sup> Colombie, 2017

<sup>146</sup> CICLOPLAST, 2020

<sup>147</sup> Lassen *et al.*, 2019



### 6.3 Landfill

In Europe, 24.9% of plastic post-consumer waste and 18.5% of packaging goes to landfill<sup>148</sup>. However, figures for foamed polystyrene are not available. Anecdotal evidence from discussions with foamed polystyrene users and responses to the survey (see Annex 1) suggest that foamed polystyrene is frequently disposed of through mixed waste that goes to landfill. Given the constraints to recycling and disposal noted above, it seems likely that a significant proportion of marine foamed polystyrene disposed of in mixed waste would go to landfill.



#### TSUKIJI FISH MARKET, TOKYO

Fish boxes are the marine foamed polystyrene product with the highest turnover. Companies dispatch produce without expectation that the fish boxes will be returned, meaning they are often only used once.

## 7 RELEVANT REGULATIONS

### 7.1 International regulations

The following international regulations are of relevance to pollution from marine uses of foamed polystyrene.

#### 7.1.1 Convention for the Prevention of Pollution from Ships 1973/1978 (MARPOL) under the International Maritime Organization (IMO)

The IMO is responsible for the administration of the International Convention for the Prevention of Pollution from Ships 1973/78 (MARPOL)<sup>149</sup>. “Ship-sourced” disposal of plastics is prohibited under MARPOL, in exclusive economic zones and waters beyond national jurisdiction. The key provision is Regulation 3.2 in Annex V, which prohibits the discharge of all plastics into the sea. When plastic is mixed with other debris, the mixture must be treated as if it were all plastic.

Enforcement of MARPOL requires strong monitoring, control and surveillance, which is especially difficult in areas beyond national jurisdiction. The fact that foamed polystyrene breaks up readily also makes it even more difficult to trace any polystyrene marine pollution back to the source.

<sup>148</sup> PlasticsEurope, 2019

<sup>149</sup> Haward, 2018



### 7.1.2 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 and 1996 Protocol (London Convention/Protocol) under IMO

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 and its 1996 Protocol (London Convention/Protocol), have also recognised the problem of plastic pollution and marine litter<sup>150</sup>. As with MARPOL (above), this prohibits the dumping of waste (including foamed polystyrene) from vessels at sea, but it is also very difficult to enforce.

## 7.2 National or sub-national regulations

Polystyrene use in the marine environment is governed by regulations in some countries or sub-national areas. The following are some examples of regulations that were identified during this research; it is not intended to be an exhaustive list.

### 7.2.1 United States of America

There are a number of state-level regulations regarding the use of foamed polystyrene in water:

- **Oregon State** requires that foamed polystyrene structures, buoys, markers, ski floats, bumpers, fish trap markers and other devices (with some exceptions) be encapsulated using approved materials and methods, and that all unused or replaced polystyrene foam must be removed from State waters and disposed of in an approved manner at an upland disposal site or recycled<sup>151</sup>. Similar regulations apply in **Arkansas, California, Delaware, Georgia, Iowa, Rhode Island, and South Carolina**<sup>152</sup>.
- **Washington State** requires that foamed polystyrene buoys and structures (e.g. pontoons) be encapsulated in a shell or wrap resistant to UV damage and abrasion<sup>153</sup>.
- **San Marcos, Texas** city ordinance prohibits the use, possession or disposal of foamed polystyrene products in any city park or in or upon the waters of the San Marcos River.
- **San Francisco, California** city ordinance prohibits foamed polystyrene dock floats, beach toys, mooring buoys, anchor or navigation markers not wholly encapsulated or encased within a more durable material<sup>154</sup>.
- **The United States Military's** Corps of Engineers prohibits the use of expanded polystyrene for any floatation products at military boat docks (predominantly on lakes) unless encased in an approved protective coating<sup>155</sup>.

### 7.2.2 Costa Rica

Costa Rica has introduced legislation that from 2021 will prohibit the import, sale, and distribution of foamed polystyrene throughout the country, albeit with exceptions for 1) electronic appliance packaging; 2) industrial uses, and 3) foamed polystyrene applications “for which no environmentally-viable alternative exists”<sup>156</sup>. It is unclear whether marine foamed polystyrene would fall within the third category.

<sup>150</sup> Haward, 2018

<sup>151</sup> Oregon State, 1992

<sup>152</sup> Marcy & Johnson, 2009

<sup>153</sup> Washington State, 2014

<sup>154</sup> San Francisco State, 2016

<sup>155</sup> Marcy & Johnson, 2009

<sup>156</sup> Whyte, 2019

### 7.2.3 South Korea

South Korea's Ministry of Oceans and Fisheries has committed to replacing traditional foamed polystyrene buoys with "eco-friendly or biodegradable" alternatives by 2025<sup>157</sup>.

### 7.2.4 Taiwan

Taiwan has banned ocean oyster aquaculture during typhoon season, and provides government subsidies to help farmers remove their rafts in preparation. It also requires all oyster farmers to register their rafts; has established a deposit return scheme for buoys; and has banned uncovered foamed polystyrene buoys, promoting alternatives made of HDPE, polymer-coated polyurethane, and expanded polypropylene<sup>158</sup>.

