TECHNICAL INFORMATION PAPER NO.19

Response to plastic pellet incidents

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Contents

Introduction

Concern over the extent of plastic and microplastic contamination of our oceans has steadily increased over many years. It is, however, still a relatively new area of research and the full extent of the impacts of microplastics on the marine environment, wider ecosystems and human health are not yet fully understood. One source of microplastic pollution is the plastic pellets used as the feedstock to manufacture all plastic products, which are transported worldwide to meet the global demand for plastic production. Chronic losses of plastic pellets mainly occur from the terrestrial based components of the supply chain, with shipping only contributing a very small percentage to the volume of pellets lost[1]. Despite being a rare occurrence, losses of plastic pellets during shipping incidents have highlighted significant challenges to responding to such incidents.

Regardless of the quantity lost, the difficulties of responding to a plastic pellet incident arise from the characteristics of the pellets (their density, small size and light weight), how easily they are subsequently influenced by meteorological and oceanographic conditions and the extensive geographical area they can therefore affect. Recent cases have demonstrated that responses are likely to be labour intensive and protracted. The key to a successful response is to be well organised, and to respond promptly, with a targeted, proportionate deployment of resources focused on recovering the bulk of the plastic pellets from the affected area as quickly as possible.

To date, there have only been a small number of large-scale responses to plastic pellet incidents, thus the collective experience and knowledge of governments and industries on best practice in this field is currently relatively limited. Nonetheless, important lessons have been learnt from these responses. This TIP aims to encapsulate knowledge gained from ITOPF's significant involvement with plastic pellet incidents, providing considerations for contingency planning and guidance on strategies and techniques that have proved effective during previous responses.

Many of the principles of responding to oil spills are relevant to a plastic pellet response, therefore readers will find it useful to also refer to other relevant ITOPF TIPs[2].

1. Eunomia (2018) Investigating options for reducing releases in the aquatic environment of microplastics emitted by products
2. TIP 9 Disposal of oil and debris; TIP 10 Leadership, command & management of oil spills; TIP 15 Preparation and submission of claims from oil pollution; TIP 16 Contingency planning for marine oil spills

What are plastic pellets?

Plastic pellets, often referred to as 'pre-production plastics' or 'nurdles', are the raw materials used in the production of plastic products. Pellets can be produced using fossil fuel derived plastic (from oil and gas), bio-based plastic and bio-degradable plastic (from plants) or be made from recycled plastic or a combination of these.

Many plastics are made from organic polymers, most commonly polyvinyl chloride (PVC), polypropylene (PP), low-density polyethylene (LDPE) and high-density polyethylene (HDPE). The polymerisation process utilises different catalysts, traces of which might be found in the final polymer products as impurities. Polymers are often blended with additives to achieve the desired colour and performance characteristics of the plastic.

Polymers are typically produced in the form of flakes or powders. They are then converted into pellets for transporting to manufacturing facilities worldwide. This process involves melting the polymers to form continuous strands, which are then cooled and once solidified, cut into shape.

Pellets are manufactured in varying sizes but typically range from 2 mm - 5 mm, meaning they are classified as a 'microplastic'. They typically weigh between 0.02-0.025 g, and although the size of the pellets is relatively consistent, their colour and shape can vary (Figure 1).

Given their small size, plastic pellets are easily and often spilled during all stages of the production chain ending up in the marine environment through various direct and indirect pathways.

FIGURE 1 **Examples of different forms of plastic pellets**

Globally, plastic pellets represent a significant source of microplastics entering the marine environment. Losses occur due to pellet handling across the production and supply chain with routine operations frequently resulting in chronic, small-scale, losses either directly to the marine environment or indirectly from land-based losses via waste/storm water drainage systems or rivers and waterways. Conversely, acute losses involve larger-scale, more sudden, significant releases of pellets, such as the accidental loss of containers falling overboard during shipping incidents. Estimates made in 2018 on the volume of plastic pellets lost in Europe along the different stages of the production chain indicated that maritime transport accounts for less than 1% of the estimated losses[1].

1. Eunomia (2018) Investigating options for reducing releases in the aquatic environment of microplastics emitted by products

Shipping of plastic pellets

The supply and demand chain for plastic pellets is global. Where transport at sea is required, most plastic pellets will be carried onboard container ships, packaged in one of four main ways (Figure 2).

Despite there being international rules and regulations governing many aspects of containership design, operations and carriage of containers, including stowage, packing and labelling, accidents can still occur. In 2024, the World Shipping Council (WSC) reported that the rolling average losses for the previous three years (2021-2023) was 1,061 containers per year. Spikes in the annual number of container losses can be attributed to significant losses resulting from shipping incidents[3].

Vessels are regulated by the International Maritime Organization (IMO) and are required to carry a manifest detailing the cargo onboard (description of goods, quantity of packages, etc.) and a separate manifest for any dangerous goods (which is typically a much more limited document compared to the cargo manifest). Since plastic pellets are not classified as hazardous, they are not listed on a Dangerous Goods Manifest, nor are they assigned a UN number or a Proper Shipping Name. Instead, they are listed in the cargo manifest by a wide range of trade names or as a general description of the goods (see INFOBOX overleaf).

Furthermore, since the carriage of plastic pellets by sea falls outside the requirements of the International Maritime Dangerous Goods (IMDG) code, there are currently no mandatory requirements relating to the packaging of pellets inside a container or the stowage of a container onboard the vessel.

The ambiguity surrounding how plastic pellets are recorded on shipping documents can lead to difficulties and delays in establishing whether a container(s) of plastic pellets is involved in an incident and any subsequent assessment of the properties of the pellets involved.

FIGURE 2 Forms of packaging used in the transportation of plastic pellets and indicative load capacity (kg)

Palletised 25 kg bags

Depending on dimensions, a pallet may hold approximately 50 bags. Each 25 kg bag contains approximately 1 million pellets, so each pallet may hold approximately 50 million pellets

Bulk bag

Each bulk bag (500 kg - 1000 kg capacity) contains between 20 – 40 million pellets

Octabin

Each octabin (500 kg - 1300 kg capacity) contains between 20 – 52 million pellets

Dry bulk liner

A dry bulk liner inside a 20-foot container (with a maximum loading capacity of 25 MT) contains approximately 1 billion pellets

3. World Shipping Council. (2024). Containers Lost At Sea – 2024 update, **www.worldshipping.org/news/world-shipping-council-releases-containers-lost-at-sea-report-2024-update**

A recent run of incidents, including a significant one in Sri Lanka, 2021, increased awareness and concern over the problems that can arise from large-scale losses of plastic pellets from a shipping incident (Figure 3). With added impetus, in 2023, IMO produced voluntary recommendations for all those involved in the maritime carriage of plastic pellets aimed at reducing the environmental risks associated with their transport, addressing packaging, labelling and stowage. IMO is also working longer term to develop mandatory instruments to further improve legal requirements on the labelling, loading, stowage and handling of plastic pellets in packaged form.

Incident 1: Selected information for plastic pellets cargo from a Cargo Manifest which included 1,368 entries

Vessel slot	Container number	Weight (Tonnes)	Container size	Number/Kind/Description of goods
280210	ABCD1234567	18.9	20 D	660 Bag(s) of 660 BAGS CONTAINING **FD0274**
150310	ABCD1234568	19.6	20 D	1 Bag(s) of 01 X 40' CONTAINERS CONTAINING: 17340.00 KGS **EPOXY RESIN, PLASTIC**
280202	ABCD1234569	29.8	40 H	1020 Bag(s) of 2040 BAGS CONTAINING: **LOW DENSITY POLYETHYLENE (LDPE) "LOTRENE" FE8000** NET WT: 51.000 MT GROSS WT: 52.000 MT

Incident 2: Selected information from a Bill of Lading for two plastic pellet containers

Marks and Numbers (16)	No. of PKGS (17)	Description of goods (18)	Gross weight (19)	Measurement (20)
ABCD0123456	990	KG BAG 55 BAGS / PALLET BAG LOADED ONTO 18 PALLETS LOADED INTO 1 40' CONTAINER **DOWLEX ™ 2607 G POLYETHYLENE RESIN 25**	25121.250 KGS	41.729 CBM
XYZA0123457	20	6 x 40 HC CONTAINERS: 120 BAGS on 120 PALLETS **S-PVC RESIN SE-1000**/132 MT NET WEIGHT: 132,000.00 KGS BAGS	22428.000 KGS	54.422 CBM

Information on plastic pellets onboard a ship may be obtained from either the cargo manifest or the Bill of Lading (BOL)- a legal document issued by a carrier (transportation company) to a shipper detailing the type, quantity, and destination of the goods being carried. Plastic pellets are typically listed under different trade names, rather than explicitly described as plastic pellets. Example 1 shows how a container of plastic pellets was referred to in the manifest simply as 'FD0274'. Other possible trade terms to be aware of include 'resin', 'prill', 'chips bottle'. Plastic pellets have also been listed in manifests according to their polymer type (i.e., HDPE, MDPE, LDPE), or more generically as 'epoxy resin, plastic'.

FIGURE 3 Confirmed and unconfirmed ship-related losses of plastic pellet containers (2011-2024)

CMA CGM BIANCA, 2020
USA
Pellet loss:
Four containers fell into the Mississippi River during operations.

Unknown, 2023
France
Pellet loss:
A container lost in the Atlantic Ocean was thought to be the source of extensive shoreline pellet contamination in France.

TRANS CARRIER, 2020
North Sea
Pellet loss:
~ 13.2 MT lost from a single container after the container liner was punctured during transit. Pellets reported in Norway, Sweden and Denmark.

Unknown, 2023
UAE
Pellet loss:
A lost container was thought to be the source of pellet contamination of beaches in Dubai, including fully intact bags.

Unknown, 2023
India
Pellet loss:
Pellet strandings, including intact one-tonne bags, observed on beaches of Mumbai.

YONG XIN JIE No.1, 2012
Hong Kong
Pellet loss:
Five containers (~125 MT lost during a typhoon

TOCONAO, 2023
Spain
Pellet loss:
At least one container lost during transit along the Portuguese and Spanish coast. Shorelines in northern Spain affected; clean-up was concluded within a few months.

MSC ZOE, 2019
Netherlands
Pellet loss:
Unconfirmed quantity lost during a storm in the North Sea, contaminating beaches around the Wadden Sea.

INCIDENT IN SOUTH AFRICA, 2020
Pellet loss:
Six containers (~ 150 MT) lost, affecting >2000 km of coastline. Clean-up took over three years.

MSC SUSANNA, 2017
South Africa
Pellet loss:
Two containers (~ 50 MT) lost during a storm. Clean-up took over three years.

X-PRESS PEARL, 2021
Sri Lanka
Pellet loss:
Unknown quantity of the 422 containers carrying pellets onboard lost following a fire. Extensive contamination experienced along the Sri Lankan coastline.

RENA, 2011
New Zealand
Pellet loss:
Four containers (~100 MT) lost following the vessel grounding. Pellets still reported 10 years later.

ON-SITE ATTENDANCE BY ITOPF
REMOTE ADVICE PROVIDED BY ITOPF
NO ITOPF INVOLVEMENT

Behaviour of lost plastic pellets

Behaviour of pellets in the marine environment

The fate of a container falling overboard, and the way plastic pellets are carried inside the container, will dictate how plastic pellets enter the marine environment (Figure 4).

Once in the marine environment, regardless of the type of packaging used to transport the plastic pellets (25 kg bags, bulk bags, octabins etc.), with time, the structural integrity of the packaging will eventually deteriorate, releasing the contents. This may happen at-sea or on the shoreline.

FIGURE 4 Pathways of plastic pellets release following containers loss

There may be an instantaneous release of loose pellets/packaged pellets if a container breaks open during a stack collapse or on contact with the sea after falling overboard.

If a container is lost overboard but remains intact, it could drift and strand and then break up and release its cargo (loose or packaged pellets).

A container may remain intact, drift and then sink to the seabed with no immediate release of its contents. However, if left in-situ for a long period, the container and its packing materials may degrade and eventually lose some or all the plastic pellets.

The key factors influencing the likely fate and behaviour of plastic pellets once released into the marine environment are their density, their mobility (subject to prevailing meteorological and oceanographic conditions) and, once stranded on the shoreline, their remobilisation under the influence of coastal processes (see Figure 5).

Whether or not a plastic pellet will float or sink once released is primarily a function of the polymer type (Figure 6). However, the stated density of a plastic pellet only reflects the properties of the production polymer, not the density after additives have been combined. Therefore, the actual behaviour of a pellet will depend on how similar its true density is to that of seawater.

