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Managing Port and Shipping Waste

Challenges and Best Practices

Research note

This research paper was prepared by Thomas Bell of the PEMSEA Resource Facility for the Incheon Port Authority (IPA), as part of PEMSEA-IPA ongoing collaboration around the topics of knowledge sharing, environmental management, conservation, monitoring and managing marine resources, and sustainable development for the seas of East Asia.

Along with listed references, information in this document comes from direct experience in executing PEMSEA projects and discussions with PEMSEA partners and cooperating organizations throughout the East Asian Seas region.

Selected Glossary

Biodegradable Waste – See *Organic Waste*

Blackwater – Liquid waste discharged from ships including human sewage.

Greywater – Liquid waste discharged from ships consisting of dirty water from washing and cleaning.

International shipping / International voyage – Shipping routes which move between ports in two distinct states

Oily wastes – Liquid waste originating from ship operation, such as lubricants, residues, fuel sludge, liquid leaks, and similar.

Operational waste – Waste produced by the activity of a ship, such a lubricants, oily residues, and exhaust.

Organic Waste - Waste which can decompose through organic processes or processes imitating organic processes.

Port Authority – The body responsible for the overall operation of a port, although some aspects of port management may be subcontracted to other bodies

Port Reception Facility – A dedicated physical location at a port at which waste is deposited. Usually onshore, but occasionally floating platforms are used.

Solid Waste – Non-liquid garbage created on ships from both ship operations and from human activity. Can include organic waste.

Selected Acronyms

CSR – Certificate of Service Rendered, usually issued by ports to acknowledge waste has been delivered.

EAS – East Asia Seas, usually referring to the region including the countries surrounding these shared seas.

MARPOL – International Convention for the Prevention of Pollution from Ships, sometimes rendered as MARPOL73/78.

PPP – Public-Private Partnership, bringing together public and private capital into joint ventures.

PRF – Port Reception Facility, the area of the port designated to receive some or all types of waste.

WOBVIF – Waste on Board Vessel Information Form, used in the Philippines by ships to notify ports of incoming waste.

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EXECUTIVE SUMMARY

This paper seeks to provide a review of the development of port sustainability in concept and in practice, with a specific focus on waste management systems within ports. The handling and treatment of ship waste discharge has evolved over time, as shipping has changed and as the understanding of the human impact on the environment has increased.

The general trend among international regulations surrounding waste is to shift it away from disposal at sea and towards disposal on land. There is also a trend towards increasing the efficiency and potentially recyclability of waste, meaning actions such as waste segregation are becoming increasingly important.

Such trends mean greater need at ports for efficient and effective waste management systems, which must receive increasing levels of waste from ships, even as the global shipping industry continues to expand. Waste management has become a key role of ports, with such waste needing to be removed from ships through port just like goods and passengers.

Efficient waste management provides a good service for ports with positive economic, environmental, and reputational benefits. Those with the best capacity to deal with a particular ship's waste is more likely to see that ship call there. Ports which can rapidly shift waste will have quicker ship turnaround, decreasing wasted ship time and increasing port throughput.

At the same time, as waste management may prove an economic burden, imposing sanitary and safety concerns as well as more direct disposal costs, for both ports and shipping, it needs to take place within a robust regulatory and monitoring framework. Ports and ships working to meet established standards are at a disadvantage if others are avoiding compliance. As a result, improved sustainability is best

achieved through broader engagement in developing regulations and monitoring and enforcement mechanisms through transparent stakeholder consultation including port authorities, shipping representatives, local communities living near the ports, and local and national authorities.

Around the world, there are many innovative practices to improve waste operations. Increased digitization allows for earlier notification of incoming waste, better monitoring of waste flows, and easier sharing and analysis of data. Improved segregation on both ships and in ports allows for waste to be more efficiently, and more effectively, treated. Some waste may even undergo minimal treatment while on ships. New waste fee structures accommodating such changes and other considerations are needed to create appropriate incentive structures.

As with regulations, innovations can benefit from enhanced cooperation among stakeholders. Ports can engage with governments and the private sector to prompt attention to shipping-related innovation. Mixed funding schemes, such as public-private partnerships, provide more opportunities for ports to improve and futureproof their activities.

As understanding and research and innovative technologies around waste management continue to increase, national and international expectations are likely to change with changing knowledge. At the same time, shipping volumes will likely keep rising as the global economy expands.

As a hub of the global shipping network, the fate of the seas of East Asia is intertwined with the sustainability of global shipping. While this will be a challenge, it also provides an opportunity, for the ports around these seas to become global leaders in port sustainability innovation.

THE WASTE MANAGEMENT CHALLENGE

(Danny Cornelissen / portpictures.nl)

Handling waste is one of the perennial challenges of human societies. That problem has become an acute global issue in the modern era, a product of increasing population, growing prosperity, growing urbanization, and changing lifestyles. Waste increases not only at an absolute level, but at a per capita level in increasingly concentrated areas. This increasing waste has social and environmental consequences, including transboundary ones as waste moves across international borders.

Harms from waste include marine plastic pollution, clogging infrastructure, disposal harm such as burning and exposure to contaminants, ecosystem harm, damage to economic activities such as

aquaculture and tourism. Waste management is also strongly impacted by economic inequality.

Unsafe sewage disposal *(Sustainable Sanitation Alliance)*

Waste production and management is a complex process which involves a broad spectrum of society, reflecting the choices and circumstances of individuals, companies, and governments. Waste management expectations and needs can also shift rapidly as society shifts, in ways that are difficult for any entity within the waste network to adapt to at an effective rate. Waste management increases in complexity, absolute cost, and land requirements.

Effective management is also highly variable on a multitude of local contexts. Local diversity in terms of socio-cultural beliefs and practices, capacity, resources, political leadership, priority needs, and other

considerations complicate technology and capacity transfer both between and within jurisdictions. Cultural differences can make as much of an impact as commercial and practical ones. In the ASEAN region, waste management is often viewed as a public good and therefore the responsibility of government, be it at the national or local level. As such, there has not been much incentive from the private sector nor individuals to pay for waste management services.

Managing waste in the present also often faces the difficult initial hurdle of having to re-manage waste that was not properly managed in the past, on top of improving systems for existing waste. These up-front commitments and the difficulty of scaling waste management processes across jurisdictions lead waste management to be expensive, as does the need to further iterate and adapt waste management processes as circumstances change.