### 7.2.5 Canada

Canada is currently considering new legislation requiring foamed polystyrene buoys and structures (e.g. pontoons) to be encapsulated in a shell or wrap resistant to UV damage and abrasion<sup>159,160</sup>. See Canada case study on page 22.

### 7.2.6 UK

As far as we are aware, there are no regulations specifically concerning foamed polystyrene in the marine environment in the UK. Efforts to reduce pollution are part of wider rules on marine litter. The main regulatory control of litter from shipping in the UK has generally been transposed from the IMO directives above. Enforcement of the regulations in the UK is handled as follows:

- If plastic pollution emanates from a land source into an estuary or the marine environment then it falls within the remit of the Environment Agency, whose jurisdiction extends 1 nautical mile for the purposes of the Water Framework Directive but up to 3 nautical miles for the Environment Act.
- If waste is mishandled or deliberately disposed of illegally from sea-going vessels, then this would fall under the jurisdiction of the Maritime & Coastguard Agency<sup>161</sup>.
- Harbour authorities facilitate the reception and disposal of waste from ships and within the harbours themselves.

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<sup>157</sup> Chang-won, 2020

<sup>158</sup> Shor, 2019

<sup>159</sup> Liberal Party of Canada, 2017

<sup>160</sup> Personal communications

<sup>161</sup> Personal communications

## Taiwan Case Study

Taiwan has a centuries-long history of oyster farming, and oysters represent the biggest share of the island's aquaculture industry. Oyster farmers employ a traditional floating raft culture system, with the most common type of oyster rack used in Tainan City, southern Taiwan, being a bamboo raft supported by polystyrene blocks or buoys<sup>162</sup>. Typically, each farmer has approximately 60 rafts that require 700 to 900 blocks of foamed polystyrene in total<sup>163</sup>. In Tainan City in 2015, 200 farmers owned 9,000 rafts, supported by between 120,000 and 200,000 buoys, around one third of which require replacement every year. These discarded, damaged buoys are the primary source of marine pollution in the region<sup>164</sup>.

Derelict raft gear produced by oyster farming activities is widely dispersed along the southwest coast of Taiwan<sup>165</sup>, and is lost to the marine environment via three principal pathways<sup>166</sup>:

1. Accidental loss through detachment from the raft, e.g. in bad weather;
2. Deliberate discarding at sea for convenience, to avoid the significant costs of time, effort and boat engine fuel required by oyster farmers to haul rafts back to the shore;
3. Damage to rafts through gear interaction with vessels – particularly common during harvest.

Even when foamed polystyrene is collected to be taken on-shore for recycling, loose parts are still lost to the environment during loading onto recycling trucks<sup>167</sup>.

In an effort to curb the amount of foamed polystyrene debris entering the environment from oyster farms, the Tainan City government has adopted a set of administrative and regulatory measures over the past decade:

- Oyster farming is prohibited between July and September to minimise the loss of buoys and rafts during typhoon season. All rafts must be returned to shore after harvest and stored in designated sites.
- Oyster farming is limited to a designated area along the coastline, to reduce farm expansion, facilitate monitoring, and encourage compliance.
- The government restricted the issue of new farming licences to deter expansion of the industry.
- In 2010, an Extended Producer Responsibility scheme was introduced, requiring all oyster farmers to register rafts with the government and visibly mark them once registered<sup>168</sup>.
- In 2015/2016, a reward scheme was launched to promote recycling of buoys, in which farmers receive NT30/USD 1 per foamed polystyrene buoy that they deposit at government collection points. Twelve thousand buoys (25% of the estimated total) were collected in the first year<sup>169</sup>.