FIGURE 5 Behaviour of plastic pellets once lost to the marine environment

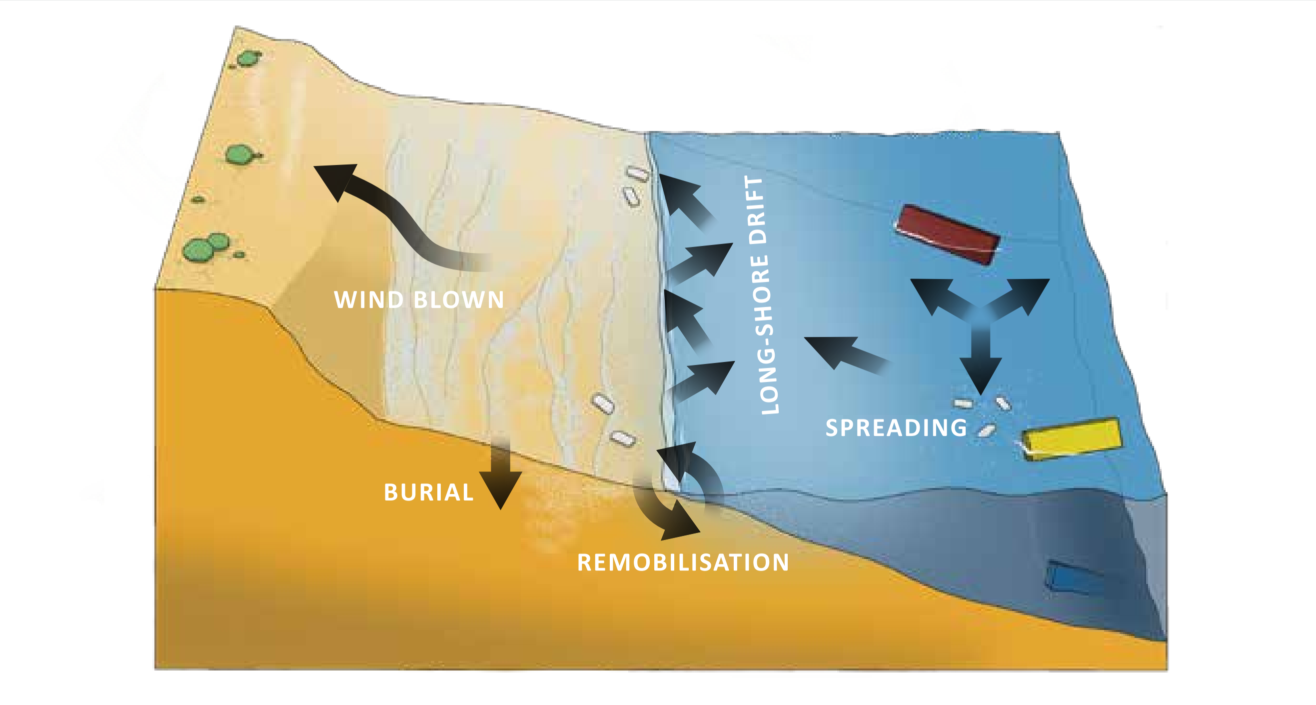
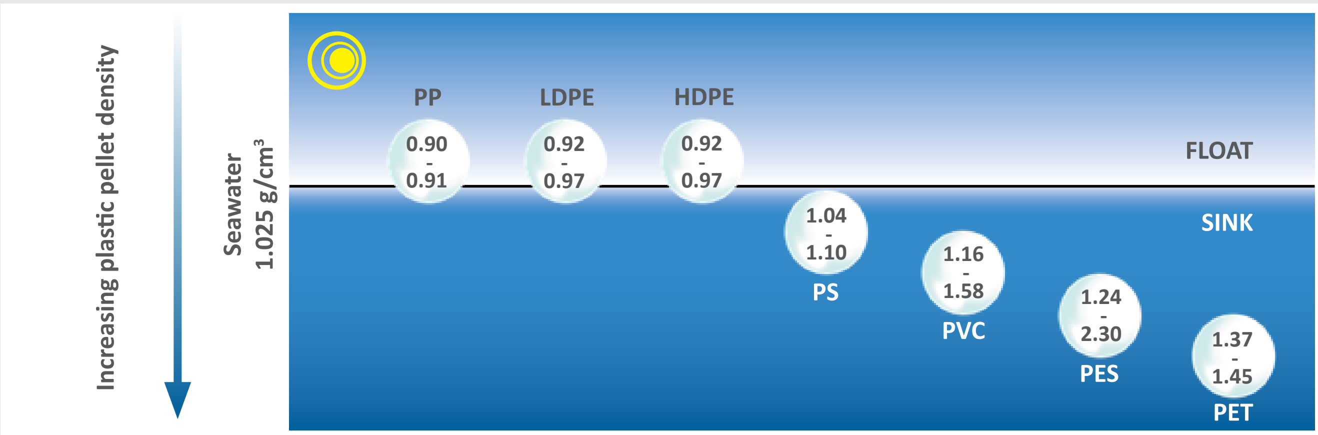


FIGURE 6 Anticipated behaviour of different polymers based on their density ranges, modified from Hidalgo *et al.*, 2012[4]. Factors such as changes in seawater density and salinity, turbulent sea conditions and biofouling may affect plastic pellet behaviour



4. Valeria Hidalgo-Ruz, Lars Gutow, Richard C. Thompson, Martin Thie (2012). Microplastics in the marine environment: A review of the methods used for identification and quantification. Environmental Science and Technology, 46, 6, 3060–3075 **www.pubs.acs.org/doi/10.1021/es2031505**

Marine microorganisms (e.g. bacteria, fungi, protozoa and algae) will rapidly colonise the surface of a pellet forming a biofilm. As the degree of fouling progresses, the density of the plastic pellet subsequently increases, leading to a reduction in the buoyancy of the pellet.

The time taken for loose plastic pellets and packaging to come ashore will depend primarily on the incident location as well as the prevailing meteorological and oceanographic conditions, but could range from hours to weeks.

Areas which naturally accumulate marine debris have been shown to collect high concentrations of stranded pellets, where they typically come ashore as a single or multiple bands at the highwater mark or across the shoreline, respectively (Figure 7).

Whilst recent plastic pellet spills have demonstrated that plastic pellets can travel significant distances from the original point of release (over 2,000 km has been recorded during an incident in South Africa), there has been limited research into the fate and behaviour of pellets at sea following an accidental release.

Due to their light weight, once onshore, it is possible that plastic pellets can be remobilised though the action of winds, waves and tides and transported along the shoreline through processes such as longshore drift. They can also become buried within sediments, notably through the actions of waves and winds (which may be exacerbated during seasonal fluctuations), and potentially due to trampling.

FIGURE 7 Potential distribution patterns following a loss of plastic pellets. A) Bulk contamination following a significant loss; B) typical banded stranding pattern, influenced by metocean conditions and pellet concentrations; C) stranded intact packaging following a loss

Weathering of plastic pellets

The durable characteristic of plastic also makes plastic pellets highly persistent. However, like other plastic, prolonged exposure in the marine environment will, over time, cause the pellets to degrade, initially leading to discolouration and cracks appearing on the surface (Figure 8).

The degradation mechanisms for plastics can be classified as either mechanical (abrasion from contact with the sea floor or other objects, wave action or movement through the sea) or chemical (such as photo-oxidation and hydrolysis). Research has shown that degradation of plastics occurs primarily through solar UV-radiation induced photooxidation reactions, with rates dependent upon factors such as temperature, polymer type and additives present. However, all these degradation processes are slow, taking in the order of decades to centuries.

Weathering of burnt plastic pellets

There is currently very little information regarding the fate and behaviour of burnt plastic pellets. Following a fire onboard the containership X-PRESS PEARL, plastic pellets were exposed to intense heat causing them to melt and agglomerate into large and small, more brittle, pieces with less uniformity in appearance (Figure 9). Compared to the unburnt plastic pellets, the burnt material was observed to have come ashore over a relatively limited area. This incident identified the need to further study whether the increased buoyancy and size of these burnt plastic pellet agglomerations affected their transportation by ocean currents and winds.

FIGURE 8 **Scanning electron microscope (SEM) image of lightly weathered pellet (A) and heavily weathered pellet (B) taken from Jiang *et al*. 2021[5]**

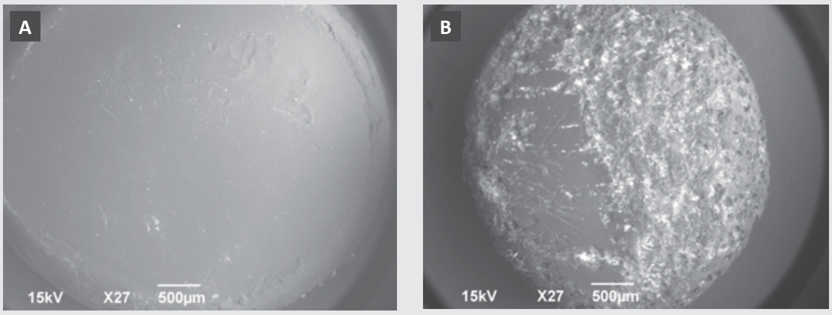


FIGURE 9 **Plastic debris originating from X-PRESS PEARL, Sri Lanka, 2021, demonstrating a continuum of plastic spanning from white unburnt pellet to conglomerated burnt plastic. James *et al*. 2023[6]**

5. Xiangtao Jiang, Kaijun Lu, Jace W. Tunnell, Zhanfei Liu (2021). The impacts of weathering on concentration and bioaccessibility of organic pollutants associated with plastic pellets (nurdles) in coastal environments. Marine Pollution Bulletin, Volume 170. **www.doi.org/10.1016/j.marpolbul.2021.112592**

6. Bryan D. James, Christopher M. Reddy, Mark E. Hahn, Robert K. Nelson, Asha de Vos, Lihini I. Aluwihare, Terry L. Wade, Anthony H. Knap, and Gopal Bera (2023). Fire and oil led to complex mixtures of PAHs on burnt and unburnt plastic during the M/V X-Press Pearl disaster. ACS Environmental Au 2023 3 (5), 319-335, https://pubs.acs.org/doi/10.1021/acsenvironau.3c00011

CASE STUDY

Major Plastic Pellet Spill

Containership X-PRESS PEARL caught fire on 20th May 2021, eventually sinking at Colombo Anchorage, Sri Lanka on 2nd June 2021, 9 NM northwest of Colombo Port. The vessel was carrying 1,486 containers, 81 of which were declared as dangerous goods including, *inter alia*, nitric acid, sodium hydroxide, vinyl acetate, lithium-ion batteries and fire extinguishers. The vessel was also carrying approximately 422 containers of plastic pellets.

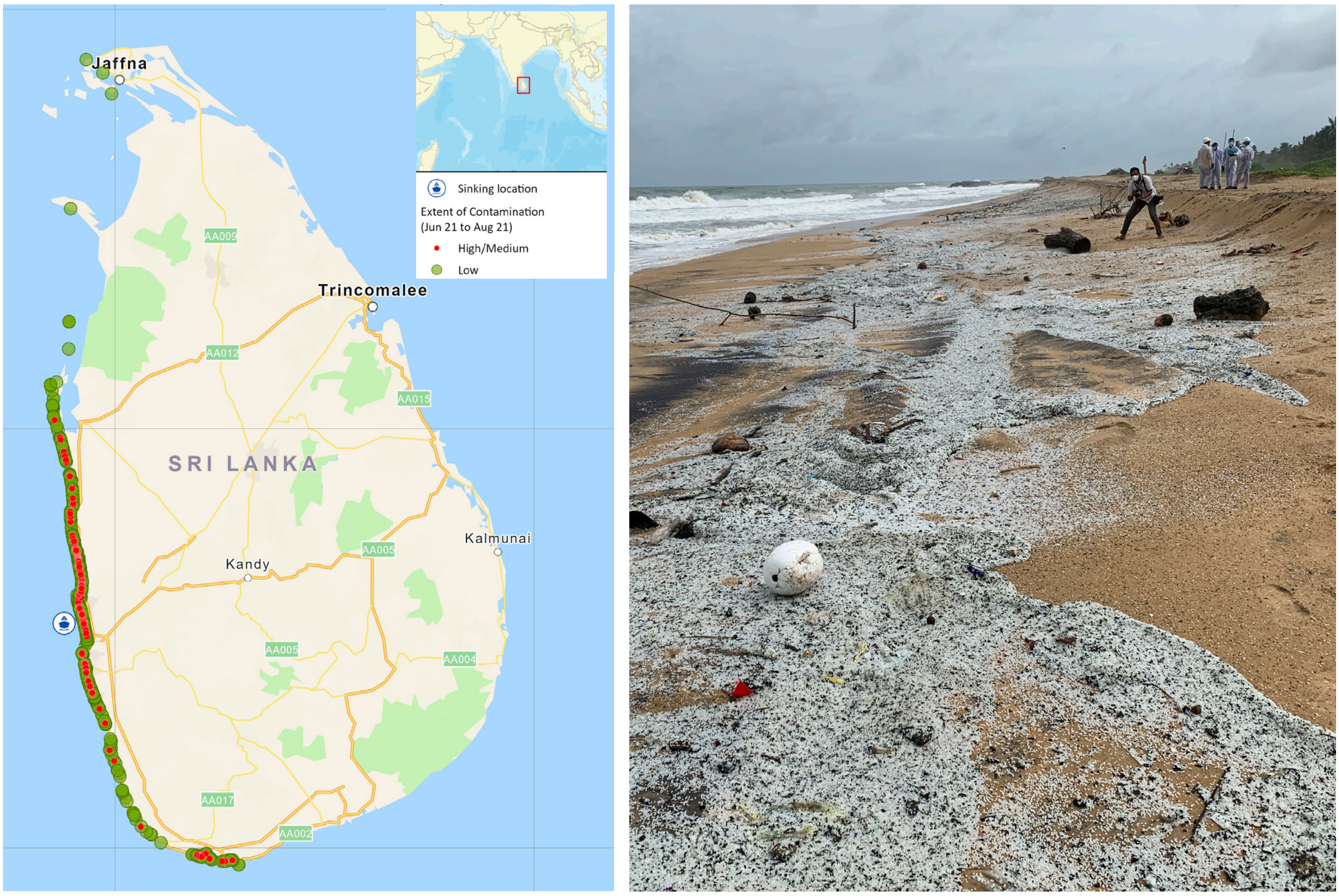
As the fire took hold and spread, the container stacks collapsed and multiple containers, as well as burning liquids and debris, fell overboard. The exact number of containers of plastic pellets lost to the marine environment or consumed by the fire is unknown. Large quantities of plastic pellets – burnt and unburnt – stranded hours after debris was initially observed falling overboard.

A shoreline response was rapidly mounted by the Sri Lankan government, with thousands of military personnel mobilised for the bulk recovery of stranded pellets. The pellets initially stranded over approximately 30 km of shoreline, but due to their mobility, and prevailing meteorological and oceanic conditions, plastic pellets were eventually observed across 300 km of coastline (Figure 10). The propensity of the pellets to remobilise meant that surveys to assess shoreline strandings needed to be conducted frequently. In some environments, pellets were found to be buried down to a depth of 1.5 m.