Waste management is also unappealing as a topic, and is traditionally unlikely to be considered a political priority. There are times when this changes, and over the past few years, there has been increasing interest in effective waste management. Globally, waste collection in low-income countries improved from 2012-2018, increasing from 22% to 39% at the same time as the proportion of organic waste dropped from 64% to 56%, while waste-to-energy in upper-middle-income countries increased from 0.1% to 10% driven by China, and globally recycling and composting increased (Kaza et al., 2018).

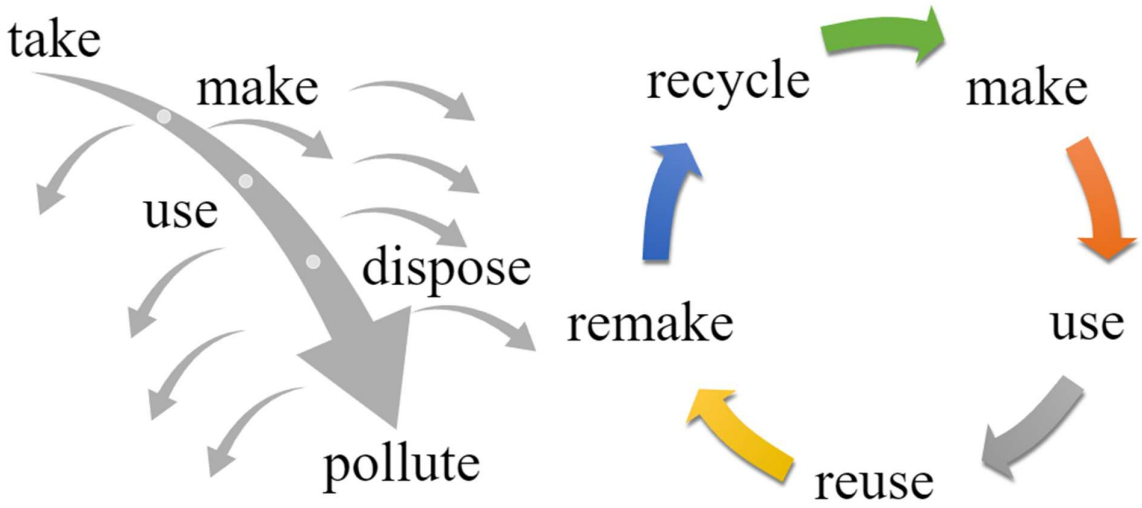
Worldwide, 2.01 billion tonnes of municipal solid waste are generated each year as of 2018, with at least 33% unmanaged or ill-managed (Kaza et al., 2018). When waste is disposed of inadequately, this worsens pollution (Tseng & Ng, 2020).

Waste levels increase faster for each increase in income for those at lower initial income levels (Kaza et al., 2018). Increasing urbanization also increases waste generated per capita. This means a lot of waste growth is expected to emerge in developing countries in East Asia, as both populations and prosperity continue to increase, and populations tend to concentrate in urban areas.

Waste flowing into the sea at Komodo, Indonesia (Thomas Bell/ PEMSEA)

Waste management is an ongoing cost, which may require further capital investment. Waste solutions need to be locally applicable, with considerations for waste management systems heavily affected by issues such as demography, geography, economic activity, consumption patterns. Waste management is also usually handled locally, with most national involvement related to setting overall regulations and potentially funding (Kaza et al., 2018).

Waste is considered part of the wider issue of sustainability. Sustainability has grown in importance in discussions of development, with an ultimate aim of ensuring any improvements are of long-term benefit and managed in a way that ameliorates as many potential issues as possible. It often includes not only environmental considerations, but socioeconomic ones as well. For waste, this is most clearly expressed in the desire to shift from a 'linear economy' to a 'circular economy'. Under a pure circular economy, material would not exit the economic system as waste, but instead be reused in some fashion.



(Cathrine Weetman 2016 / Wikimedia Commons)

Shifting to a life-cycle approach is challenged by a non-holistic waste management regime, with separate types of waste often being regulated in different ways by different bodies. This brings issues regarding coordination, as well as unintended incentives and diffuse responsibilities that lead to waste being shifted rather than efficiently dealt with (Argüello, 2020).

WASTE IN THE MARINE ENVIRONMENT

Waste being removed from a ship in Batangas, Philippines (PEMSEA)

Sources

While there is a lot of pollution in the maritime environment, much of this is not from waste originating at sea. Most maritime pollution instead originates from land, moving into the ocean through processes ranging from deliberate dumping to incidental leakage. This leaage can be regular and continuous processes, as well as occur due to one-off extreme weather events.

Nonetheless, sea-based sources are thought to produce around 20% of the waste that ends up in the ocean. A big component of this ocean-originating waste comes from the maritime shipping industry. Global

shipping capacity has steadily expanded over the past few decades, and is expected to continue growing as the global economy expands. It plays a key role in the global economy, with more ships in use each year for goods transport, fishing, and recreation. Ships carry over 90% of the world's food and commercial goods (Dabrowska et al., 2021).

The environmental impact of shipping has been recognized for a long time, but increasing attention is being paid to it as pollution—and the awareness of pollution—increases. This awareness is growing not only among civil society, but among governments and the shipping industry, as concerns about climate change and long-term sustainability become more prominent.

Waste is often dumped by ships at sea, either to avoid costs, or because port facilities are inadequate to collect the waste produced on the ship. Such dumping can be accidental or deliberate.

One source of shipping pollution is operational waste, caused by the regular running of the ships. Historically, a big cause of very visible pollution has been oil discharges. Operational oil discharges may fall afoul of international rules and regulations, but regularly occur nonetheless. Such disposal can be caused by there being no adequate or nearby facilities, or to save money. Other waste sources include bilge water, other oil product leftovers, and exhaust cleaning residues.

Many ships also generate waste through cargo residue, handling leftovers, damaged items, packaging, and various paper and plastic waste. With air pollution becoming a more recognized issue, actions taken to prevent such pollution produces other kinds of waste, such as equipment containing ozone depleting substances and sulfur oxide scrubbers that clean exhaust gas before it enters the environment.

Much operational ship waste comes with particular challenges regarding management due to its potentially hazardous nature.

A second cause of waste from ships is human activity. Human produced sewage from ships contributes to marine pollution, although less than land-based sewage. This and other similarly contaminated water is known as "Blackwater". "Greywater" is water from sinks, showers, baths, washing water. Some solid waste, including paper, macroplastic, and microplastics, is also produced from on-board human activity.