<sup>162</sup> Chen *et al.*, 2018

<sup>163</sup> *Ibid.*

<sup>164</sup> Liu *et al.*, 2015

<sup>165</sup> *Ibid.*

<sup>166</sup> Chen *et al.*, 2018

<sup>167</sup> Liu *et al.*, 2015

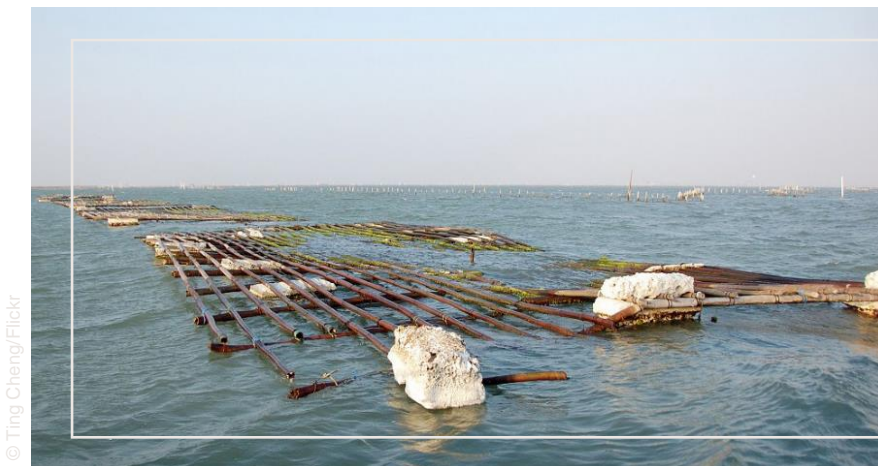
<sup>168</sup> Chen *et al.*, 2018

<sup>169</sup> Sirui, 2018

- In 2016, a per-raft fee of NTD 300/USD 10, later increased to NTD 400/USD 14, was introduced to cover the costs of retrieving derelict foamed polystyrene rafts (though the actual cost per raft for retrieval is significantly higher)<sup>170</sup>.
- In 2019, Tainan announced a ban on uncovered foamed polystyrene buoys, charging fines of NTD 10,000/USD 339 for violations, and investing in programmes to provide alternative buoys made of high density polyethylene, polymer-coated polyurethane, or expanded polypropylene<sup>171</sup>.

Though these efforts constitute important steps towards reducing foamed polystyrene pollution in Taiwan, concerns remain regarding their effectiveness: enforcement is weak, and buoys and rafts are still lost to the environment (whether damaged by vessels or in bad weather outside the typhoon season) or deliberately discarded. Tainan Fishery Port and Offshore Management Office director Zhou Nanchao said in an interview with Taiwan's Central News Agency (CAN) that three alternatives to foamed polystyrene are being explored: 1) high density polyethylene (HDPE), which he notes is widely used in Europe and the USA, 2) foamed polystyrene covered in a protective polymer composite, and 3) expanded polypropylene, another foamed plastic that is more durable than foamed polystyrene<sup>172</sup>. However, alternative buoys are more expensive and less convenient for farmers to use. Furthermore, the fees paid by farmers are far too low to cover the full cost of foamed polystyrene disposal, but there is strong opposition to any increase in the amount paid<sup>173</sup>.

Recommended measures for the Taiwanese government going forward include that foamed polystyrene should be taxed rather than banned, with resulting revenue invested in the recycling of oyster farming waste into new products, as well as awareness campaigns and enforcement against the illegal dumping of buoys and rafts<sup>174</sup>. Participative reforms are highlighted as a key pathway to change, in which farming communities are directly involved with government efforts to introduce eco-labels, waste management principles, co-drafted legislation, and more accessible eco-friendly buoys<sup>175,176,177</sup>.



### TAIWANESE OYSTER RAFT

Foamed polystyrene blocks keep these bamboo rafts afloat. When no longer usable, some farmers will discard the floats in the sea.

<sup>170</sup> Chen *et al.*, 2018

<sup>171</sup> Sirui, 2018

<sup>172</sup> *Ibid.*

<sup>173</sup> Chen *et al.*, 2018

<sup>174</sup> Shor, 2019

<sup>175</sup> *Ibid.*

<sup>176</sup> Chen *et al.*, 2018

<sup>177</sup> Liu *et al.*, 2015

## 8 POTENTIAL SOLUTIONS AND RELEVANT INITIATIVES

In the survey conducted as part of the research for this report (see Annex 1), several participants reported efforts to reduce the amount of polystyrene entering the waterways from marine and coastal activities, either as a targeted project or as part of wider anti-littering campaigns; one respondent is directly involved in a regional effort to work with businesses that use foamed polystyrene (such as sailing clubs) to identify alternative materials for their products.

### 8.1 Potential alternatives to foamed polystyrene

#### Hard plastic

Air-filled HDPE and other hard plastic can be used instead of both covered and uncovered foamed polystyrene for buoys, floats and pontoons. Air-filled hard plastic is less buoyant than foamed polystyrene and if split, such as during a storm, it could quickly fill with water, no longer staying afloat. However, hard coverings over foamed polystyrene would have an equal likelihood of splitting, allowing the foamed polystyrene interior to fragment. Air-filled hard plastic would not bear the same risk of rapid fragmentation by biotic and abiotic factors that is seen with foamed polystyrene products.

#### Expanded polypropylene

Expanded polypropylene (EPP) has been proposed as an alternative to EPS as it has greater shock and break resistance, and is a more inert material<sup>178</sup>. However, it is also more expensive, with EPP fish boxes costing two or three times more than EPS fish boxes<sup>179</sup>. EPP is more readily recyclable, but would present the same physical hazard in the marine environment as EPS if simply replaced with no additional measures to support good maintenance, recovery and end-of-life processing.

#### Extruded polystyrene

In a laboratory study, isopods burrowed more often into EPS floats (43.5% floats burrowed) than polyethylene-encapsulated EPS (30.4%) and XPS (0%). XPS is noticeably harder and denser than EPS (28-45kg/m<sup>3</sup> compared to 11-32kg/m<sup>3</sup>)<sup>180</sup>, and may be too hard for boring<sup>181</sup>, therefore may seem a preferable material for marine uses. Conversely, however, XPS's higher density may mean that more XPS than EPS would be needed for some of its key maritime applications that involve buoyancy (e.g. more XPS floats may be needed to keep an aquaculture raft afloat). Davidson (2012) recommends that the best material combination to prevent isopod damage in floats would be a hardened polyethylene shell around XPS foam<sup>182</sup>. This would seem likely to also be the case for buoys and other maritime polystyrene prone to isopod damage.