CASE STUDY LEARNING POINT

This case demonstrated that expeditious clean-up, targeting concentrations of plastic pellets, is essential for minimising their spread. Given the mobility of pellets, effective communications, and rapid mobilisation of clean-up teams in response to shoreline plastic pellet sightings is key to efficiency. Any delays that may allow further spreading, burial or mixing with other debris can greatly protract the response. Recovering buried pellets can be resource intensive and reduce the overall efficiency of a response.

FIGURE 10 **Extent of ship-sourced plastic pellet contamination from June-August 2021 following the X-PRESS PEARL incident, Sri Lanka, May 2021, showing a typical representation of a high/medium level of contamination**



Effects of plastic pellets on marine resources

Concerns over the possible environmental effects associated with microplastics arise from their highly persistent nature combined with their small size, which allows them to be readily available to a wide range of marine organisms. Although scientific studies have documented various impacts of microplastics on marine organisms, this research predominately demonstrates effects at organism level (such as survival and growth rates). There is currently no substantial body of evidence demonstrating effects of microplastics at a population level i.e. changes to the abundance level of a given population. Indeed, demonstrating any effects on marine populations is challenging due to the difficulties of gathering comprehensive and accurate data on population levels and understanding population trends. Based on current levels of knowledge and experience, significant uncertainty exists regarding the possible environmental effects following an acute discharge of plastic pellets to the marine environment.

Pathways

During any plastic pellet response, the possible environmental effects of the incident will need to be examined. Research into microplastic effects has demonstrated several possible pathways that should be considered.

Although scientific studies have demonstrated varying effects of microplastics (not necessarily plastic pellets) on various organisms in laboratories, these effects have been shown to be dependent upon the size, shape and chemical composition of the microplastic and its abundance (i.e. dosage).

PHYSICAL INGESTION

For some marine organisms, ingestion of plastic pellets and the potential for bioaccumulation is an issue. Active feeders may consume pellets either directly while feeding or indirectly when consuming a lower trophic organism that had ingested pellets. Passive, filter feeding organisms may accidently consume pellets whilst filtering water for food. As pellets degrade and break down into smaller fragments, they become more bioavailable to a greater number of marine organisms.

Fish, seabirds and marine mammals have been found to have plastic pellets within their digestive systems. The effects of ingestion are generally caused by physical damage (such as inflammation following abrasion), blocking feeding appendages or the intestinal tract and changes to feeding patterns because of false satiation.

Research demonstrates that microplastics retention time is significantly influenced by the characteristics of the plastic (polymer type, shape and size) and species studied. Therefore, knowledge of how retention time is linked to impacts for varying marine organisms across different habitats and climates is limited.

ADSORPTION AND BIOFILMS

Studies have established that as plastic pellets begin to weather, they can adsorb persistent organic pollutants (POPs) from the water - these include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and organochlorine pesticides (e.g. DDT, DDE). If these pellets are then ingested, these higher concentrations of pollutants (relative to the surrounding water) become more bioavailable to the marine organism.

Research has also shown that biofilms formed on the surface of plastic pellets can act as a vector for pathogenic microorganisms such as *Escherichia coli* (E. coli).

LEACHING OF CHEMICAL ADDITIVES

Although plastic pellets are considered inert and therefore not classified as a marine pollutant, the potential for ecotoxicological effects arises from the chemical additives leaching from the plastic pellets into the surrounding environment or biota. Research has shown that polybrominated diphenyl ethers (PBDE), phthalates, nonylphenols (NP), bisphenol A (BPA) and antioxidants are the most common plastic additives found in marine environments. Exposure to these chemicals may disturb biologically important processes, potentially resulting in endocrine disruption, which in turn can impact survival rates, reproduction, and development.

SMOTHERING

Once ashore, plastic pellets have the potential to affect terrestrial habitats through smothering caused by their accumulation into thick layers. There is also the potential for microplastics to affect soil fauna and microbial communities – although there is limited research in this area.

Impact assessment studies

The need to commission studies to examine any environmental impacts of the incident should be considered from the outset. Potential exposure pathways, the expected vulnerability of resources and seasonal variations in sensitivities are all factors to consider when determining the need for an impact assessment study. The objective and scope of any impact assessment studies required will depend upon the resources at risk of being affected. If an incident occurs within or near an important fishing ground, then studies may be required to assess seafood safety, or if plastic pellets have come ashore during the winter season in an area designated as important for overwintering birds, studies to assess rates of avian ingestion may be relevant.

Any post spill studies assessing the long-term effects would need to address the challenges of differentiating between the effects caused by incident-related plastic pellets as opposed to those caused by other stressors such as background pollution levels, overfishing, elevated sea temperatures, salinity changes and other readily available microplastics.

CASE STUDY

Assessing Environmental Effects

During a North Sea storm, a container of 2-3 mm polypropylene plastic pellets stored on the deck of TRANS CARRIER, a roll-on/roll-off cargo vessel, suffered a puncture, resulting in a spill off the coast of Denmark of approximately 13.2 MT of pellets overboard. Over two weeks later, after travelling more than 300 NM from the incident location under the influence of waves and currents, plastic pellets started washing up on the shores of Norway and Sweden, resulting in widespread shoreline contamination. In response, a significant shoreline clean-up operation was mounted, and a variety of clean-up techniques were employed to recover the pellets.

FIGURE 11 Investigation of the impact of a plastic pellet spill on deceased Eider ducks collected near the spill location © Norsk institutt for naturforskning

Due to concerns around the environmental impact of the pellets, post-spill monitoring was conducted by the Norwegian Institute of Marine Research as part of its on-going monitoring series. A survey of the stomach contents of fish fry and coastal fish species from the affected areas around Østfold was carried out[7]. Six hundred and thirty-three individual fish, covering nine fish species, were collected and their stomach contents examined in a laboratory. The results indicated that no pellets were present within the stomachs examined, suggesting that there was little interaction between the sampled fish species and plastic pellets within the affected area.

CASE STUDY LEARNING POINT

The incident reinforced how impacts should be considered on a case-by-case basis, and how specific post-spill monitoring studies may be required. Even if studies do not provide clear evidence of a link between the pellets and observed impacts, as in this case, the potential for physical and toxicological effects and the persistence of pellets in the environment mean that a clean-up response is usually necessary.

During the shoreline clean-up period, a concerning mass mortality event of Eider ducks was observed which prompted investigations by the Norwegian Institute for Nature Research into the potential impacts of plastic pellet on birds[8]. During the investigation, 104 deceased Eider ducks were collected with the aim of assessing the birds' body condition and to identify any physiological abnormalities (Figure 11). It was determined that the birds were severely emaciated, and it was concluded that they had likely died from starvation. As the ingestion of plastic by marine organisms can lead to 'false satiation', leading to death by starvation, further investigation was deemed necessary. Of the 104 ducks assessed, 50 were randomly selected for further investigation of their digestive tracts. The study found that 4% (2/50) ducks had consumed plastic pellets, but only in small quantities - one pellet in one individual and four in another. It was therefore concluded that the intake of plastic pellets in sampled Eider ducks could not explain the mass mortality event.

7. https://www.hi.no/hi/nettrapporter/rapport-fra-havforskningen-2020-45
8. https://brage.nina.no/nina-xmlui/handle/11250/2681831?locale-attribute=en

Information gathering

Experience has shown that organising and implementing an early, targeted response is extremely important when responding to plastic pellet incidents. Gathering information in a timely manner, on which to base early response decisions, is therefore also crucial.

Notifications

Recognising the risk posed to the safety of navigation and the environment by the loss of containers overboard, IMO adopted amendments to the International Convention for the Safety of Life at Sea (SOLAS), 1974 Chapter V, which require the Master of every ship involved in the loss of container(s) to report such incidents without delay and to the fullest extent possible to ships in the vicinity, to the nearest coastal State, and also to the flag State.

As with the X-PRESS PEARL incident, a container ship incident may involve multiple contaminants; plastic pellets, oil (likely to be bunker fuel oil) and HNS in packaged form. Therefore, the initial notification of an incident may come from the shipowner as per their requirement to also report any oil and/or HNS spill from the vessel.

Cargo assessment

Personnel tasked with obtaining information will need to work through the cargo manifest which, depending on how many containers are being carried, can be a voluminous document. Information on the manifest might be quite generic and manufacturers may need to be contacted to obtain the exact composition of the plastic pellets.

Even when it is confirmed that containers have been lost overboard, information on the number of containers and the cargo within may not be immediately available. Depending on the circumstances of the incident, identifying which containers have been lost overboard can take time, and may require some form of survey.

INFORMATION TO GATHER FROM SHIPOWNER OR OPERATOR

- Contact details of the person reporting the incident
- Name of vessel and owner
- Date and time of incident
- Position (e.g. latitude and longitude)
- Cause of the incident and nature of the loss (is there an oil and/or chemical spill as well, is there a fire onboard?)
- Number of containers lost, and number containing plastic pellets
- Cargo manifest and/or Bill of Lading
- How the plastic pellets are packaged (25 kg packages, bulk bags) inside the containers
- Have the plastic pellets been exposed to fire or another heat source?
- If possible, the type of polymer(s)
- If possible, details of the manufacturer(s) of the pellets

Aerial surveillance

Conducting surveillance is crucial for gaining an understanding of the nature and scale of the incident. However, for large scale plastic pellet spills, the characteristics of the plastic pellets makes aerial surveillance, with the aim of tracking the movement of individual pellets, extremely challenging. During the TRANS CARRIER incident, for example, the authorities were unable to detect plastic pellets on the sea surface when conducting aerial surveillance using drones.
The objective of any surveillance mission during a plastic pellet incident should be to locate and track containers and/or packaging rather than the pellets themselves (Figure 12).

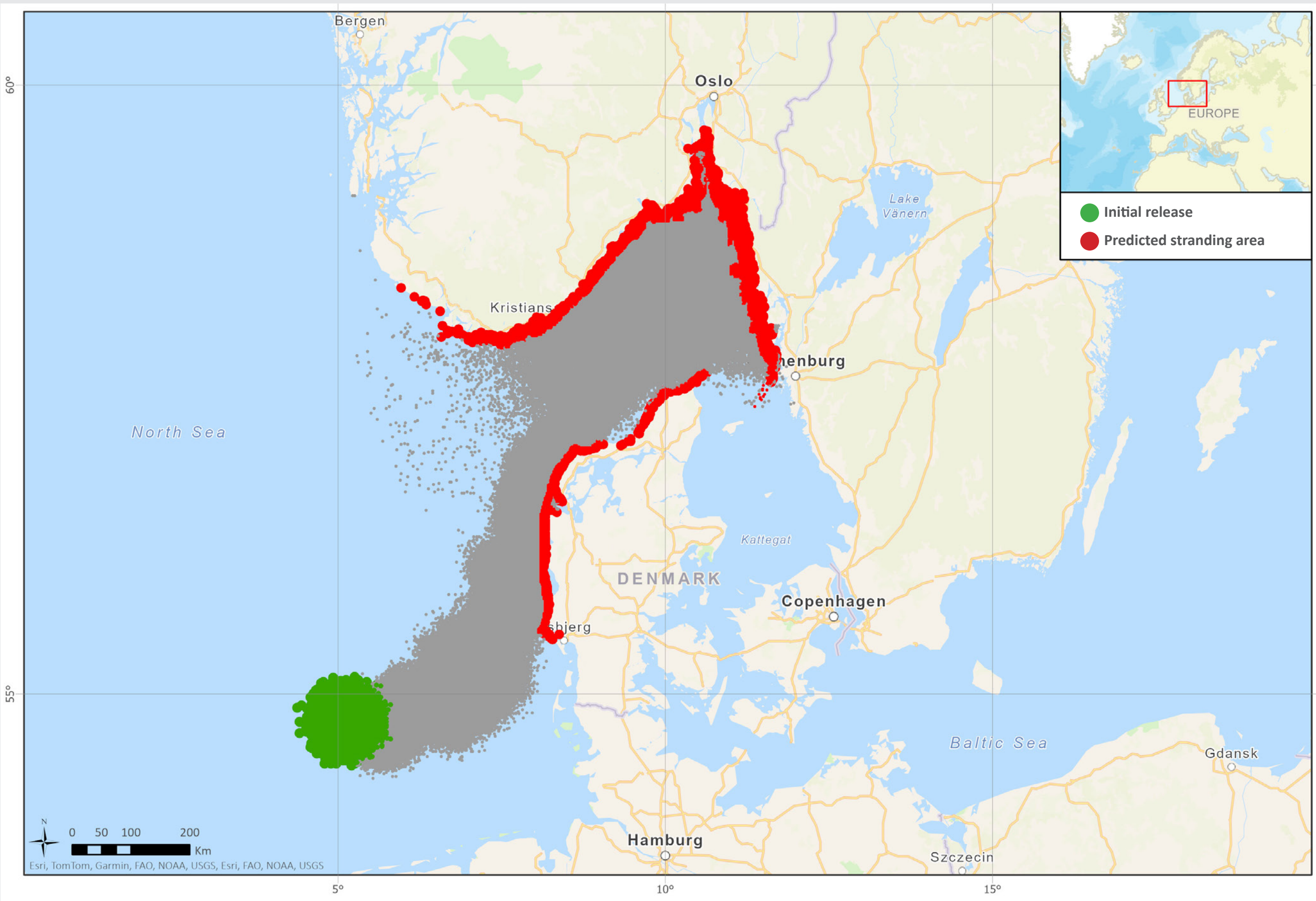
FIGURE 12 **Identifying even packaged pellets at sea or on the shoreline can be challenging. The flexibility of rotary wing aircraft, as opposed to fixed wing aircraft, to fly at low altitudes and speeds, and their ability to hover makes them a more suitable platform for conducting plastic pellet aerial surveillance**

Modelling

Modelling, in combination with real time information, can be a useful tool to help predict the movement of plastic pellets in the marine environment (Figure 13). Although models built specifically to predict the movement of plastic debris do exist, national competent authorities may not necessarily be able to access such tools. Competent authorities are more likely to have arrangements in place to access models for predicting the fate and behaviour of oil, which based on past plastic pellet cases have been shown to be applicable. Search and rescue models have also been successfully utilised to model the trajectory of packaging and intact containers.