Sewage outflow pipe leading directly to the ocean (John Collins / geograph.org.uk)

An estimated 636,000 tonnes of waste enters the ocean from ships, although the expected amount differs depending on the type of ship, with cruise ships producing the most (Dabrowska et al., 2021). Mixed waste streams make taking specific action on any particular type or source of waste potentially tricky. For example, organic food waste from

ships is often contaminated with inorganic materials, such as plastic from packaging (Vaneeckhaute & Fazli, 2020).

Fate and impact of waste at sea

Historically, the ocean was seen as a place where waste could be put out of sight and thus out of mind, a vast endless repository that could absorb an infinite amount of waste. However, these attitudes are changing. It is now understood that humans have a very significant impact on the ocean, which may not be able to simply recover from waste entering it.

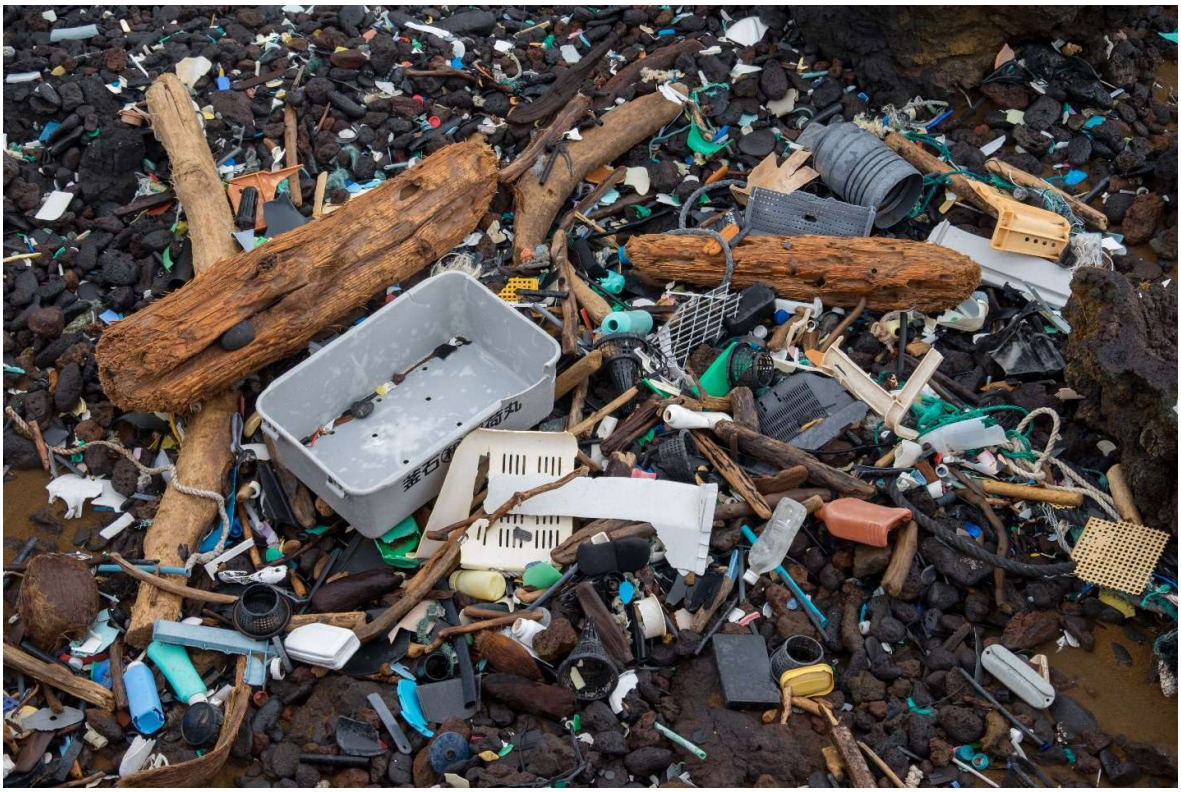
Due to the interconnectedness of the oceans, waste disposed of in one part of the ocean can end up elsewhere in the global ocean. This makes marine pollution an international and transboundary issue. Historic marine pollution can reach otherwise almost pristine environments, as well as linger in the environment for a long time after they entered the ocean. Substances which have been previously banned can be found even now (Dabrowska et al., 2021), and waste that is dumped today will continue to trouble the future.

Garbage on shores comes from the land, from fishermen, or from waste coming from rivers and nearby seas. In a small number of areas there are concentrations of waste from passing ships where disposal is seen as more convenient than disposal in ports. Other times, waste may collect along the shore due to the movement of water currents, even if that shore is far from the waste's origin point.

Waste litter along the shore of an isolated cove (Thomas Bell / PEMSEA)

Waste often settles within the ocean, either on the ocean floor, floating near the surface, or anywhere in the water column in between. The largest zone of oceanic plastic waste accumulation is the Great Pacific Garbage Patch (GPGP). This 1.6million km^2 area includes potentially over 100 thousand tonnes of plastic, of which 46% is fishing nets and 75% comes from pieces larger than 5cm (Dabrowska et al., 2021).

The smaller pieces, known as microplastics, create additional issues, especially regarding potential entry into the food web. Research on these different types of plastic impact is a growing field. Meanwhile, under the current course of action it is expected that plastic weight in the ocean may overtake fish weight by 2050 (Dabrowska et al., 2021).



(Justin Dolske / Flickr)

Oceanic pollution has many impacts. Environmental impacts include damage to marine wildlife, which can be affected by both solid and liquid waste. Perhaps a million seabirds are thought to die each year from plastic pollution alone, and numerous examples of other species dying from plastic entanglement or ingestion are known. Waste can pollute the seabed, harming benthic ecosystems. It can also deoxygenate water, with oxygen levels though to have decreased by an average of 2% since the mid-20th century, corresponding with a significant increase in the number of deoxygenated hotspots.

There are many types of hazardous waste, from explosives to carcinogens. Chemicals have impacts on wildlife and thus onto human health, being found in water supplies and the food chain. Waste can also have direct impacts on human health, especially on coastal

communities. This human impact extends also into economic damage, as pollution harms livelihoods and living standards.

Ports face particular challenges in providing a location where waste leakage and discharge will be uniquely concentrated, threatening both its water quality and the soil and groundwater quality of nearby areas. Such activity can have social, economic, and health impacts on nearby human communities in addition to their broader environmental impacts (Alamoush et al., 2021).

A lot of information remains unknown, with more research needed on waste magnitude, temporal and spatial variability, interactions with the environment, the path it takes from its source, and its ultimate fate (Dabrowska et al., 2021). Waste lost at sea can wash back to shore, but it more likely will remain in the ocean forever. Regional variation also means some areas will serve as concentrated waste sinks, serving as the end point for waste from around the world.