#### Laminated corrugated cardboard fish boxes

Swedish-Finnish company Stora Enso produces cardboard fish boxes with an exterior polyethylene laminate and an interior polytetrafluoroethylene (PTFE) laminate to make the boxes water-resistant. Stora Enso suggests that these boxes reduce transport and storage costs compared with EPS fish boxes due to their lower volume<sup>183</sup>. Given that laminate is

<sup>178</sup> Colombie, 2017

<sup>179</sup> Personal communications

<sup>180</sup> Australian Urethane & Styrene, 2009

<sup>181</sup> Davidson, 2012

<sup>182</sup> *Ibid.*

<sup>183</sup> Lassen *et al.*, 2019



difficult to recycle and boxes would likely have the same level of reusability as EPS fish boxes, although this might reduce foamed polystyrene pollution, it does not immediately appear to be an alternative that would make a significant contribution to addressing the problem of marine pollution overall.

Other companies are also exploring corrugated cardboard or solid board boxes with polyethylene or wax lining. All such boxes require separate thermal insulation. Some of the proposed options for insulation include:

- Blown plastic foam pads of a polymer that is more readily recyclable than polystyrene. During discussions, such a box was estimated to cost twice as much as a foamed polystyrene box<sup>184</sup>. However, this cost differential is not reflective of the added cost of storing and transporting foamed polystyrene boxes, which are more bulky than cardboard boxes and cannot be flat-packed or stacked.
- Wool, either simply spun and dried or treated with chemicals. Discussions highlighted very contrasting reviews of wool thermal insulation. The cost was estimated to be three times that of foamed polystyrene boxes<sup>185</sup>.
- Silicone or polyethylene gel packs. However, it was highlighted that the quality of these gel packs is important, with lesser quality gel packs potentially snagging on shellfish shells/pincers and leaking, thereby killing and/or contaminating produce. It is estimated that 6 – 8 gel packs are needed per 40L fish box, which are unlikely to be returned to the company.
- Dry ice in plastic bags, which works well but is much more expensive.

It is worth noting that, as with other plastic products, a number of supposedly “biodegradable”, compostable and bio-based products have emerged as purportedly more sustainable alternatives to foamed polystyrene. As these alternatives emerge, it will be extremely important to monitor the claims that companies make about their products, to ensure that these are not misleading. This is particularly important as “biodegradable”, compostable and bio-based plastics can cause the same degree of harm in the marine environment as conventional plastics like foamed polystyrene.

### **Returnable, reusable bulk bins**

A study commissioned by Scottish Sea Farms and undertaken by Caledonian Environment Centre at Glasgow Caledonian University found that replacing EPS fish boxes with returnable and reusable hard plastic bulk bins (likely HDPE or polypropylene) minimised plastic use and CO<sub>2</sub> emissions from production, processing, transport and recycling<sup>186</sup>. Scottish Sea Farms has been trialling this delivery system to supply produce to M&S since June 2017, and calculates that 780,000 polystyrene boxes have been avoided as a result (and an estimated 4,100 tonnes of CO<sub>2</sub>).

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<sup>184</sup> Personal communications

<sup>185</sup> Personal communications

<sup>186</sup> Fish Farmer Magazine, 2019

## ALTERNATIVE MATERIALS

Reusable options and hard plastic coatings reduce the amount of waste produced and the likelihood that these products will become pollution, respectively. However, any type of plastic can become pollution and needs to be used carefully.



## 8.2 Increasing recycling of foamed polystyrene

Some stakeholders in the fisheries and aquaculture sectors consulted during this research indicated a willingness to pay more for their foamed polystyrene boxes fish boxes in order to have them appropriately disposed of at end of life. However, it should be noted that the individuals that provided information to this project were, inevitably, those with an interest in and concern about foamed polystyrene waste and pollution, so this view may not be representative of the industry as a whole.

A project by Spanish organisation CICLOPLAST, funded by the EU LIFE programme, is working to develop a system that facilitates EPS fish box collection, storage, pre-treatment and conversion to new polystyrene food packaging through what appears to be a combination of mechanical recycling and waste to energy<sup>187</sup>. The project aims to create a system that could lead to a 70% reduction in landfilled EPS fish boxes in Spain and 50% reduction in Italy, the UK and Greece in 3 – 5 years, and 80% reduction of landfilled EPS boxes within 5 – 10 years of the project's implementation in other countries<sup>188</sup>.

Another EU LIFE project, PolyStyreneLoop, is assessing the economic feasibility of developing a closed-loop industrial-scale chemical recycling scheme for HBCD-containing polystyrene foams<sup>189</sup>. The process involves chemically separating the HBCD from the polystyrene polymer, which can then be reused. Restrictions on the movement of Persistent Organic Pollutants (such as HBCD) across borders affects the ease of shipping HBCD-containing EPS for recycling, but the project is attempting to address this constraint. The widespread detection of HBCD in sea-floating buoys along the South Korean beaches and Asia-Pacific coastlines more broadly sparked concern that this was a result of recycling HBCD-containing foamed polystyrene (e.g. from construction) into buoys<sup>190</sup>.