Ideally, modelling should be conducted as soon as the location of the incident is known or be used to 'backtrack' from where the pellets have come ashore or where containers have been located to indicate where they might have originated. As with all modelling, the accuracy of the results will depend upon the quality of oceanographic and atmospheric information entered, with the level of accuracy diminishing closer inshore due to the difficulties of reproducing the complex coastal processes occurring in this environment. Additional caveats to those usually issued when considering modelling results may be necessary to account for the fact that the model may not be specific to plastic pellets.

FIGURE 13 GNOME (NOAA) trajectory modelling outputs from the TRANS CARRIER pellet release, demonstrating the initial release location and predicted stranding area



Shoreline surveys

Surveying plastic pellets on the shoreline can be challenging due to the propensity of the pellets to remobilise and become buried within sediment. Therefore, surveys need to be repeated frequently, especially for high energy shorelines, to ensure that responders have accurate information on which to base decisions. Where buried plastic pellets have been identified, systematic surveys of the sub-surface layer will be required to record the thickness (and depth from the surface) of any layers of buried pellets.

Different survey techniques will probably be appropriate for different stages of the response. During the initial emergency phase, when the aim of the surveys is to rapidly assess the overall extent and level of contamination, spot surveys can be conducted quickly to give a snapshot of the contamination level at numerous sites across a wide geographic area. However, since spot surveys have the potential to misinterpret the level of contamination across a segment of shoreline, it is recommended that, as soon as time allows, spatially continuous surveys are conducted across the affected segments of shoreline (i.e. 50 m intervals or when the contamination level changes) so that any changes in the contamination level are fully understood. Utilising local knowledge to help identify natural accumulation points, which might act as 'hot-spots' for pellet strandings, will help in prioritising shorelines for both initial and repeated surveys.

Even if response personnel are trained in methods of surveying oiled shorelines, staff are unlikely to have experience of assessing levels of plastic pellet contamination. From the start of the incident (and ideally as part of the contingency planning process), criteria should be established to classify the level of plastic pellet contamination and standardised forms adopted to record survey results. Those conducting the surveys should conduct on-site joint training to calibrate their findings and ensure a common understanding of the agreed criteria for defining contamination levels.

Figures 14A and 14B provide examples of methods used during plastic pellet responses to determine the level of contamination, all of which could be adapted to suit incident specifics. It may be appropriate to use more than one method during the response.

FIGURE 14A Example of a qualitative survey method for determining levels of plastic pellet shoreline contamination

Visual assessment

This basic survey methodology can be undertaken rapidly across a wide geographic area and **is therefore ideally suited for use during the emergency phase of the response.**

Based on visual observations, the 'average' contamination level of the shoreline is agreed and recorded.

Criteria can be related to thickness, spread and propensity to remobilise. The criteria may need reviewing as the response progresses and the overall level of contamination diminishes.

Survey results, including photos, should be recorded on a survey form/ mobile survey app.

The table shows the visual assessment criteria used during the X-PRESS PEARL incident. The criteria for determining contamination classification will vary on a case-by-case basis.

For example, the medium level of contamination shown on the left might represent what is regarded as a high level of contamination during another incident.

Contamination level	Criteria
HIGH	Pellets across large/wide areas and in high concentrations mixed with large amounts of flotsam and jetsam. • **Contamination across the shoreline (intertidal and supratidal)** • **The presence of buried pellets** • **Consistent re-contamination of pellets**
MEDIUM	Pellets across large spatial extents, consistent, condensed accumulations. May be mixed with other debris or not. • **Contamination in the intertidal and possibly supratidal** • **No buried pellets** • **No obvious repeated re-contamination**
LOW	Pellets scattered lightly and sporadically across and throughout the shore. • **Patchy inconsistent contamination, primarily in the intertidal, not into the supratidal** • **No buried pellets** • **No obvious re-contamination**

FIGURE 14B Examples of semi-quantitative and quantitative survey methods for determining levels of plastic pellet shoreline contamination

Timed count

This is a semi-quantitative method whereby pellets are collected by hand for a set period of time and then quantified. During the X-PRESS PEARL incident, a modified version of the Tunnell *et al*. method was adopted and used during the project phase of the response **to generate more detailed information to record how contamination levels changed spatially and temporarily.** [9]

Instead of a ten-minute timed count, a shorter period was deemed appropriate and, due to the high levels of contamination, pellets were weighed as opposed to counted.

For a given area of shoreline, a location representative of the 'average' level of contamination is selected. Pellets are collected by hand into an open top container – with efforts made to avoid collecting sticks, plastic or other substrates / debris. The combined weight of the container and pellets is noted, with the weight of the container subtracted to give the net weight of the plastic pellets.

The weight is entered into a mobile survey app/ survey form/ database. Low, medium and high contamination levels are assigned based on arbitrary limits, which need to take into account background levels of plastic debris and shoreline use, and the sites are classified accordingly.

Contamination level	Weight of plastic pellets
HIGH	> 30 g
MEDIUM	5-30 g
LOW	< 5 g

Spatial/Quadrat count

The Plastic Pollution Index (PPI) developed by Fernandino *et al*. can be used to classify sandy beaches according to the abundance of plastic pellets. **Methods such as this would generate more detailed data and may be ideally suited for use during impact assessment studies.** [10]

A 1 x 1 x 0.05 m quadrat is randomly placed at the most recent high tide mark and a second positioned at the landward limit of the shoreline – this could be a natural limit (e.g. vegetation) or anthropogenic (e.g. a sea wall).

The surface layer of sediment from each quadrat is collected, and the plastic pellets are separated via flotation by mixing the sediment with seawater. For rocky shores, pellets can be collected by hand.

The number of pellets are then counted and recorded for both sample locations and the level of contamination is classified according to the PPI classification below.

To obtain an accurate representation, this should be repeated at several intervals along the section of shoreline.

Contamination level	PPI	Concentration of pellets
VERY HIGH	PPI > 3.0	> 150
HIGH	2.0 < PPI ≤ 3.0	100-150
MODERATE	1.0 < PPI ≤ 2.0	50-100
LOW	0.5 < PPI ≤ 1.0	25-50
VERY LOW	0.0 < PPI ≤ 0.5	0-25

If the opportunity to gather 'real-time', pre-contamination, information on background levels of plastic debris presents itself, then such data collection efforts are recommended. If possible, removing any pre-existing plastic debris on shorelines prior to contamination with plastic pellets is also recommended.

Gathering existing pre-incident baseline data on the background levels of plastic contamination for the affected shorelines can be useful when determining strategy, techniques, and end-points for shoreline clean-up operations.

9. Tunnell, J. W., Dunning, K. H., Scheef, L. P., & Swanson, K. M. (2020). Measuring plastic pellet (nurdle) abundance on shorelines throughout the Gulf of Mexico using citizen scientists: Establishing a platform for policy-relevant research. Marine Pollution Bulletin, 151, 110794. **https://doi.org/10.1016/J.MARPOLBUL.2019.110794**

10. Fernandino, G., Elliff, C. I., Silva, I. R., & Bittencourtc, A. C. S. P. (2015). How many pellets are too many? the pellet pollution index as a tool to assess beach pollution by plastic resin pellets in Salvador, Bahia, Brazil. Journal of Integrated Coastal Zone Management, 15(3), 325–332. **https://doi.org/10.5894/RGCI566**

Scientific assessment

Characterisation

Analysing the physical and chemical characteristics of plastic pellets involved in an incident can provide an improved understanding of how they are likely to behave in the marine environment. Such studies may be beneficial if uncertainty exists regarding the density of the pellet(s) and may also provide more accurate input for any fate and transport modelling.

If a plastic pellet pollution incident involves a simultaneous release of HNS, then studies to assess potential interactions between the plastic pellets and other possible contaminants to examine if/how their composition has changed may be valuable. Such studies could help inform decision makers on whether the collected plastic pellets should be treated as hazardous or non-hazardous waste and used to inform any assessments on the likelihood of impacts the contaminated pellets may have on the environment (e.g. due to potential toxicological effects). Characterisation studies should also be conducted on any burnt plastic pellets/agglomerations to assess the impact of the fire (for example, to investigate the presence of combustion products on the burnt pellets/agglomerations).

Where uncertainty exists regarding the classification of pellets as hazardous or non-hazardous, having the national competent authority reach an early decision on this can significantly influence the effectiveness of the initial response. Delays in decision making could cause bottlenecks in the response since it dictates the level of personal protective equipment (PPE) to be worn, how collected pellets are disposed of and messaging to the public.

Identification

Although laboratory analysis to 'fingerprint' plastic pellets for the purpose of identifying the source of pollution is possible, the need for such studies should be considered according to the beneficial use of the results. If one or more containers have been lost from a vessel, then the number of plastic pellets, and packaging, will be significant, and responders are likely to be able to identify patterns in the strandings ashore. Furthermore, it is usually possible to visually distinguish whether plastic pellets are associated with the incident based on their appearance (fresh pellets will show no signs of ageing (discolouration, abrasion marks) compared to pellets from other chronic sources).

Fingerprinting studies may, however, be useful when uncertainties exist over whether plastic pellets coming ashore outside the previously identified main area of contamination are linked to the incident, or if the incident occurs near facilities producing plastic pellets which may act as a source of chronic releases. Fingerprinting of plastic products is commonly undertaken by thermal analysis (e.g. pyrolysis gas chromatography mass spectrometry (pyr-GC-MS), differential scanning calorimetry or thermogravimetry (TGA) based methods). Before commissioning such studies, relevant parties should be aware of the limitations of cost, timescales for results and possible challenges of obtaining proprietary information on the plastic pellets.

Response options

Following a shipping incident, responding to the loss of plastic pellets may only be one facet of a wider response. Various scenarios can be anticipated regarding the scope of a response, but if multiple response streams are occurring simultaneously, then coordination between these will be essential.

At-sea response

As with any type of pollution incident, the selection of techniques used to form an appropriate response will depend upon the incident specifics. However, experience shows that the prospect of conducting 'traditional' containment and recovery operations at sea using booms and skimmers is limited for a plastic pellet spill, compared to oil spills.

The feasibility of mounting a response at sea will largely depend on whether the plastic pellets remain in their packaging or become loose. For incidents involving the immediate release of loose plastic pellets, at-sea response is unlikely to be feasible for several reasons.

- The rapid dispersal of loose pellets from the incident location means that, once notified of the incident, authorities are unlikely to be able to mobilise the required resources in a suitable time frame to allow for effective containment and recovery operations, especially if the release occurs close to land.
- At-sea response was trialled during the TRANS CARRIER incident but was discontinued because of the inability of the responders to locate the pellets both visually and using sensors.
- Loose pellets may become entrained in oil and could hinder any traditional at-sea response operations to contain and recover the oil, as they will essentially act as debris, potentially clogging skimmers, limiting sorption and negatively affecting other recovery devices.

In situations where the natural geography or artificial environment of the incident location acts to limit the spread of loose plastic pellets (in a port area for example), then containment and recovery could be appropriate. In these instances, booms used for oil spill response would be applicable to help contain the pellets, which could then be recovered, for example by using nets with a suitable size mesh.

Once loose pellets start to spread widely at sea, it is likely that the only feasible response option will be to leave them to come ashore, or perhaps deflect them to/from specific areas, and recover them from the shoreline.

However, if pellets remain inside shipping containers and/or their packaging, then response efforts at sea are likely to focus on source control, tracking, tracing and recovering the containers and/or packages. This could initially involve conducting surveillance, preferably by air, to locate and track lost containers and/or packaging, supported by modelling. Where feasible and necessary, operations may be conducted to recover packaging and/or containers, possibly using divers and/or remotely operated vehicles (ROVs).