THE SHIPPING INDUSTRY AND MARINE WASTE

(Port Authority of Thailand)

The role of ports and ships

The maritime shipping industry is a huge business, carrying the great majority of global trade volumes. Over 4 million port calls are made by ships of 100 gross tons each year. This economic network is supported by ports, which have huge direct and indirect roles in the global economy. Ports link oceans to hinterlands, with the impact of shipping extending across both land and sea (Alamoush et al., 2021). It is likely that maritime shipping will continue to expand into the future, and therefore the impact and management of its externalities must be carefully considered in planning for that future.

Ports form linkages connecting a country to global trade, and are key in servicing the local and regional economy. They have multiple uses, leading to complex management needs. Port operations are unique, varying by use cases, size, geography, regulations, and more. Their development is affected by, and affects, the development of nearby areas. This puts them at the center of discussions and debates on international waste management, interlinking them with international conventions and regulations as much as they are linked to national and local ones.

Port operations have impacts beyond the boundary of the port area. Their operations in some areas, including waste management, may be intrinsically linked with the operations in the same sector of their local government. Ports may have their own system, or may work within another system, for example contracting the same waste operators as their nearest city. At the same time, actions of ports can thus cause change throughout wider supply networks, giving them significant influence in other areas of the economy.

Ports serve as waste waypoints, taking waste from shipping and moving it into established hinterland systems. Occasionally, they also serve to shift waste between hinterland waste systems. This can be especially the case when ports serve smaller areas, which do not have the benefits of scale for waste management that larger areas would have (Lin et al., 2018). Hinterland distances vary, for example waste from Seoul can travel up to 64km to reach final disposal sites (Kaza et al., 2018).

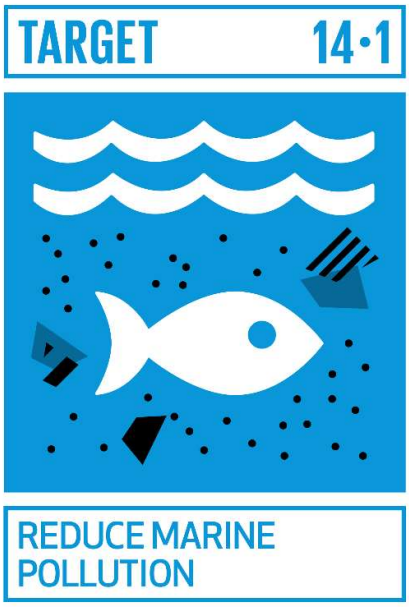
Ports can be directly linked into waste networks, with ships used to transport waste (Gary Miller / NARA)

Shipping produces waste during regular operations as well as during accidental events. 80% of pollution originating from ships is from operational oil discharges (Mazzoccoli et al., 2020), which are not always in line with international law. Other pollution comes from exhaust, leading to many regulations to 'scrub' pollutants such as sulfur oxides from this exhaust as it leaves the ship. Different types of ships also produce different amounts of waste. For example, cruise ships, produce an outsize amount of waste compared to other forms of shipping (Sanches et al., 2020).

The safe management of ship-sourced waste is dependent on ports having adequate reception facilities, and in some ways in how these facilities are integrated or related to wider waste management networks (Argüello, 2020). Waste is also produced as part of port operations.

Ports can combine ship-origin waste with waste originating from the port area (Sanches et al., 2020).

Historically, many port authorities were not involved in waste management. Direct contacts were made between ship companies and private waste management companies. This means there was often no oversight, regulation, or monitoring, and little information available on different models and best practices. This also meant that there could be little understanding of compliance, leading to significant incentives towards illegal dumping.



Over time, the role ports play in waste management has come under scrutiny. A growing idea is that of the "triple bottom line", where ports should consider social and environmental goals as well as economic ones, as part of a wider shift towards sustainability (D'Amico et al., 2021). Effective waste management has become integrated into international sustainability thought. For example, UN Sustainable Development Goal (SDG) 14 includes "By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution". Achieving this will require innovation from ports to be achieved.

However, much work remains in understanding both the factors behind port sustainability and how to improve sustainability across ports with wildly varying roles and contexts (Alamoush et al., 2021).

Waste is part of a wider environmental program for ports, although air quality and climate change emissions often take higher priority. Nonetheless, waste is the most monitored of environmental issues (Puig et al., 2022). Where waste facilities are inadequate, local pollution in the port area increases (Tseng & Ng, 2020).

Ports often exist in urban areas, which are more likely to have established and effective solid waste management systems. This potentially also means ports can increase the burden on nearby waste management systems, serving as effective importers of waste alongside other items they import (Sanches et al., 2020).

Collecting solid waste from a ship (Hervé Cozanet / Marine-marchande.net)

The way ports are embedded into local, regional, and international networks and systems means there are many stakeholders involved in

port management, including port authorities, municipal authorities, shipping companies, logistics companies, financial companies, terminal workers and unions, container operators, technology companies, civil society groups, and more (D'Amico et al., 2021).

Differences in priority also affect port sustainability options (Du et al., 2019). Small and medium ports often place a higher priority on waste management, likely due to missing simple economies of scale that large and very large ports have (Puig et al., 2022). While there may be universal tools, goals, and enabling factors that apply to improving the sustainability of all ports and port cities, each individual urban and industrial use case will be different (D'Amico et al., 2021).

Almost all ports in Europe have a dedicated Environmental or Sustainability manager with specific and documented responsibilities, responsible for meeting external standards and the maintenance of internal quality (Puig et al., 2022).

Ports can exert significant impact on shipping, by exerting influence on ships that dock in their ports which can have ripple effects within the shipping network. The wide linkages of ports also provide opportunities for them to play a strong role in the development of a circular economy (Karimpour et al., 2019). Given their existing role as a nexus for material movement, they would play a significant role in any non-local circular economy network. Their common presence near industrial and business areas (Karimpour et al., 2019) further lends to this, as such areas are likely best placed to engage in the shift towards a circular economy.

The many ways ports can contribute to sustainability has led to the introduction of the concept of a 'green port', combining environmental sustainability efforts and social considerations with continued economic

growth and expansion (Di Vaio et al., 2019). The efficiency of port operating capabilities also plays a significant role in elevating it against competition (Nguyen & Woo, 2021).

Historical development

Transfer of hazardous waste between ships (MC2 Ecklund / U.S. Navy)

Waste management was historically seen as a national matter, with legal regimes considering it an issue generated within a state and thus the concern only of that state (Argüello, 2020). Time saw waste outputs grow more complex, for example through the expansion in the amount of e-waste produced on ships (Sanches et al., 2020).