<sup>187</sup> Centro Eco EPS, 2017

<sup>188</sup> CICLOPLAST, 2020

<sup>189</sup> PolyStyreneLoop, 2020

<sup>190</sup> Jang *et al.*, 2017

In the UK's March 2020 budget, a plastic packaging tax was announced, to apply to all plastic packaging with less than 30% recycled content. This tax will be introduced in April 2022 and will cover filled and unfilled plastic packaging originating domestically or internationally. As fish boxes are a type of packaging, it is expected that this tax would also apply to them, unless they are included under the initial exemptions. Whilst this will not address the problem of pollution from foamed polystyrene (as products with recycled content would pollute in the same way as those made from virgin plastic), it would create a demand for recycled polystyrene and thus boost the recycling sector.

While increasing recycling has the potential to decrease marine pollution from foamed polystyrene, it will not eliminate it, and recycling foamed polystyrene poses multiple challenges (see section 6.1). The priority must be on solutions that decrease reliance upon foamed polystyrene products and reduce generation of foamed polystyrene waste.

### 8.3 Intergovernmental initiatives to address foamed polystyrene pollution

#### 8.3.1 The Baltic Marine Environment Protection Commission (Helsinki Commission; HELCOM)

HELCOM is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, to which the European Union and the nine countries with Baltic Sea coastlines (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden) are party.

HELCOM published a Marine Litter Action Plan in 2015, including the following (Article RL9)<sup>191</sup>:

*1) Compile information on the prevalence and source of expanded polystyrene (EPS) in the marine environment, and 2) engage with industry to make proposals for alternative solutions (e.g. use of other materials, establishment of deposits, return and restoration systems, overpackaging reduction).*

Action on Article RL9 is led by Denmark and carried out in cooperation with the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and the OceanWise project (see below), and should result in recommendations for contracting parties on, for example, changes to product design and best practices for handling EPS (note that this refers to all sources of EPS, not just marine sources). An overview of the most significant sources of EPS ending up in the marine environment from the HELCOM catchment area has already been produced. The work is funded by the European Maritime and Fisheries Fund, administered by the Danish Fisheries Agency, Ministry of Foreign Affairs.

As of June 2020, the only contracting party reported to have progressed Article RL9 at a national level was Finland, which is developing wood-based materials to replace EPS fish boxes for transporting and storing fish<sup>192</sup> (see section 8.1). EPS fish boxes have already been replaced to some extent with cardboard boxes in Finland. As noted above, further information on this initiative and the use of cardboard fish boxes would be useful.

<sup>191</sup> HELCOM, 2015

<sup>192</sup> Personal communications

### 8.3.2 OceanWise

OceanWise is an initiative to reduce foamed polystyrene pollution in the Northeast Atlantic, driven by the EU Marine Strategy Framework Directive and the OSPAR Convention's Regional Action Plan on Marine Litter, which includes the following action:

*Action 49: Investigate the prevalence and impact of expanded polystyrene (EPS) in the marine environment, and engage with industry to make proposals for alternative materials and/or how to reduce its impacts.*

This work is being led by Portugal, with support from Ireland and 13 government, academic and private sector partners/associate partners, including OSPAR Commission. It is funded by the European Regional Development Fund INTERREG Atlantic Area<sup>193</sup> and is operating from January 2018 to December 2020. The overarching aim of OceanWise is to develop long-term measures to reduce foamed polystyrene pollution into the Northeast Atlantic Ocean through applying best practices in use, manufacturing, recycling and uptake of foamed polystyrene. OceanWise is pursuing the following approaches in order to achieve this aim<sup>194</sup>:

- **Dialogue Labs:** These are multi-stakeholder meetings, with the aim of identifying which foamed polystyrene products are most likely to pollute the ocean and what the main barriers, policy options and opportunities are in terms of solutions. Dialogue Labs have been held in Lisbon, Vigo, London<sup>195</sup>, Dublin and Lorient.
- **Living Labs of Eco-Innovation:** The aim is to find alternative materials, specifically citing “biodegradables” or materials “less likely to pollute the ocean”, and practical options to reduce, reuse, recycle and recover foamed polystyrene. The Living Labs of Eco-Innovation also encourage testing of identified solutions, particularly within target industries.
- **Knowledge Hub:** A platform where OceanWise can share information regarding the findings of Dialogue Labs and Living Labs of Eco-Innovation.

OceanWise has identified fishing (fisheries, aquaculture and seafood), food goods (distribution, supermarket chains), consumer (appliances), outdoor festivals and tourism as priority industries. Solutions and aspirations relevant to the fishing industry proposed in the dialogue labs covered topics including:

- Replacement of EPS with other materials
- Reusable fish boxes for fishing and aquaculture
- Collection points for fish boxes
- Incentivising recycling of EPS and fishing gear, including ensuring that all fishing gear is returned to land for appropriate recycling
- Creation of a management entity for maritime waste
- Schemes to promote adoption of good practice, with campaigns to raise awareness at fishing ports.