Xinhua / Alamy Stock Photo

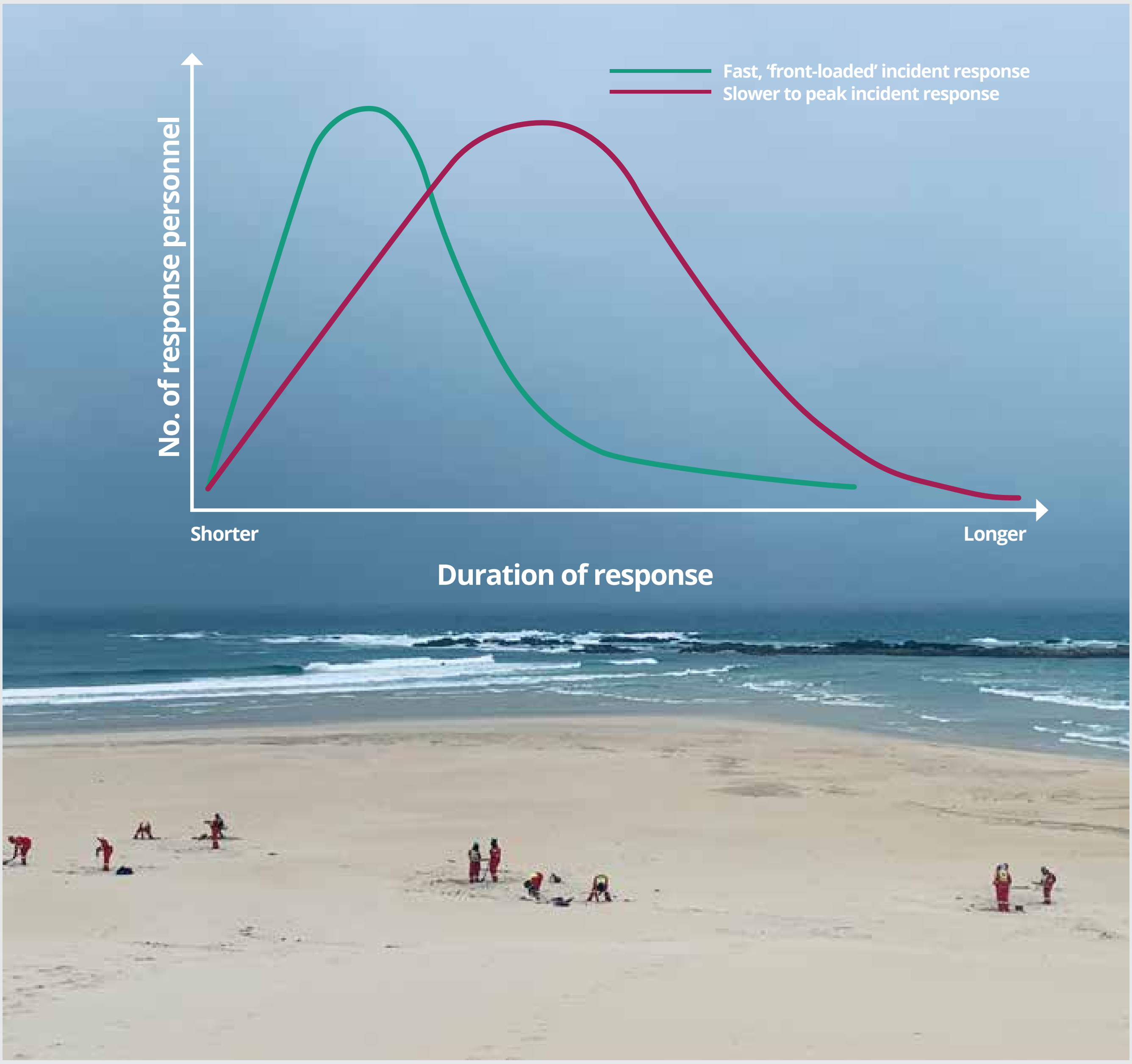
Shoreline response

Once ashore, the highly mobile nature of plastic pellets means it is crucial to rapidly mobilise an appropriate number of personnel to engage in shoreline clean-up operations with the priority of targeting the highest accumulations of pellets. In particular, any stranded intact bags of pellets should be removed from the shoreline as quickly as possible, before they are damaged or degrade and spill their contents.

Experience has shown that shoreline clean-up operations are likely to be labour-intensive, extremely protracted, lasting months and even years until sign-off is achieved.

Ensuring that the peak number of personnel is reached as quickly as possible from the onset of the response, will be crucial to success (Figure 15).

FIGURE 15 Indicative timeline of a plastic pellet response highlighting the importance of rapidly implementing a well organised and correctly scaled response during the early stages of an incident



Stages of a shoreline response

Plastic pellet clean-up operations typically comprise three phases (Figure 16). The first 'emergency phase' may be relatively disordered where the focus is on organising the response structure and mobilising resources quickly to remove the bulk of the pollutant. As soon as surveys establish which shorelines have the greatest level of contamination, these areas should be assigned the highest level of priority in order to minimise recontamination by remobilisation.

As the situation becomes more stable and the response enters the 'project phase', the greater level of control allows for improved forward planning of response operations and for resources to be mobilised with additional consideration. However, as the bulk of the plastics pellets are removed and the level of contamination diminishes, it becomes relatively harder to ensure that recovery operations remain efficient.

Unlike for oil spill response where a third 'final polishing' stage of cleaning operations may be achieved through natural cleaning, for plastic pellets there will be no self-cleaning, just potential remobilisation, so the third phase will involve continued monitoring. During this phase, clean-up endpoints will have been achieved in most areas; however, since pellets can continue to come ashore over extensive areas (possibly for years) a monitoring programme may be desirable to assess any levels of recontamination and the need to resume clean-up activities. Such studies would need to consider the potential for chronic contamination of plastic pellets from other sources not related to the incident.

FIGURE 16 **The successive phases of a plastic pellet shoreline response**

EMERGENCY PHASE

- Initial period of response
- Priority is to remove the bulk of the pellets as quickly as possible and prevent them remobilising
- Focus of source control operations is likely to be on locating containers/ packaging and stabilising the situation
- Although choosing selective techniques should still be considered, the focus is on removing the greatest concentration of pellets
- This phase may last days to weeks

PROJECT PHASE

- Responders have a clearer understanding of the situation
- Significant concentrations of pellets may still be on the shoreline at the start of this phase
- Source control work may be on-going, with continuing recovery of containers/ packaging (if deemed necessary)
- Priority remains for responders to target heavy accumulations
- Higher priority is on being selective in recovering only pellets, rather than large volumes of additional material
- Working towards achieving agreed end-points for each section of shoreline
- This phase may last months to years

MONITORING PHASE

- Most clean-up operations terminated by the start of this phase
- Response efforts largely focused on monitoring for re-strandings and assessing the need for further mitigation measures
- Small, mobile response teams may be on call as contamination is identified
- This phase may last months to years

Shoreline clean-up techniques

Many of the response techniques employed for plastic pellet responses have relied heavily on low technology, manual recovery techniques and adapted off-the-shelf tools and technology designed for oil spill response. Although recent incidents have stimulated some research and development, there is currently no specifically designed piece of equipment for recovering plastic pellets that has been effectively employed during an active response.

Manual recovery methods

Manual recovery techniques have been the principal method employed for shoreline clean-up operations during recent plastic pellet incidents. However, manual techniques are labour intensive and may involve hundreds of people engaged in shoreline cleaning over a wide geographic area for a protracted period.

Manual recovery using shovels and buckets is especially suited to the recovery of bulk pellets and has the advantage of being readily available. These tools, used in conjunction with simple, heavy-duty sieves constructed from robust materials able to withstand salt-water corrosion with appropriately sized meshes, have demonstrated to be very effective as a means of recovery and separation, although this technique is slow and arduous. Double layer sieves comprise two layers of different size mesh, resulting in an extra separation which is ideal for areas with high levels of background debris.

Sieves

Advantages

- Readily available and cheap to make if not available
- No training required
- Easy to maintain or fix if broken
- Highly selective (dependent on mesh size)
- Easy to transport

Considerations

- Efficacy can be reduced on wet sediment
- The level of fabrication needs to withstand stresses of demanding use
- Can easily break if not properly maintained
- Continuous exposure to salt water leads to corrosion, therefore mesh should ideally, as a minimum, be made from galvanised or stainless steel
- Double layered sieves can be heavy to transport
- Large resource requirement for both the equipment and personnel
- Can be physically demanding to use
- Can be a slow process to recover pellets distributed over a wide area

Hand trommels have also shown to be a key technique and are commonly used in the aggregate industry whereby material is fed into the device which is then sorted by size. The perforated cylindrical drum is angled so that when material passes through the screen (which can consist of more than one mesh size with the smallest at the feed end going to the largest), smaller sized materials are retained with large pieces of debris leaving the drum at the far end. With appropriate mesh sizes, hand trommels can be very useful for separating plastic pellets from sand.

Hand trommels

Advantages

- Widely available and cheap to manufacture if not
- Easy to maintain or fix if broken
- Effective on most sediments
- Highly selective (dependent on mesh size)
- Can process large volumes relatively quickly

Considerations

- Efficacy can be reduced on wet sediment
- Some have limited mobility (e.g. trommels without wheels)
- Sometimes heavy and difficult to manoeuvre
- Less favoured than the more mobile hand sieves

Mechanical recovery methods

Mechanical trommels work in the same manner as hand trommels but are motorised to increase the processing speed. These units, which can be fabricated on-site if not available in country, can be scaled-up and mounted on trailers or All-Terrain Vehicles (ATVs).

Vibrating table sieves, or screeners, employ the same method as hand sieves, but have the advantage of being mechanised. This system offers flexibility as it can be designed as a single or multi-stack system depending on the location, pellet size, sediment types and background levels of plastic debris. The system can be scaled-up and fixed on ATVs or trailers to increase mobility and processing speed.

Mechanical trommels/ vibrating tables

Advantages

- Can reduce labour effort of manual methods
- Highly selective (dependant on mesh size)
- Can be mounted on vehicle for ease of transport
- Widely available for industrial purposes or can be fabricated if needed
- Highly effective on dry sediments
- Can be used as a secondary waste separation technique on site or in storage facilities

Considerations

- Requires access for vehicles and suitable terrain
- Requires suitable sediment
- Requires finding suitable manufacturer or supplier in country
- Currently not a globally stockpiled piece of equipment used in pollution response

Vacuum recovery systems (such as those available from hardware stores used to collect leaves) have proven to be relatively effective at recovering high concentrations of plastic pellets. However, these off-the-shelf pieces of equipment need to be modified by adding filters to prevent collection of other large debris. Furthermore, since these units are not designed for use on sandy shorelines or recovering hard objects, the structural integrity of the internal components can quickly deteriorate due to abrasion and/or corrosion from the saline conditions. Industrial vacuum systems (such as those from public utilities or the agriculture sector), and those designed specifically for oil spill response, can be adapted to recover plastic pellets. However, these systems can only be used where there is suitable site access, and as the concentration of pellets diminishes, the ratio of sand to pellets recovered may make the systems ineffective.

Vacuum systems

Advantages

- Good for surface recovery on certain sediments
- Readily available (e.g. public utilities or agriculture), only needs minor adaptations
- Variety of types (backpack, wheeled, truck or trailer) allows flexibility of use
- Backpack systems can be deployed quickly and are highly manoeuvrable
- Very limited training required
- Vacuum trucks provide vacuum, temporary storage and transport in a single system
- Effective at recovering plastic pellets in large concentrations
- More effective when pellets are in high concentrations on hard surfaces (e.g. wet sand or rocky shorelines)

Considerations

- Backpack-mounted vacuums can be laborious to carry for long periods
- Less effective for lower concentrations of pellets; can recover large quantities of sand in dry conditions
- Can easily break if not maintained properly
- Good access required for the deployment of vacuum trucks
- Potential for blockages in areas of high levels of other debris
- Requires energy supply to maintain operations
- Potential for noise pollution to disrupt wildlife in sensitive habitats
- Placing mesh over the nozzle may help reduce collection of larger sized material

Beach cleaning machines (or beach combers) are used to clear debris from amenity beaches and have been widely used following oil spills to remove tar balls from wide, flat beaches where there is dry sand and good access. The equipment can be self-propelled, walk-behind or tractor drawn. Having been designed to recover larger sized debris, they are unable to recover plastic pellets effectively, although manufacturers may be able to make appropriate modifications. Such equipment might be of use in a plastic pellet spill, if large volumes of debris are hampering clean-up efforts, in which case a preliminary beach sweep might be helpful.

Beach cleaners

Advantages

- Readily available
- Less laborious
- Often able to cover larger areas of shoreline in a given time than manual techniques
- Can be applied to recover other macro debris

Considerations

- Typically requires adaptation to be suitable for plastic pellet recovery
- Expensive
- Requires specific training
- Relatively slow on challenging terrain
- Poor selectivity
- Reduced efficiency on beaches with high background levels of debris and large shoreline gradients

Heavy machinery such as bulldozers and excavators can be used to remove plastic pellets from the near surface layer, particularly on sandy beaches. Whilst having the advantage of removing bulk quantities quickly, the technique is not selective and therefore generates high volumes of additional waste. If this technique is employed, it is recommended that it is used in conjunction with a form of separation (ideally on-site), so that the sand material can be returned to the beach. Front end loaders can be combined with manual sorting techniques whereby workers load selectively recovered pellets into the loader bucket.

Mechanical excavators

Advantages

- Can be used to quickly remove bulk quantities of pellets from shoreline to prevent remobilisation
- Able to move large quantities of recovered pellets over a large area
- Combined with manual sorting techniques to accelerate removal of recovered pellets from the shoreline zone

Considerations

- Poor selectivity can lead to generation of large amounts of additional waste
- Requires secondary segregation of waste which may add time and cost to operations
- Not as selective so requires additional training of operator
- Requires careful management of operations to not disrupt the beach profile
- Not suitable for use in sensitive shorelines such as saltmarshes

Flushing and flooding systems, similar to those used in oil spill response, can help recover plastic pellets. Depending on the circumstances, several variations of this techniques are possible, for example, a low-pressure high volume flushing operation could be set up, flooding lances could be used to help mobilise buried pellets, or natural streams could be utilised.

Whichever method is employed, there will need to be some form of containment and recovery (such as booms or mesh traps and manual sieves). Experience has shown that a significant volume of other, light debris can also be mobilised, often overwhelming the containment capacity, therefore requiring careful management with additional segregation of the recovered material.