As evidence has become clear that waste can, and does, have significant impacts both on other nations and on the global commons, international

agreements have slowly developed to set common standards and understanding.

In 1954 marine pollution obtained international attention through the OILPOL convention (International Convention for the Prevention of Marine Oil Water). Oil spills were a notable problem, in particular the 1967 SS Torrey Canyon oil spill near the English Channel. The 1972 London Convention on the preventing of marine pollution through waste dumping was the next major step (Di Vaio et al., 2019).

This period saw an increase in international awareness of sustainability, including the establishment of the UN Environment Programme in 1972 (Alamoush et al., 2021). The International Maritime Organization developed the 1973 MARPOL convention (International Convention for the Prevention of Pollution from Ships), which viewed waste management through the lens of pollution reduction. With this greater scope, it replaced the more limited OILPOL (Di Vaio et al., 2019).

The various annexes to MARPOL differ in their focus on pollution, and gradually came into effect beginning in 1983 (Di Vaio et al., 2019). Sustainable development defined by the UN in 1992 (De et al., 2019). The London Protocol was amended in 1996 (Di Vaio et al., 2019). In the meantime, the broader United Nations Convention on the Law of the Sea came into effect in 1982, providing a broad international base for maritime management.

At this time, all forms of pollution, including dumping at sea and other forms of waste discharge, were much more common than they are now. MARPOL 73/78 was developed in part to provide a framework to reduce all sorts of marine pollution, and its annexes have been updated over time as new understanding emerges (Sanches et al., 2020). It now covers almost all of the world's merchant shipping.

International Convention for the Prevention of Pollution from Ships (MARPOL) Annexes

Annex I Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983)

Covers prevention of pollution by oil from operational measures as well as from accidental discharges; the 1992 amendments to Annex I made it mandatory for new oil tankers to have double hulls and brought in a phase-in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003.

Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983)

Details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk; some 250 substances were evaluated and included in the list appended to the Convention; the discharge of their residues is allowed only to reception facilities until certain concentrations and conditions (which vary with the category of substances) are complied with.

In any case, no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.

Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992)

Contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications.

For the purpose of this Annex, "harmful substances" are those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code) or which meet the criteria in the Appendix of Annex III.

Annex IV Prevention of Pollution by Sewage from Ships (entered into force 27 September 2003)

Contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land.

Annex V Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988)

Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastics.

Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005)

Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designated emission control areas set more stringent standards for SOx, NOx and particulate matter. A chapter adopted in 2011 covers mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships.

Regulations for treating waste differ greatly depending on the waste involved. Some materials considered very hazardous are strictly controlled. Others are treated more flexibly, for example sewage is often allowed to be discharged far from land, and even closer to land if it is disinfected prior to discharge. Research into marine plastic waste began significantly in the 1990s. The impact of such marine waste has steadily increased, with less than 10% of solid waste being recycled, and 10% ending up in the ocean (Dabrowska et al., 2021).

Waste being burnt on an oil platform (Shane T. McCoy / U.S. Navy)

MARPOL includes six different annexes for different forms of shipping waste, including oil, liquid waste including sewage, solid waste including both organic and inorganic waste, and air pollution (Vaneeckhaute & Fazli, 2020).

The MARPOL Annexes are:

- Annex I–Regulations for the Prevention of Pollution by Oil,
- Annex II–Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk,
- Annex III–Prevention of Pollution by Harmful Substances Carried in Sea in Packaged Form,
- Annex IV–Prevention of Pollution by Sewage from Ships,
- Annex V–Prevention of Pollution by Garbage from Ships,
- Annex VI–Prevention of Air Pollution from Ships.

In 2011 MARPOL Annex V was revised to more expansively cover ship-sourced waste (Argüello, 2020). MARPOL Annex V entered into force in 2018, and required ships of a certain size to have placards noting discharge requirements, a garbage management plan, and a garbage record book (Dabrowska et al., 2021).

MARPOL is maintained and amended through the Marine Environment Protection Committee (MEPC) of the IMO (Dabrowska et al., 2021). While it has regulations, it lacks enforcement mechanisms, which often need to be addressed through national laws (Argüello, 2020).

In the EAS region, the status of countries' ratification of the MARPOL Convention and its annexes are as follows (PEMSEA, 2021):

MARPOL 73/78	KH	CN	ID	JP	KR	LA	MY	PH	SG	TH	TL	VN
Annex I/II	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓
Annex III	✓	✓	✓	✓	✓		✓	✓	✓			✓
Annex IV	✓	✓	✓	✓	✓		✓	✓	✓			✓
Annex V	✓	✓	✓	✓	✓		✓	✓	✓			✓
Annex VI		✓	✓	✓	✓		✓	✓	✓			✓

The applications of MARPOL apply to waste processing on ships, and transfer from ships to port. They do not apply to the rest of the waste stream after this transfer, including handling at the port, further processing, and final disposal, which for the most part falls outside of international regulations on waste management at sea (Argüello, 2020).

Various legal frameworks are emerging outside of MARPOL. The European Union has begun managing waste regulations on a supranational level. Groups like the G20 and ASEAN have released various action plans on marine litter. These action plans often focus not just on reduction, but on shifts towards a circular economy where waste can re-enter the economic system.

Other international standards have evolved, such as the International Organization for Standardization (ISO) standards for environmental sustainability: ISO 14001. The Port Environmental Review System (EcoPorts) was developed by ports to serve as a common environmental management standard. The EU Eco-Management and Audit Scheme (EMAS) was developed by the European Commission, while the European Seaport Organisation facilitates regional cooperation. The American Association of Port Authorities similarly facilitates cooperation and has created an environmental management guide book. The International Association of Ports and Harbours has worked with the World Port Climate Initiative to establish environmental guidelines and create the World Ports Sustainability Program. Other international groups are the World Association for Waterborne Transport Infrastructure and the International Institute for Sustainable Seaports (Alamoush et al., 2021).

Current practices, laws, and policies

While regulations regarding waste management have increased throughout history, in many cases they remain inadequate to prevent unsustainable damage, or are too vague to effectively enforce. Even where there are sufficient regulations on paper, violations can be common and remain unpunished (Dabrowska et al., 2021).

Historical international action on certain types of pollution has in some cases achieved had considerable success. The volume of chemical and radioactive pollution entering the oceans has been significantly reduced. However, other wastes, which received less attention in the past, have become more prominent. A key example is plastic waste, which is rapidly increasing in volume (making up perhaps 85% of total marine waste) while its impacts remain unclear (Dabrowska et al., 2021).