<sup>193</sup> OceanWise, 2019

<sup>194</sup> *Ibid.*

<sup>195</sup> In the UK, the dialogue lab was attended by Centre for Environment, Fisheries and Aquaculture (Cefas), British Plastics Federation (BPF), Brunel University London, Seachill (UK fish processor), Vita Cellular Foams, Department for Environment, Food and Rural Affairs (Defra), Jablite, OSPAR Secretariat, Norfolk City Council, CoolSea and the Joint Nature Conservation Committee (JNCC), representing waste management, alternatives to foamed polystyrene, companies (retail and wholesale), producers of plastic and marine litter policy experts.

Each workshop also sought attendees' opinions on predefined options for tackling EPS/XPS. Those relevant to marine sources of foamed polystyrene were:

- Creation of financial incentives to stimulate the recycling of EPS and XPS aboard ships, at auctions and in aquaculture.
- Ending the use of EPS and XPS in the fisheries sector (signal booms and other artefacts), as well as their use for tourist navigation.

Both these suggestions received mixed feedback from stakeholders attending the workshops, with some feeling neither had strong viability, or would take a very long time (10 – 20 years) to implement.

### 8.3.3 British-Irish Council (BIC)

The British-Irish Council made a commitment to “*working together, with industry, to develop solutions for the collection and recycling of end of life fishing gear from its main fishing ports*” in the BIC communiqué of their 2019 symposium. It is not known if any further action has been taken on this.

### 8.3.4 The European Commission

The European Commission's *European Strategy for Plastics in a Circular Economy*, published in 2018, includes a proposal for a new Directive on Port Reception Facilities with a two-fold objective<sup>196</sup>:

*“To protect the marine environment by reducing discharges of waste from ships; and to improve efficiency of maritime operations in ports. This will be achieved by seeking further alignment with the MARPOL Convention, which has introduced a stricter regime for garbage discharges and has also become more stringent over time in relation to other types of waste from ships, and proposing a number of measures which specifically address the problem of marine litter from ships... including waste from the fishing sector.”*

Further investigation would be necessary to explore how this is being (or will be) taken forward.

## 8.4 Non-Governmental Organisation (NGO) initiatives

The initiatives detailed below are those that have been identified during scoping research, which attempted to find initiatives specific to foamed polystyrene (rather than multiple types of plastic pollution). They are a small representation of the types of efforts currently underway to tackle foamed polystyrene. As with the rest of this report, research focused on initiatives underway in the UK, and as such there are likely several international and/or small-scale initiatives that have not been captured below.

### 8.4.1 Fidra

Scottish NGO Fidra has a project on EPS fish boxes used in Scottish aquaculture. They are exploring alternative delivery (e.g. bulk bins) and material models (e.g. Tri-Pak's CoolSeal and Vericool packaging) to compare to EPS.

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<sup>196</sup> EMSA, 2020



#### 8.4.2 KIMO International

KIMO enlists fishing vessels to take part in their Fishing for Litter programme to collect marine litter caught in fishers' nets during routine fishing activities. Fishers deposit their bags of marine litter at participating harbours, and harbour staff move the litter into disposal facilities. Pilot schemes were run by KIMO International as part of the Save the North Sea project in Scotland, Sweden, Netherlands and Denmark. Since then, in the UK an additional Fishing for Litter South West project has been set up, with KIMO UK running Scotland and Cornwall/Devon projects<sup>197</sup>. Kimo International's Faroe Islands coordinator notes that "*The proportion of plastic/polystyrene is largest, making up 95% of the litter collected*"<sup>198</sup>. KIMO International and national subsidiaries do not appear to differentiate between foamed polystyrene and other plastic products. However, it is reported that in Denmark plastic fragments, buoys/floats and insulation are among the 15 most commonly found objects<sup>199</sup>.

#### 8.4.3 Keep Britain Tidy

Keep Britain Tidy led a BeachCare programme in 2019. As mentioned in 4.2, they collected 480 snapped bodyboards from two UK beaches in Cornwall and Devon. The foamed polystyrene interior from these bodyboards has been repurposed to create insulation for beehives at Quince Honey Farm, to protect bees during the winter, and local company Cornish Whispers' workshop. A further 200 bodyboards were sent to SWM recycling, who will turn the boards into insulation blocks<sup>200</sup>. As part of tackling this problem, Keep Britain Tidy suggests that consumers should rent or buy better quality bodyboards that are less likely to break and that consumers either have the responsibility to return or intend to reuse.

#### 8.3.4 Global Ghost Gear Initiative (GGGI)

The GGGI has a Best Practice Framework for the Management of Fishing Gear (Wild Capture)<sup>201</sup> and is in the process of developing a Best Practice Framework for the Management of Aquaculture Gear. The latter will most likely include best practice regarding foamed polystyrene.