Flushing and flooding

Advantages

- Potentially applicable to a wide range of shorelines (e.g. sandy, rocky, mangroves, rip rap)
- Equipment is readily available from oil spill responders
- Can utilise natural water supplies
- Highly selective in areas with low background levels of other debris

Considerations

- Requires constant water supply; sometimes difficult in rough sea conditions
- Containment and recovery methods need to be robust
- Requires trained personnel and good planning
- Lower selectivity in areas with high levels of natural and anthropogenic background debris

TABLE 1 Summary table on the suitability of techniques and considerations for recovering plastic pellets by shoreline type

Techniques		Manual		Mechanical					Shoreline considerations
		Sieves	Hand trommel	Mechanical trommels	Vacuum	Beach cleaners	Excavators	Flushing and flooding	
Selectivity		High	High	High	High	Low	Low to moderate	Moderate to high	
Suitability for shoreline type	Rocky shore								• Experience from the TRANS CARRIER incident in Norway highlighted that although there may be large deposits of pellets, sometimes these may be concealed under several layers of stone. • In some instances, crowbars have been used to lift rocks so that the pellets become accessible for vacuuming. • For smaller sized stoney beaches, the stones may need be moved around to expose the pellets, which can create demanding working conditions.
	Sandy beach								• Greatest accumulations of pellets are likely to be found at the high-water mark, although beaches with high energy waves may see deposits above the high-water level. • Accretion and erosion processes mean pellets can quickly become buried, then uncovered and remobilised. • Significant time and resources are likely to be required to systematically excavate sediment to recover buried plastic pellets.
	Gravel beach								• Vacuum cleaners have the tendency to also recover small sized gravel material (2 mm - 6 cm). • Turning the vacuum on and off to allow some of the beach material to fall out of the vacuum and then sieving the collected material may overcome this issue.
	Rip rap								• Rip rap may trap plastic pellets deep into the spaces between the rocks/concrete. • From a sensitivity perspective, a range of clean-up techniques could be applicable. • Access issues may dictate that vacuum and low pressure flushing and flooding are the only viable techniques.
	Tidal flat								• Difficult shoreline to clean up. Important to remove pellets before they are covered by vegetation. • There is relatively little remobilisation if the pellets are covered by vegetation. • If the underlying surface is hard, vacuuming will work and can take place in winter if conditions are dry.
	Marsh								• Pellets coming ashore in these low-energy environments are more susceptible to becoming trapped and less likely to remobilise. • Access issues may dictate available response options, but any response operation should be as minimally invasive as possible to avoid causing habitat damage through trampling.
	Mangrove								• These typically low energy habitats can trap pellets in the intricate root system, which are unlikely to be remobilised except during significant storm events. • Prior to starting any work, consider background level of plastic debris and the risk of damaging the habitat during cleaning operations. • Any operations should be as minimally invasive as possible, and techniques such as low pressure flushing or vacuum systems, conducted from the backshore, are recommended.
Relative cost		$	$	$$$	$	$$	$$$	$$	
Rate of recovery		Slow	Slow	Moderate	Moderate	Moderate	Fast	Moderate	
Range of access		Excellent	Excellent	Good	Good	Good	Limited	Good	

Suitable technique

Potentially suitable technique

Unsuitable technique

Experience from the X-PRESS PEARL incident showed that melting and burning of the plastic pellets (as a result of being exposed to fire onboard the vessel) made the shoreline clean-up operation more complex, since, compared to un-burnt pellets, burnt residues were not only more difficult to identify on the shoreline, but were also more brittle and presented in varying sizes (some pieces were smaller than the original pellet size, but some formed larger amalgamations), requiring recovery methods to be adapted to suit the vast range of sizes.

FIGURE 17 Density separation of recovered plastic debris to minimise the recovery of other organic shoreline debris (e.g. shells, sediment and vegetation)

Secondary pellet separation

Depending on the ratio of plastic pellets to other material collected, a secondary phase of separation may be necessary to avoid generating excessive volumes of waste. This may be particularly beneficial for material collected from sandy beaches in the later stages of clean-up operations when the material collected may contain a large proportion of clean organic beach material.

Several techniques have been utilised for secondary separation and, depending on the density of the plastic pellets and the nature of the material being segregated, a combination of techniques may be appropriate.

Filtering the material by size, using industrial scaled trommels or sand sifters, is a method that depends on there being a significant enough difference between the size of the plastic pellets and the sediment, and is most effective on dry sand.

Another method is to utilise the different densities of the collected materials, essentially allowing the plastic pellets to float on the water surface (see Figure 17). Depending on whether the pellets are contaminated, will influence the possibility of decanting back the sea water used in any density separation processing, or whether the water itself requires further treatment.

Where the plastic pellets have a similar density to much of the organic debris in the mixture, then separation by wind/air can also be an effective technique. This can be achieved either naturally ('winnowing') or using simple ad-hoc systems. Winnowing in-situ is an option if the material is dry, and where conditions allow (Figure 18).

FIGURE 18 Wind separation, or winnowing, of plastic pellets mixed with organic debris

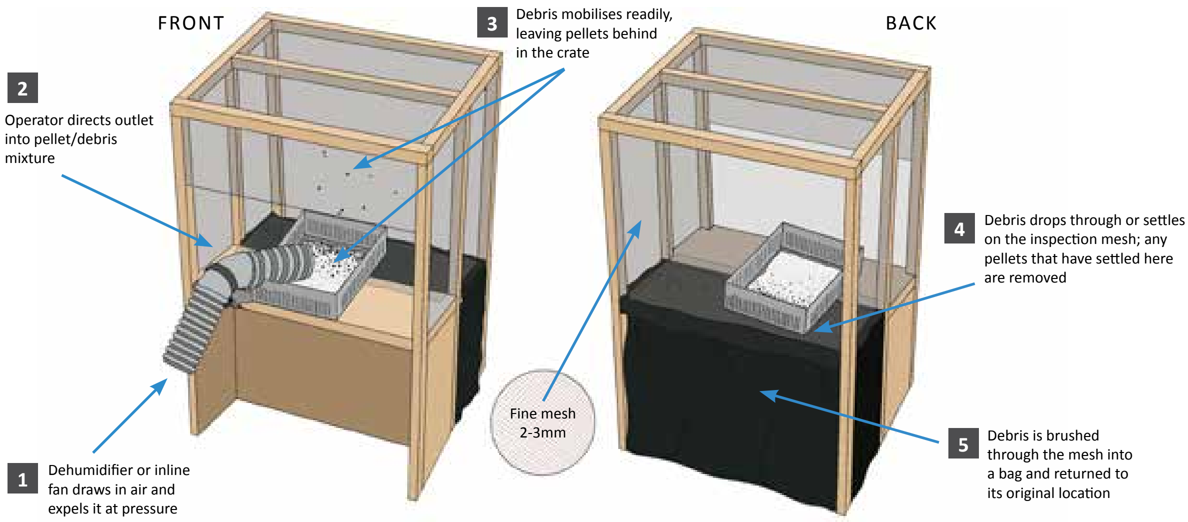
If the mixture has a high moisture content, it can be taken offsite and dried prior to separation by air injection in makeshift devices, as illustrated in Figure 19. This technique requires premises with a large floor space for drying.

Secondary separation should be carried out as close as possible to where the material has been collected. After processing, the segregated organic matter and sediment should be returned to the point of collection.

FIGURE 19 **Ad-hoc systems of pellet separation by air-injection can be particularly effective in reducing the volume of waste generated during plastic pellet spills**

Following initial sieving to remove large debris and sand, the sieved material is left to dry on tarpaulins (approximately 48-72 hours)

Pellet separation by air-injection (prototype design drawings and in use during trials)



The level of pellet separation achieved by the end of processing

End-points for clean-up

Although clean-up end-points relate to the final phase of operations, the chosen end-points will influence the overall strategy and choice of clean-up techniques and provide a benchmark against which progress can be monitored. Establishing end-point criteria for plastic pellet incidents is likely to require significant discussion, notably with the appropriate government agencies, and should therefore be considered from the start of the response. Recovering 100% of the pellets lost is not a realistic or feasible target. The criteria for terminating clean-up efforts are best considered jointly amongst all stakeholders.

Factors to consider when determining end-points include:

- The type and importance of the shoreline affected- is it a highly valued amenity beach, a designated wildlife sanctuary, an industrial area, or a remote stretch of shoreline
- The level of residual contamination
- The operational feasibility of getting equipment on the shoreline
- Potential impacts of shoreline clean-up operations compared to the risk posed by leaving the remaining plastic pellets in-situ
- Local context of plastic debris on the shoreline
- Proximity to industrial facilities as a potential chronic source of plastic pellets

FIGURE 20 Background levels of pollution should be considered when determining appropriate clean-up end-points

Determining end-points suitable for plastic pellet clean-up is extremely incident specific, requiring the consideration of not just environmental issues, but also socio-economic and cultural factors. Comparing the level of residual contamination to background levels of plastic contamination (and the expectation of chronic strandings of pellets) will be key in determining the appropriate level of clean-up work undertaken. The reality is that plastic pellets, and other plastic debris, are ubiquitous in the marine environment and on shorelines.

The agreed end-points therefore need to consider the threat posed by any residual pellets (for example, small volumes of re-stranded pellets) on the environment compared to the threat posed by background levels of plastic debris found on the shoreline (Figure 20). Continuing labour-intensive shoreline cleaning operations to selectively remove small amounts of incident-related plastic pellets, is likely to be unreasonable if the background level of plastic debris is high.

When reaching consensus on appropriate end-points, it may be helpful to use decision making tools commonly employed during oil spill response to guide decisions makers on the selection of the most appropriate responses (such as a Net Environmental Benefit Assessment, Spill Impact Mitigation Assessment, As Low As Reasonably Possible, Lowest Practicable Level of Contamination). The agreed end-points must be clearly defined, and all stakeholders should have the opportunity to visualise what the end-point will physically look like by conducting joint surveys and inspections.

CASE STUDY

End-Points And Long-Term Monitoring

In October 2017, the container vessel MSC SUSANNA lost two containers of polyethylene pellets overboard during severe weather in the Port of Durban, South Africa. Prevailing conditions resulted in plastic pellets spreading along approximately 160 km of coastline. The subsequent clean-up involved 200-300 personnel implementing rudimentary manual collection techniques to recover plastic pellets on a daily basis over the course of three years. Following this period of regular clean-up, the response evolved into a monitoring phase with ad-hoc cleaning being undertaken in response to reports of large accumulations of plastic pellets at specific sites (Figure 21). Cessation of all final clean-up activities was achieved in June 2024, nearly seven years post incident.

As one of the first major releases of plastic pellets, determining 'how clean is clean?' was challenging. Key differences in plastic pellet pollution compared with oil spills, such as mobility, persistence and toxicity, complicated the definition of suitable end-points. For this incident, an interpretative assessment was applied as a suitable end-point, with the concept of the 'law of diminishing returns' used to determine when clean-up had reached a suitable stage, and collections were 'as low as reasonably practicable'. That was, when it was no longer efficient or practical to continue clean-up efforts to recover small quantities of plastic pellets.

For active worksites, a threshold of acceptability was defined by the competent authority in terms of the quantity of plastic pellets collected per worker per day. In this case, it was the equivalent of four plastic bottles collected per person per day. In addition to end-points, a period of monitoring was requested by authorities to ensure possible recharge events were cleared by the responsible party.

FIGURE 21 A monitoring survey carried out six years after the incident at a previously highly contaminated site

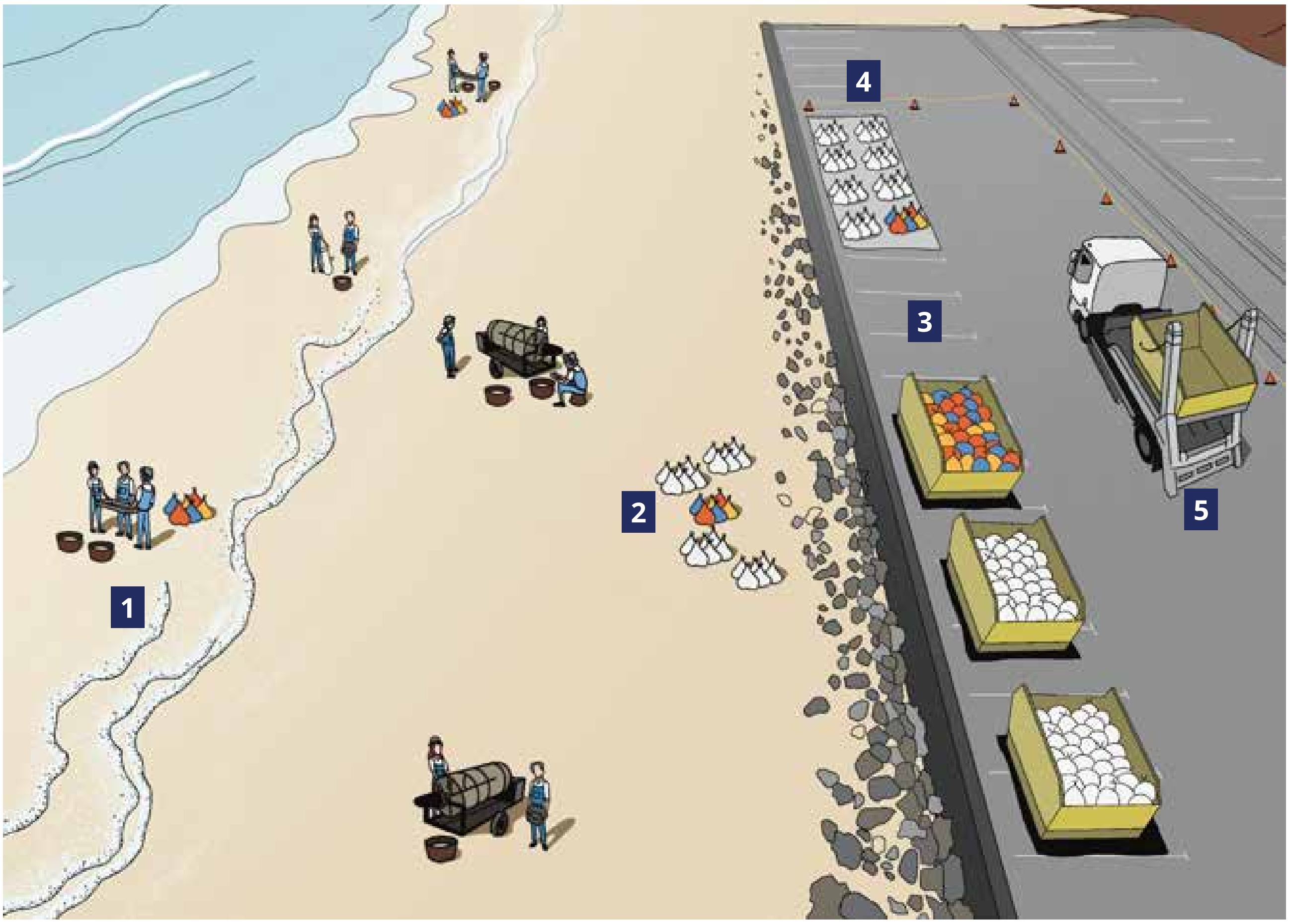
CASE STUDY LEARNING POINTS

Monitoring recovery yields by shoreline clean-up teams is essential in determining if returns are diminishing both spatially and temporarily. This approach is a useful method of determining suitable end-points, but the acceptable limits should be agreed by all parties. Furthermore, recording background levels of plastic contamination is important for potential sign-offs and carrying out a holistic clean-up.