1970: A tugboat transports waste to sea for dumping (Alexander Hope / NARA)

States retain overall responsibility for waste management, including for waste produced from ships. International conventions like MARPOL are entered into by national governments, who are responsible for transposing those conventions into domestic law. A state may impose stricter regulations on their flag ships, and on ships in their territorial waters and therefore including those using their ports, than the international standards. States can induce pressure on on-board ship practices through requirements for docking at ports, even if they are not the flag carrier of that particular ship. This can be through direct regulations, or through regulatory nudges (Argüello, 2020).

There are some exceptions allowing for solid waste discharge into the ocean under MARPOL. In general, food waste is allowed to be disposed of after some processing, so long as the ship is 3 nautical miles out to sea (Vaneeckhaute & Fazli, 2020). This can be made stricter, as it has in the Baltic, where it is prohibited within 12 nautical miles of the coast. In both cases, it is often expected that some processing occurs onboard the ship, usually shredding and compressing.

For monitoring, MARPOL requires ships carrying 15 or more people, including both workers and passengers, are required to have guidelines for waste collection, storage, management, and disposal (Vaneeckhaute & Fazli, 2020). All ships are also expected to have record books for their garbage disposal, including at disposal at sea.

Ports also have responsibilities under MARPOL, being required to have waste management plans, and to effectively provide sufficient means for waste transfer from ships. They are also expected to respond to ships noting the expected deposit of waste ahead of time, and where waste cannot be collected ports often provide information to nearby ports with adequate facilities (Vaneeckhaute & Fazli, 2020).

Ro-Ro ferry boats in Batangas Port *(D. Bautista / PEMSEA)*

States have historically been more agreeable to international agreements that deal with on-ship regulations, rather than regulations which put more responsibility and obligations on ports and therefore on port states (Argüello, 2020).

Within ports, port authorities often oversee large and complex operations with many smaller bodies operating within the port area. This complexity means that waste collection can often be overlooked as part of port activities, with little coordination and fragmented action.

Differential dues are increasing, often beyond what is needed for minimum regulations, and environmental performance in general is increasing (Puig et al., 2022). Digitization is providing new potential for port management (D'Amico et al. 2021).

Plastic regulation is becoming more common throughout the world, including bans on certain products and more regulation surrounding design and recyclability (Dabrowska et al., 2021). This may significantly affect future port and ship operations, suggesting pre-emptive segregation may be a sound investment.

The European Union requires ports to provide annual reports on their waste management, noting what waste was received from ships, including specifics for food waste (Vaneeckhaute & Fazli, 2020). The latest EU Directive (2019/883) applies to all "waste from ships", and although EU regulations in regards to shipping are considered well-developed, they still have interpretation issues in lining up with the wording of MARPOL (Argüello, 2020).

Some shipping groups have developed voluntary initiatives, such as the European Cruise Council which has its own regulations for wastewater discharge in the Baltic that are more stringent than under the MARPOL regulations. They have used this to prioritize ports with a "no special fee" agreement for receiving wastewater. Under this system, waste is included in the harbor fee, and thus is always charged to the ship. As this system is shared by multiple ports, there is no economic advantage to a port to a ship to go to a port not intending to deposit waste there (Vaneeckhaute & Fazli, 2020).

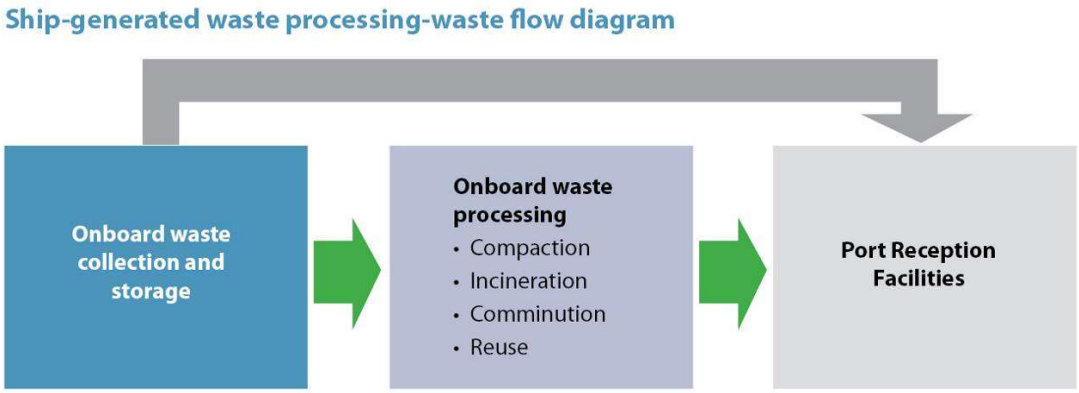
THE LOGISTICS OF PORT AND SHIP WASTE MANAGEMENT

Hauling of solid waste in Batangas Port, Philippines (PEMSEA)

Challenges

Ship-generated waste presents a microcosm of the challenges of waste management in general. Ships present relatively isolated systems, with a need to either store waste or dump it directly into the environment. With the latter becoming less acceptable due to its human and environmental effects, it is becoming increasingly important for ships to be able to store and even minimally process waste on board, and simultaneously for ports to be able to absorb ship waste deliveries into their waste management systems.

Ships face challenges in waste storage, treatment, and eventual offloading. Some ships wastes are considered hazardous, requiring certain treatments to ensure the safety of the crew and the wider environment. Unsafe disposal, including both dumping and improper procedures at ports, carries significant risks. Ships can be further challenged by expenses if the waste procedure is unduly long, lengthening port time.



(Dabrowska et al., 2021)

Ship generated waste can be handled specifically by the port depending on the scale of the port, although for most ports the waste becomes part of the wider waste stream for that local area. In places adopting life-cycle or circular economy approaches to waste, which often require large economies of scale, it is infeasible for ship and port waste to be handled outside the wider waste stream. The EU for example explicitly includes waste from ships as part of the wider waste regulatory system of the EU, which covers the movement of waste after the phase where it is collected by the port (Argüello, 2020).