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<sup>197</sup> Fishing For Litter, 2020

<sup>198</sup> KIMO International, 2017

<sup>199</sup> KIMO International, 2019

<sup>200</sup> Keep Britain Tidy, 2019

<sup>201</sup> Huntington, 2016

## 9 CONCLUSIONS AND RECOMMENDATIONS

### 9.1 General conclusions on marine uses of foamed polystyrene in the UK

Marine use of foamed polystyrene presents a considerable pollution risk. Uncovered buoys, floats and pontoons are a particular concern, as they are highly vulnerable to damage from weathering and from animals boring into or pecking at them. In Europe, many pontoons and larger buoys (e.g. those used in fish farming) are covered in hard plastic, but this does not eliminate pollution risk. Furthermore, some smaller buoys and net floats are uncovered. Outside Europe, large numbers of uncovered floats and buoys are used in aquaculture, and this has been linked with locally high levels of foamed polystyrene pollution (see section 4.1).

Foamed polystyrene fish boxes are also very common and another area of concern, with inappropriate disposal or accidental loss contributing to marine pollution. Bodyboards are frequently found washed up, particularly in the south of the UK, and contribute to foamed polystyrene pollution. Additional pollution comes from the leisure industry, where foamed polystyrene support blocks for overwintering boats are sometimes abandoned on the shore or in boatyards. Foamed polystyrene is also used inside sailing boat hulls and can be lost when boats are damaged or repaired.

Foamed polystyrene is comparatively cheap, meaning that items are often regarded as disposable or have a relatively short life. Recycling of foamed polystyrene does occur, but contamination can be a barrier for some marine uses (e.g. fish boxes contaminated with fish residue and fluids, biofouled buoys and floats). The large volume of foamed polystyrene items also makes storage and transport expensive, presenting a further challenge for recycling. Foamed polystyrene's bulkiness may also create a reluctance to bring used products to disposal facilities, which are not widespread. This can be exacerbated by the requirement for users to pay at some facilities.

Addressing pollution from marine uses of foamed polystyrene will require diverse, cross-sectoral approaches. It is worth highlighting that it is not possible to resolve the problem of foamed polystyrene pollution from marine sources by focusing purely on investment into end-of-life processing; such an approach would disregard the waste hierarchy. As with all plastic pollution issues, solutions should be focused on minimising the creation of waste as the first priority. Some options that would reduce polystyrene use in the marine environment are already available or being trialled, such as air-filled hard plastic for buoys, floats and pontoons and alternatives to foamed polystyrene fish boxes. However, the full life-cycle impacts of any alternative materials or systems need to be taken into account prior to these options being promoted. Increasing the capacity for recycling of foamed polystyrene would be one way to incentivise better disposal of items at end-of-life. Regulation merits consideration in some instances, for example banning the use of uncovered buoys, floats and pontoons. This is already in place in some countries.

Two intergovernmental initiatives in Europe are exploring the problem of foamed polystyrene pollution and it is hoped that they will lead to further action. At the grass roots level, although many of the stakeholders contacted during this study were aware of and concerned about foamed polystyrene pollution, further awareness and engagement of more stakeholders would generate wider support for tackling the problem and implementing solutions.

## 9.2 Recommendations

Building on the information gathered, the following recommendations for actions to tackle foamed polystyrene pollution from marine uses are proposed.

### 1. Promote the use of appropriate materials in floats, buoys and pontoons

The use of more durable, reusable, weather-resistant materials (such as hard plastic) for marine items should be explored and promoted, following a thorough analysis of the environmental consequences of these materials. At a minimum, foamed polystyrene used in the marine (or other aquatic) environment should be covered in a hard casing to protect it from abiotic factors (i.e. weathering) and biotic factors (e.g. burrowing by isopods, pecking by gulls). These changes could be achieved by the introduction of regulations (such as those outlined in section 7.2) or through market pressure, potentially stimulated by an awareness campaign, alongside work with producers and users.

### 2. Improve care of items containing foamed polystyrene

Damage to or loss of items containing foamed polystyrene during bad weather could be minimised by better maintenance. For example, appropriate, sheltered storage for fish boxes and securing or removing items like pontoons from the water prior to severe storms. Guidelines for foamed polystyrene users and/or training on maintenance could help to reduce accidental loss and damage of items.

### 3. Provide affordable recycling/disposal facilities at ports and harbours

Recycling and waste disposal facilities at some ports and harbours are limited and/or there is a steep cost to using them when offloading high volumes of waste, thus encouraging the dumping of waste at sea or littering on the coast. Affordable facilities should be provided at all ports, harbours and marinas to encourage responsible disposal of foamed polystyrene at end of life.

### 4. Explore and evaluate the use of alternative materials for fish boxes

A number of alternative materials for fish boxes have been put forward, which could reduce pollution from foamed polystyrene boxes. A thorough analysis of the various alternative materials is needed, taking into account their potential for reuse (including durability), recyclability, thermal insulation properties, feedstock for production, potential to become ocean pollution, amongst other factors. Investigating any claims of biodegradability on foamed polystyrene boxes is also vital, particularly given there is no standard for marine biodegradability.

### 5. Increase reuse and recycling of fish boxes

Development of a deposit return and/or other Extended Producer Responsibility scheme for fish boxes is an option to increase their reuse and recycling. It may also reduce both inappropriate disposal that can lead to marine pollution and unfavourable end-of-life processing, such as landfill, incineration and plastic to fuel. Reuse and recycling schemes should be designed for the materials identified through recommendation 4, but will likely need to be developed for foamed polystyrene fish boxes as well in the absence of the widespread availability and use of alternative materials.