Waste management

The handling of waste from a plastic pellet incident should follow the well-established principles of the waste management hierarchy – reduce, re-use, recycle, recover then dispose[11]. The overall strategy and measures detailed in oil spill contingency plans are likely to be broadly applicable for managing waste from plastic pellets incidents (Figure 22).

FIGURE 22 **Site and waste management considerations during plastic pellet shoreline clean-up operations**



1. Where possible, response techniques which are selective in reducing the amount of excess material recovered should be chosen to help minimise the amount of waste generated.

2. Responders should actively segregate the different waste streams and conduct secondary filtering of the pellets if required.

3. Early consideration needs to be given to where to set up temporary and intermediate storage areas.

4. Responders should have an awareness of the need to prevent secondary contamination during the handling of the plastic pellets through the waste management chain. If bags (or other temporary storage methods) used to store the collected materials are breached, then the plastic pellets can be readily released causing recontamination of areas, or contamination of previously unaffected areas.

5. Authorities will need to assess transport options and adhere to relevant regulatory requirements.

11. See ITOPF TIP 9 Disposal of oil and debris

Waste streams

If appropriate waste recovery separation techniques are implemented, it is likely that the main waste streams generated from plastic pellet responses will be: plastic pellets, pre-existing micro to meso plastics and relatively small quantities of organic matter. Responders can expect to collect a higher proportion of pellets to other debris during the early stages of the response when recovering bulk contamination, as well as during the end phase, when a high level of selectively is possible. The recovery technique(s) chosen, and how efficiently they are implemented, will also influence the ratio of waste streams collected, especially during the project phase (Figure 23).

In the event of a fire, an additional waste stream of burnt 'pyro plastic' may also exist, although small pieces may not necessarily need to be separated from unburnt plastic pellets.

If the loss of plastic pellets coincides with the release of oil and/or HNS, the waste management strategy may need to address not only plastic pellets but multiple waste streams, possibly including hazardous waste. Options for the storage and treatment of contaminated plastic pellets designated as hazardous waste may be limited and further analysis of the pellets may be required to establish available disposal options.

Examining options available and planning for the recovery, re-use or final disposal of plastic pellets is likely to be a time-consuming task and should therefore be a priority issue from the start of the incident.

Waste disposal

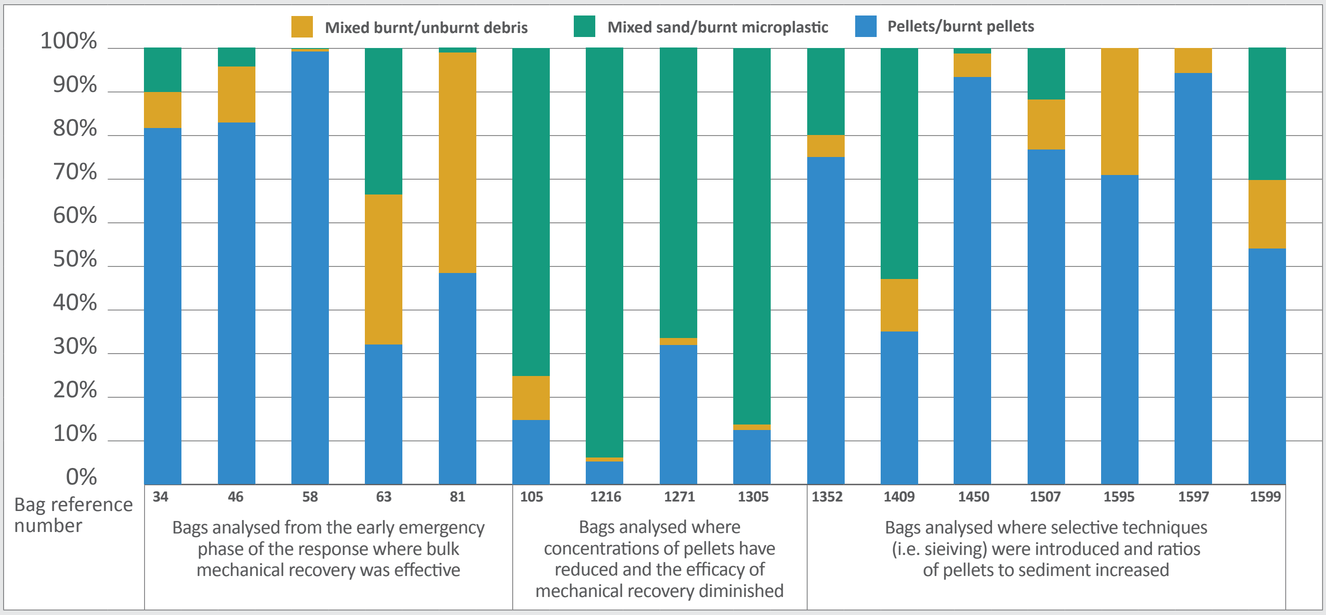
Following the waste hierarchy, where possible, the preferred choice of treatment for recovered plastic pellets should be to reuse and recycle. For example, pellets recovered in past cases have been used to make garden furniture. In some cases, however, given the unknown composition of recovered plastic pellets (i.e. a mix of polymers), reusing and recycling the waste may not be possible.

If reusing or recycling is not possible, usefully utilising plastic pellets to replace other materials to fulfil a particular function is advised. Using recovered waste as an alternative fuel in cement kilns is one example of recovering energy from plastic pellets. Alternatively, pyrolysis – the thermal degradation of plastic waste at different temperatures in the absence of oxygen – is another common method used to recover energy in the form of solid, liquid and gaseous fuels.

Disposal is considered the final resort for waste which could not have been prevented, reused, recycled or recovered. The final disposal of plastic pellets, and other waste streams, could be through landfills or through incineration without energy recovery.

The burning of collected plastic pellets in the open air as a means of waste disposal is not recommended. The smoke produced when plastic is burnt contains harmful gases which can affect human health and air quality. Any burning of plastic pellets for waste treatment should be conducted in licenced incinerators in accordance with local legislation.

FIGURE 23 **Variation in recovered waste mixture during a plastic pellet response, highlighting how recovery techniques can influence the purity (% of plastic pellets) of waste collected**



Collection and storage of waste

One of the key aspects of waste management will be to ensure that, as far as feasible, plastic pellets are separated from other collected material prior to being treated/disposed of. This will require the successful implementation of strategies and techniques aimed at minimising the amount of other material collected during recovery operations and, where necessary, the effective separation of pellets from other materials after collection.

Minimising waste and, where necessary, utilising separation techniques from the outset will reduce the volume of material being handled in the logistics chain, thereby helping to avoid 'bottlenecks' in the response.

Other benefits of reducing the amount of beach material sent for waste treatment/disposal include:

- Maximising the options available for recovery and re-use of the plastic pellets
- Allowing for greater accuracy in recording the overall weight of pellets recovered
- The economic benefit associated with a reduced volume of material needing to be treated as waste

For any collected material which contains large volumes of organic matter, requiring medium to long-term storage within an enclosed space (Figure 24), it is important to consider that microbial breakdown of the organic material could lead to the formation of gases, including hydrogen sulphide. Ideally, well-ventilated spaces should be chosen as storage areas, however, if this is not possible, authorities should undertake regular air monitoring to ensure that potentially harmful gases have not built up.

FIGURE 24 Large quantities of generated waste from X-PRESS PEARL stored in one-tonne bags. A well-ventilated and covered storage site is recommended

Recording waste volumes

Repeated survey results (especially photographs) will provide a record of how contamination levels have changed over time and allow responders to visually track the progress of clean-up operations and assess when end-points have been met for specific segments of shoreline. However, there will still be a need to gather data on the weight of collected pellets and compare this weight to that declared on the manifest (essentially creating a mass balance), since this is the most comprehensive way of measuring progress.

For this metric to be meaningful, efficient collection of pellets (e.g. minimising the amount of other shoreline material collected) and good record keeping are imperative. Labelling the bags used to store the collected waste proved useful during the X-PRESS PEARL incident as an initial and relatively simple means of recording information by location and date on the weight of material collected and recovery yield (Figure 25).

If plastic pellets are recovered mixed with other materials, and in-situ separation is not possible, then further separation once in a designated storage area is important to achieve accurate records of the weight of pellets collected.

FIGURE 25 Labelling of recovered waste enables accurate tracking of recovery yields by area, using information on collection dates, location and yields

CASE STUDY

Waste Management

During the X-PRESS PEARL incident, stranded debris was initially categorised as hazardous waste by the Sri Lankan authorities. This was due to concerns over how the composition of the polymer may have changed because of combustion and potential interaction with dangerous goods onboard. However, subsequent chemical analysis confirmed that, for parameters used to determine material hazardousness, waste collected by clean-up teams fell below the relevant levels of concern and could therefore be handled and disposed of as non-hazardous material.

As soon as possible, mechanisms to track daily pellet recovery yields were implemented (Figure 26). Information on numbers of personnel and recovery yields of plastic pellets, and sometimes other plastic debris, was recorded and sent to a central repository held by the spill managers and/or government authorities. During this incident, an online form was used for data collation, while other cases have involved the manual completion of another database (e.g. spreadsheet).

After collection, all waste was appropriately stored within jumbo bags in a well-ventilated and sheltered waste storage site. In the first two years of the response, around 2,500 jumbo bags of incident-related waste were recovered.

FIGURE 26 Proper segregation and weight reporting is important to track recovery yields and diminishing returns

CASE STUDY LEARNING POINTS

Tracking the daily recovery yields per person over time permitted authorities to accurately monitor the total waste collected and response effectiveness by assessing diminishing returns on a site-by-site basis. Recovery of plastic pellets from predominately sandy shorelines requires the expeditious segregation of plastic pellets from other beach matter to effectively manage generated waste. Response operations also demonstrated that secondary mechanical sorting and separation is best carried out once recovered material is dry.

Preparedness

States who are already party to the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (OPRC 90) will be familiar with the principles and requirements of the Convention on preparedness for oil spill incidents, all of which will be relevant when considering preparedness for a plastic pellet response. Establishing preparedness typically involves developing, testing and reviewing a contingency plan, maintaining a robust tiered response capability and implementing a suitable training and exercise programme.

Contingency planning

When developing a contingency plan for plastic pellet responses, authorities will need to follow the same steps (Figure 27) and consider the same four basic components of a plan as for other types of spill response preparedness: i) a risk assessment, ii) an overall strategy, iii) operational procedures and iv) an information directory containing supporting information and documents. Further information on the process of developing a contingency plan can be found in ITOPF TIP 16 Contingency planning for marine oil spills.

The format of the final output will be dependent on any National Oil Spill Contingency Plan (NOSCP) in place but given the degree of overlap between plastic pellet response and oil spill response, it is suggested that an addendum to an existing NOSCP is likely to be the most appropriate output.

Command structure

The potential for an oil and/or HNS response to be running in parallel with the plastic pellet response, and the applicability of many of the response principles for these pollutants, means certain measures already in place under a NOSCP are likely - at least in the first instance - to be relevant when setting up a command structure to respond to a plastic pellet incident. It would be prudent therefore to plan to use the same, or slightly adapted, organisational and management structure.

Even if there is no oil or HNS response aspect, many of the functional teams usually established for such responses will still be required albeit with a slightly different focus.