Good port facilities need to fully meet the waste disposal needs for incoming ships, which can vary based on ship type, route, and cargo. Different types of waste often need to be processed separately, and sometimes even at different times to reduce the risk of mixing. They

must also ensure that their waste handling facilities and procedures have minimal impact on the environment themselves, both operationally and in preventing waste leakage. More research is needed (Sanches et al., 2020), covering different ship types, different waste impacts, and different locales. Much work is needed even on issues where treatment methods are better known. Studies have found that only 24% of ship-generated plastic is effectively recycled (Sanches et al., 2020). Overall, life cycle assessments are needed to evaluate how shipping and ports interlink for all kinds of waste (Vaneeckhaute & Fazli, 2020).

No matter how the waste is handled, there are costs involved for the port, including operational, administration, and worker training salary costs. Port Reception Facilities need fees to recoup these costs. At the same time, cost recovery must be designed to not excessively disincentivize waste disposal at port as opposed to illegal dumping. This often requires coordination with enforcement and regulatory bodies.

Potential port policies and implications

How ports and ships are regulated has strong impacts on the environment. Ports can improve their sustainability in both energy and material use, with secure ports better protecting nearby coastal environment and coastal communities (Di Vaio et al., 2019). However, port standards remain uncodified, with standards for "green transport" and "green ships" are needed at regional and international levels (Sanches et al., 2020) to ensure proper understanding by involved stakeholders.

Wider waste management regulations affect how ports can manage their produced and incoming waste. Government policies towards promoting recyclable plastics or plastic alternatives, strengthening wider

waste management systems, fund research, sand integrating waste management into their development plans will have significant impacts on the opportunity and the ability of ports to do the same (Dabrowska et al., 2021).

(Frank Vincentz / Wikimedia Commons)

The success and viability of port operations can impact the commercial decisions of other parties regarding goods transports, for example by shifting cargo between ports or from ports to other modes. Effective management of such outcomes may however require vertically integrated supply chains (Du et al., 2019), and thus lie outside of the competency of individual ports. To solve this, ports can cooperate regionally. For example, ports in the Baltic cooperate on environmental issues, even if they compete commercially (Vaneeckhaute & Fazli, 2020).

Ports in Europe created the European Sea Ports Organisation (ESPO) (Puig et al., 2022), which helps provide a place for stakeholders to come together, a forum for ideas, tools, and methodologies to be shared, a central repository for research, and a stronger voice. Ports in China have been merged into regional port authorities, allowing for better coordination (Du et al., 2019).

On the individual port level, capacity makes a huge difference to port operations. Employee awareness of environmental policies makes a significant different to the effectiveness of port environmental strategies, and so Environmental Awareness Training is considered to be cost-effective in ensuring policies relating to Environmental Management Systems are effectively implemented (Puig et al., 2022). Over half of surveyed ports in Europe have a training program, and even more include environmental issues in the general induction programs (Puig et al., 2022).

Cost recovery and incentive structures

The incentive structure regarding waste disposal is one of the key problems in reducing the amount of waste entering the ocean from the fishing industry. Uneven waste fees and uneven application of regulations surrounding waste can distort competition between ships, and between ports. Ambiguity in interpreting such regulations and what they require can risk further distortions, as well as mismatches between expectations and practice.

Ensuring regulatory compliance and an even playing field between shipping companies and ports requires an effective monitoring system. This may require monitoring of the ships, and of the ports and companies operating within the ports. The action of the other companies

is often overlooked, as the processing and transport of waste out of the ports is a crucial part of understanding the ultimate impact of ship-sourced waste.

Waste being shipped via shipping container *(Lamiot / Wikimedia Commons)*

There are different ways to charge for waste fees, which ideally should overall reflect the costs of the waste management services. A simple pay per use scheme is common, and can stimulate a reduction in waste production (Sanches et al., 2020). This is a polluter pays principle, which aims to ensure negative externalities are paid by those who are creating them. However, setting up a fee structure can be complicated, as it needs to balance against the risks of incentivizing the dumping of waste at sea.

Cost recovery for the port can be realized through direct fees, indirect fees, or a mixture of both. Direct fees have the advantage of directly linking waste costs and waste produced. It is a simple to understand

system that can be handled quite simply between waste collectors and ships. However, linking waste fees directly to waste collected incentivizes the dumping of waste elsewhere where such disposal would cost less, either in ports with lower fees due to less effective procedures, or direct dumping into the ocean. The simplicity can also lead to a lack of transparency, due to the low number of involved parties, which may not even include port authorities. Previous studies have found that using 100% direct fees leads to less waste being discharged at ports (Argüello, 2020), suggesting that waste is being disposed inappropriately at another location.

Indirect waste fees do not have a direct link between waste volume and waste fees. Often, they are charged as a standard rate to all incoming ships, regardless of their expected waste facility use. (Such fees often do not cover cargo residues, which are treated differently to operational waste by MARPOL and many national regulations.) Having indirect fees reduces incentives to illegal or less adequate discharge, due to the cost being already built into ship operational costs. This also provides a predictable level of revenues for the waste company, and predictable fees for ships, improving planning and reducing potential administrative costs needed to adjust payments for each incoming ship or each port call. It also reduces paperwork for any other involved stakeholders, for example the revenue and cost for the port authorities can be easily understood and processed. The disadvantage of breaking the link between waste volume and waste fees is reducing pressure on shipping companies to produce less waste, and similarly creating no consequences for the unnecessary production of waste.

Combined fees attempt to balance the various incentives and disincentives for ships entering ports. A reward system for waste discharge at ports can be useful in some scenarios, for example for the fishing industry (Sanches et al., 2020).

WASTE RECEPTION FEES

Below is the table of fees collected by the PRF Provider in Batangas PMO based in PPA AO 08-2021:

Type and classification of vessel	Fixed fee in PhP	Additional service fee in PhP	
	(Covers the collection of 1.0 cu.m. or less garbage)	Excess garbage	Oily waste and noxious liquid substance
DOMESTIC			
• Motor bancas with capacity of less than 15 passengers	Exempted		
• Motor bancas and passenger/ cargo vessels with capacity of more than 15 passengers and up to 35 GT	500.00 per one (1) round trip	500.00 per cu.m.	6,500.00 per cu.m.
• Passenger/cargo vessels above 35 GT up to 400 GT			
- Short travel time	750.00 per one (1) round trip	750.00 cu.m.	6,500.00 per cu.m.
- Long travel time	750.00 per call		
• Passenger cargo/vessels above 400 GT up to 1,000 GT			
- Short travel time	1,000.00 per one (1) round trip	1,000.00 per cu.m.	6,500.00 per cu.m.
- Long travel time	1,000.00 per call		
• Passenger cargo/vessels exceeding 1,000 GT	2,000.00 per call	1,800.00 per cu.m.	6,500.00 per cu.m.
FOREIGN			
• Passenger cargo/vessels up to 1,000 GT	10,000.00 per call	10,000.00 per call	20,000.00 per cu.m.
• Passenger cargo/vessels exceeding 1,000 GT	15,000.00 per call	15,000.00 per cu.m.	20,000.00 per cu.m.