## **6. Increase awareness and share information amongst users and other stakeholders about the impacts of foamed polystyrene pollution and relevant regulations**

Some users of foamed polystyrene and other key stakeholders, such as policymakers and those involved in the plastic supply chain, may not be aware of the full impact of foamed polystyrene marine pollution, including potential impacts on the resources on which livelihoods rely (e.g. aquaculture products). They may also be unaware of regulations and other solutions for tackling foamed polystyrene pollution. Proactively sharing this information with users could help encourage engagement in addressing the problem and foster support for implementing solutions. Equally, translation of multinational regulations on marine littering and pollution, such as MARPOL, into simple guidance for the fisheries and aquaculture sectors could reinforce the need for appropriate disposal of waste.

## **7. Include information on ocean plastic pollution in free environmental safety courses for fishers**

There are mandatory sea survival, firefighting, first aid and health and safety courses that fishers in the UK must complete before going to sea in a UK-registered commercial fishing vessel. Fishers must pay for these courses, but there are additional courses that can be undertaken free of charge. It may be worth considering an additional free course on environmental safety, which could include ocean governance frameworks, such as MARPOL, and the consequences of ocean pollution.

## **8. Develop more widespread foamed polystyrene recycling**

Development of a widespread foamed polystyrene recycling industry would increase the incentive for users to bring foamed polystyrene products to collection points for appropriate disposal. Fiscal measures such as the planned UK plastic packaging tax should increase the demand for recycled polystyrene and so hopefully stimulate the development of the recycling sector. However, parallel efforts should focus on minimising the amount of marine foamed polystyrene waste generated.

## **9. Evaluate the full life-cycle cost of foamed polystyrene use**

A full life cycle analysis of the cost of using foamed polystyrene fish boxes, buoys, pontoons and other common marine products, taking into account ocean pollution that is frequently overlooked in life cycle analyses, would be valuable. This would help increase awareness of the potential for damage to the environment from marine uses of foamed polystyrene and ensure that this is better built into future costings and decision making.

## **10. Research the possibility of incorporating efforts to detect and tackle discarding of foamed polystyrene at sea into initiatives to address other ocean threats**

Acknowledging that enforcement at sea is incredibly difficult, combining efforts to tackle marine threats would be beneficial. For example, exploring whether novel technological solutions used to detect illegal fishing could be adapted to facilitate identification of polluting activities/vessels and enforcement of maritime legislation on waste discard.

#### **11. Advocate for the implementation of actions from multi-stakeholder processes to tackle foamed polystyrene**

Advocate for the development of clear, time-bound next steps towards practical trials and implementation of the potential interventions identified by intergovernmental and multi-stakeholder processes on foamed polystyrene, such as the HELCOM and OceanWise initiatives.



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## ANNEX 1 POLYSTYRENE SURVEY

### Introduction

As part of the scoping work investigating the extent and nature of marine uses of foamed polystyrene products around the UK and further afield, FFI launched an online questionnaire for distribution among people who participate in coastal and marine activities for recreational and professional purposes. We wanted to hear from a diverse range of participants, including from the sailing, yachting and cruising communities; boat-builders, marina and harbour operators; the fishing, fish processing and aquaculture industries; and beach cleaning groups and beach-users.

Survey participants were asked a range of questions regarding: 1) the types of foamed polystyrene they use in their marine activities, 2) their experience of foamed polystyrene products breaking down or requiring replacement, 3) their perceptions of foamed polystyrene pollution from other marine sources, and 4) their awareness of any efforts to curb the extent of marine foamed polystyrene pollution.

This information formed a useful supplement to the direct engagement with stakeholders, as described in section 2.1.

### Summary of engagement

Twenty-three questionnaire responses were received from participants covering a range of marine activities, with a high proportion engaged in beach cleaning and leisure activities and fewer responses from the fishing and aquaculture sectors. The majority of respondents undertake their activities around the coasts of Scotland and its islands, with further data coming from several locations along the UK's southern coast and additional responses from Italy and the USA.

### Results

The questionnaire demonstrated clear awareness amongst respondents of the use of foamed polystyrene products in the marine environment and the prevalence of foamed polystyrene pollution across numerous locations in the UK. Clearly there is bias in this sample, with respondents being those that are engaged in or concerned about the problem, so this is not likely to be reflective of stakeholders as a whole. Broken pieces of unknown origin were the most commonly reported type of foamed polystyrene along the shore, with fish boxes the most frequent of the identifiable marine-related objects seen.

Three respondents that used foamed polystyrene products in their businesses or activities indicated that they were trialling the use of other materials, or they would like to do so. However, they also recognised that foamed polystyrene is well suited for the purposes of their activity, citing price, weight, and buoyancy as key advantages. This suggests a degree of willingness to change to products with improved designs or made from materials that are less likely to result in marine pollution, provided these products are effective and not prohibitively expensive. However, this suggestion would need to be explored with a much larger and more diverse stakeholder group to draw any firm conclusions. Amongst respondents that used foamed polystyrene products, mixed household and/or commercial waste disposal was the most common form of disposal.

If you have any questions or would like more information, please contact:

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