FIGURE 27 The principal steps in establishing preparedness for an incident response

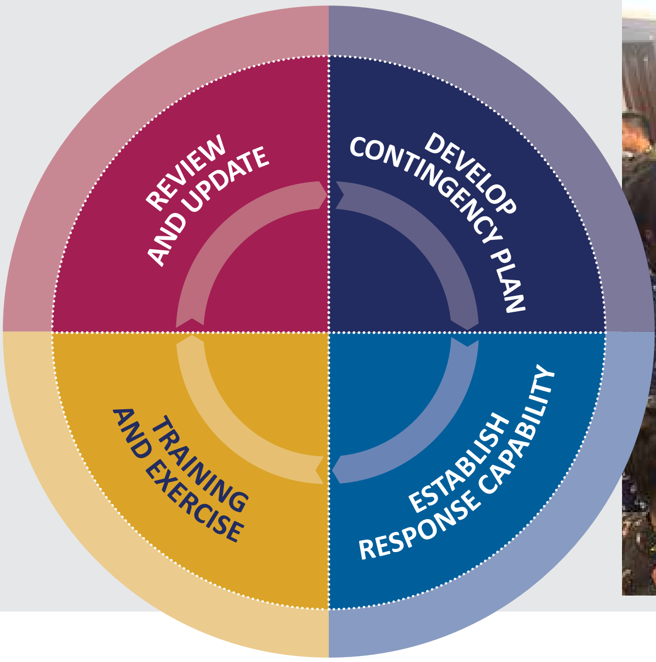


TABLE 2	Considerations for developing a plastic pellet response preparedness
1 STEP ONE - Develop contingency plan	
Notification procedures	The contingency plan should account for the differing ways in which the initial notification of a plastic pellet incident might be received (for example, directly from the vessel or via reports of strandings ashore) and reflect this in the notification procedures.
	Recent incidents have shown that there is often a lack of clarity regarding the government department responsible for leading plastic pellet spills, causing a delay in the initial response. Typically, the national competent authority designated to respond to oil/chemical spills will also be best placed to respond to plastic pellet incidents.
Prioritising resources	Any addendum to a NOSCP should refer to the availability of any existing sensitivity maps, databases and/or GIS and consider how these resources may be used during a multifaceted response. Compared to the typical priorities for oil spill response, the ecological and economic sensitivities will differ for a plastic pellet spill.
	Priorities for plastic pellet spills may be weighted towards bulk recovery from areas with the highest levels of contamination, even if they are of relatively lower environmental sensitivity, to reduce the chance of pellets remobilising. In sensitive areas, such as bird nesting sites, operations to recover small quantities of pellets may cause greater impact/disturbance than benefit.
Impact assessment studies	National authorities should develop a plan for assessing environmental impacts following a plastic pellet spill which could be based and adapted on the assessments already done for other pollutants.
2 STEP TWO - Establish response capability	
Volunteers and public involvement	Typically, the inert nature of plastic pellets makes involving volunteers in front line operations (as opposed to support functions) more straightforward compared to other pollutants. Volunteers could theoretically assist with operations to recover plastic pellets from the shoreline, conduct pre-emptive beach cleans, or help in the effort to report and record the locations where plastic pellets are coming ashore.
Managing data	Utilising information from the public on the location of plastic pellet strandings can be advantageous considering the potentially wide geographic area that may be affected. However, significant planning is required if this data is to be managed effectively for timely use by decision makers and responders. Consideration should be given to platform suitability for hosting information (a dedicated website, social media, publicly available centralised database/GIS), the level of data interrogation available to the public, and guidance for the public on how to gather the required information.
3 STEP THREE - Training and exercise	
Conducting training and exercise events	Plastic pellet incidents typically involve a sizeable deployment of personnel for shoreline clean-up operations, from various backgrounds and with differing knowledge bases. It is recommended that all personnel, who are not considered to be suitably trained, undergo basic induction training covering response strategies and tactics, operation of equipment, health and safety, and record keeping requirements. Such a training package would ideally be prepared during the contingency planning stage and be quickly adapted at the start of an incident to include specific information.
	The infrequency with which plastic pellet incidents occur means the effective transfer of knowledge between national authorities, and other relevant parties, and experience gained from conducting training and exercises becomes even more important compared to oil spill training.
4 STEP FOUR - Review and update	
Reviewing the plan	As with any contingency plan, it should be reviewed on a regular basis to ensure that it remains relevant. Responding to major losses of plastic pellets from shipping incidents is a relatively new field, and therefore, plans should be updated to reflect new knowledge and experience gained in this area.

CASE STUDY

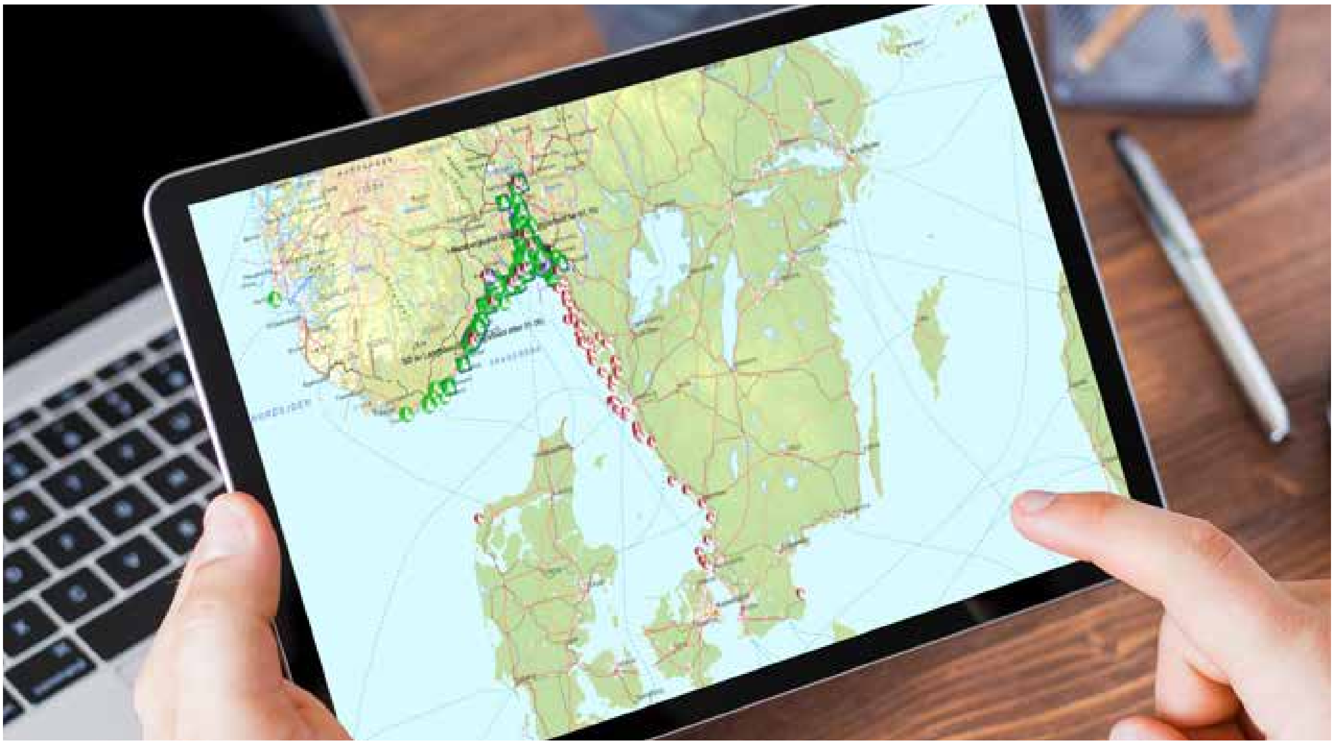
Public Involvement

During the TRANS CARRIER incident, a simple yet highly effective web-based mapping system was established by the Norwegian Coastal Administration (NCA) to map shoreline pellet pollution, assign clean-up resources and track clean-up progress (Figure 28). This live GIS acted as a common operating picture for the authorities, the public and commercial entities, allowing all stakeholders to work together to respond to the pollution. Crucially, members of the public, in both Norway and Sweden, were able to use their mobile phones to access the web-based map, report plastic pellet contamination and upload relevant photos. The authorities then validated the sightings, assigned resources (if clean-up was feasible and safe), and monitored clean-up progress geographically and temporally.

Mapping the contamination in this way also allowed microplastic accumulation zones, caused by localised hydrodynamics, to be identified.

This system permitted swift information gathering over wide stretches of coastline, and it was effectively used by the authorities during response decision making. The system was rapidly created and distributed on social media and was adopted internationally to combat a transboundary pollution incident. It provides an excellent example of how public involvement can be utilised effectively during a response to facilitate intergovernmental and inter-organisational alignment and collaboration.

FIGURE 28 Norwegian Coastal Administration's incident reporting system, recording public and governmental pellet observations, inspection progress and clean-up sites. Map taken from: www.beredskap.kystverket.no/plastpublic/transcarrier



CASE STUDY LEARNING POINT

Coordinating public contamination reports via the use of mobile GIS software proved to be an effective way of utilising volunteers and local knowledge. Efficient incorporation of this knowledge helped clean-up teams identify plastic accumulation sites, improving the efficiency of subsequent operations.

Cost recovery

Liability and compensation for responses to plastic pellet incidents is an immature area compared to similar arrangements for oil and HNS spills. The loss of plastic pellets may occur in the waters of the coastal State in which the damage has occurred, or the pellets might be lost from a ship on the high seas. Ultimately, the liability and compensation will depend upon the national and international regulations in force in the coastal State (country) in whose waters the damage or loss has occurred.

Liability

Although there is no specific liability and compensation arrangement for plastic pollution following shipping incidents, the Nairobi International Convention on the Removal of Wrecks (2007) (WRC), which entered force in 2015, provides an international framework for wreck removal and may be applicable to incidents involving lost containers of plastic pellets. In countries that have not ratified or acceded to the WRC, the requirements for clean-up and compensation will be subject to domestic law of the coastal State impacted by plastic pellet pollution or, where applicable and in force, the Convention on Limitation of Liability for Maritime Claims (1976) (LLMC).

The WRC gives signatory States the legal basis to remove, or have removed, wrecks that may have the potential to adversely affect the safety of lives, goods and property at sea, as well as the marine environment. The Convention's broad definition of 'wreck' effectively means that objects (such as containers and their cargo) lost overboard following a maritime casualty are themselves considered as wrecks even when the ship itself has not become a wreck. The Convention makes the registered owner of a ship liable for locating, marking and removing a wreck deemed to be a hazard in a State's Convention area. Under the Convention a 'hazard' includes threats that 'may reasonably be expected to result in major harmful consequences to the marine environment, or damage to the coastline or related interests' (such as ports, fisheries, tourism, health of the coastal population) in one or more States.

Under the WRC, all ocean-going vessels (over 100 gross tons) are obliged to obtain insurance to cover any harm they accidentally cause to people, property and the environment. This insurance, provided typically by a Protection & Indemnity (P&I) Club, covers a wide range of third-party liabilities, including wreck removal, cargo loss and damage, pollution by oil and other hazardous substances, and damage to property. In addition to providing insurance, the insurer will, on behalf of the shipowner, handle covered claims submitted. Whether under international compensation regimes or under domestic legislation, claims for compensation will be channelled to the insurer. Given the central role the insurer is likely to play in the cost recovery process following a plastic pellet incident, early engagement between the insurer and those parties likely to submit claims is recommended.

Claims for compensation

In addition to possible environmental impacts and removal or clean-up costs to mitigate this, plastic pellet incidents have the potential to also impact socio-economic activities. Incidents may cause business interruption to commercial entities, such as ports, due to on-going clean-up operations. Amenity beaches heavily contaminated with pellets may need to be closed during clean-up operations, and the presence of high levels of plastic pellets may cause disruption to fisheries, aquaculture or sea salt production activities.

Claims resulting from recent plastic pellet incidents have demonstrated that four categories of claims can be expected (see Table 3).

Much guidance already exists[12] on the process of preparing and submitting claims from oil spill incidents, the principles remain relevant to plastic pellet incidents. In cases where incidents result in claims not only for costs associated with responding to plastic pellets but also for costs associated with responding to oil pollution, the guidance is especially relevant.

12. ITOPF TIP 15 on the preparation and submission of claims from oil pollution provides useful guidance on information to be recorded and evidence to support claims

TABLE 3	Categories of possible claims for plastic pellet incidents	
Channel of liability	**Category of claim**	**Examples of costs/losses**
Wreck Removal Convention (if affected coastal State has acceded to the WRC) or, if not, the domestic law of affected coastal State	 Clean-up and preventative measures	• Costs associated with efforts to locate, track and remove containers and their packaging/ pellets • Costs in relation to assets deployed during clean-up operations to remove the plastic pellets • Waste management costs • Compensation may also be payable for reasonable costs associated with the capture and any rehabilitation of wildlife, collection of carcasses and scientific studies to determine impacts/cause of mortality
Domestic law of affected coastal State	 Economic losses	• Consequential economic loss (for example, due to port closures during clean-up work) • Pure economic loss (for example, loss of earnings associated with a reduction in tourism activities due to reduced visitor numbers)
	 Property damage	• Costs associated with damage caused due to clean-up activities • The cost of cleaning/replacing mariculture structures contaminated with pellets • The cost of cleaning/repairing water intakes of desalination plants/aquaculture facilities blocked or infiltrated with plastic pellets
	 Environmental impact studies and monitoring	• The cost of plastic pellet characterisation and/or identification studies • Costs in relation to longer-term environmental monitoring studies

Key Points

- It may take a significant amount of time for national authorities to confirm that containers of plastic pellets have been lost following a shipping incident and to then gain an understanding of the properties of the plastic pellets involved.

- Once released into the marine environment, plastic pellets are highly mobile and subject to the influences of prevailing meteorological and oceanographic conditions with the potential to spread considerable distances from their point of release.

- An early priority should be to locate the source(s) of release of the plastic pellets and, if possible, prevent further releases.

- The extent and speed with which loose pellets start to spread will largely dictate response options at-sea.

- When ashore, the actions of coastal processes can result in pellets being re-mobilised and becoming buried resulting in changing patterns and levels of shoreline contamination.

- The prompt deployment of a substantial number of personnel for targeted shoreline clean-up operations, to recover the bulk of the plastic pellets as quickly as possible, will be key to avoiding a protracted response.

- An early decision on whether the plastic pellets will be deemed a hazardous material will help facilitate a well organised response and waste management strategy.

- Separation techniques which minimise the amount of other beach material sent for treatment or disposal are the preferred response technique.

- Tracking the weight of recovered plastic pellets is the most effective method of monitoring the overall progress of shoreline clean-up activities and places emphasis on the importance of accurate record keeping and selective segregation strategy.

- The anticipated environmental impacts relating to a plastic pellet spill from a shipping incident are not well understood, and so national authorities may need to commission impact assessment studies to answer specific concerns about local sensitivities.

- National authorities should consider how contingency planning requirements for plastic pellet incidents might build upon existing national contingency plans for oil spills and plan for scenarios involving simultaneous responses to multiple pollution types.

- Due to plastic pellets not being classed as dangerous goods under the IMDG code, liability and cost recovery for such responses is a subject area that is less established compared to arrangments for oil/HNS compensation.

Response to plastic pellet incidents

PROMOTING EFFECTIVE
SPILL RESPONSE

ITOPF LIMITED
DASHWOOD HOUSE, 69 OLD BROAD STREET,
LONDON, EC2M 1QS
Tel +44 (0)20 7566 6999 **E-Mail** central@itopf.org

ITOPF LIMITED (SINGAPORE)
LEVEL 17, THE EXECUTIVE CENTRE, FRASERS TOWER,
182 CECIL STREET, SINGAPORE 069547
Tel +65 6978 2100 **E-Mail** central@itopf.org

itopf.org