(PPA, 2022)

The EU has adopted a polluter pays principle, requiring externalities such as the impacts of waste to be borne by the ships and ports that produce these externalities. EU ports levy both direct and indirect waste management fees for ships, and these fees can differ depending on the type of ship, the operating hours of the port, and the nature of the waste. These fees must cover at least 30% of the total costs of waste management to the port, including both direct operational costs and administrative costs (Argüello, 2020). This provides some incentive to ports to improve the efficiency of their waste management, which may bring down operational costs and thus the fees they need to charge

ships. Mixed fee structures may similarly increase waste disposed of, and thus waste fees paid, to other port systems.

The administrative burden on ports can also increase cost, and therefore making it more efficient can save costs for ports and thus for ships. Port reporting requirements can be quite flexible. On the EU level, ports are allowed to accept data according to their needs, and simplified digital procedures can be used (Argüello, 2020).

Similar considerations regarding incentives also apply to waste regulations, which port cost recovery systems need to take into account. Mandatory discharge requirements and their implementation must carefully consider the needs of those using the port facilities. Implemented wrongly, or with insufficient monitoring and enforcement mechanisms, it can provide incentive to discharge waste at a port with inadequate facilities, or to discharge at sea (Argüello, 2020).
Impacts of waste disposal on other aspects of shipping can also be considered, for example good waste disposal in a port can be an attractive draw for ships with multiple options available. Waste management also feeds into the wider reputation of both ports and their associated cities, as sustainability becomes a more valued asset in the minds of businesses and consumers (Sanches et al., 2020).

Measurement and monitoring

Incentive structure are strengthened by the inclusion of effective monitoring and enforcement regimes, which not only directly impact the system by capturing violations and reducing environmental pollution, but also provide reassurance to all stakeholders that the playing field is being kept even and that they are not at an unfair competitive disadvantage (Argüello, 2020).

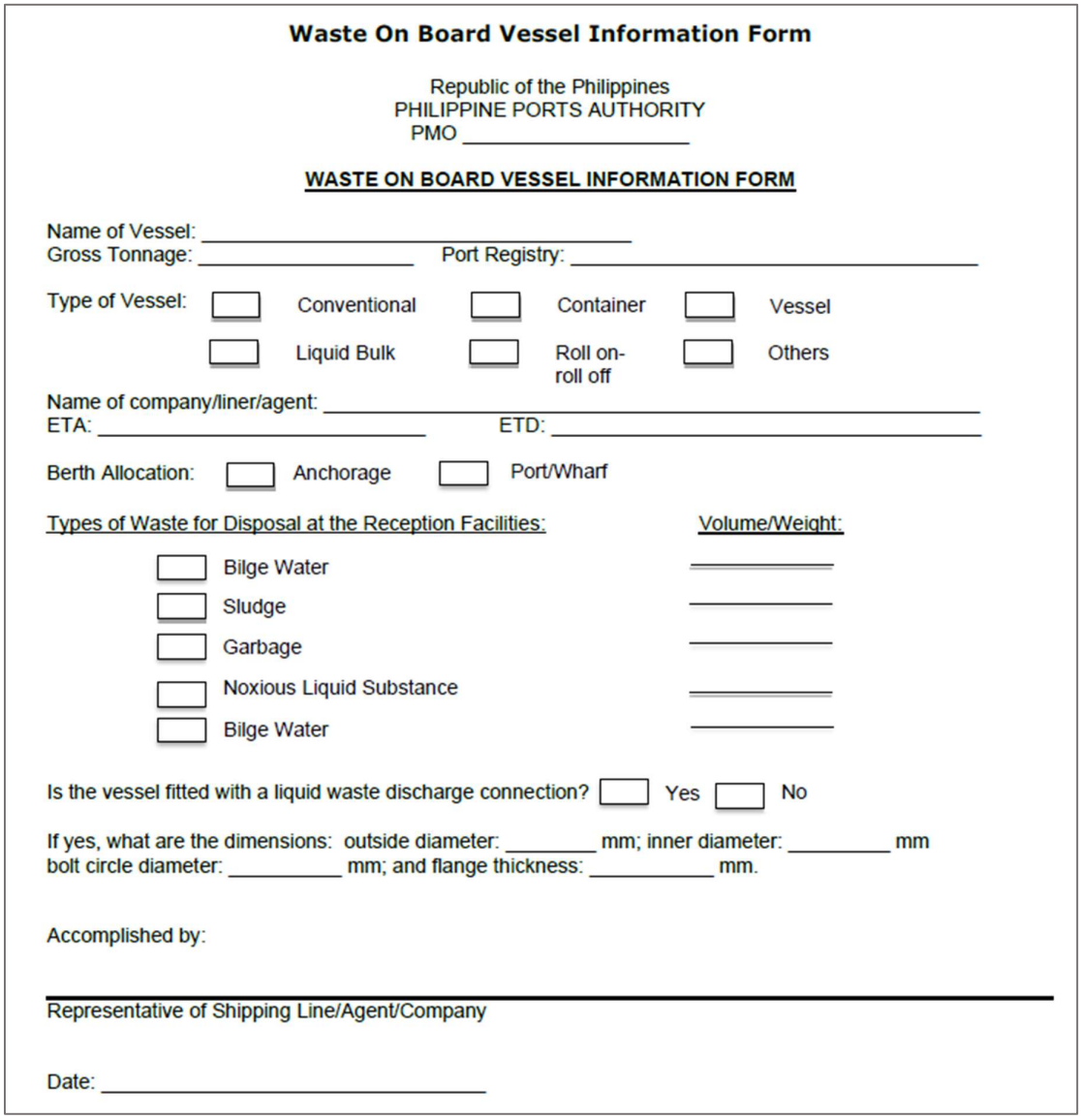
Specific performance indicators are needed for an effective monitoring program (Puig et al., 2022). Many frameworks exist for different performance indicators, such as the Balanced Scorecard (BSC). Such frameworks allow multiple indicators to be assessed in addition to financial ones, allowing for a more holistic assessment of strategy and growth. This can support new innovations and ideas, and promote new solutions to meet an overall strategy. When used in ports they can balance the differing roles of public and private stakeholders. Studies have found it can specifically help with waste management in ports, providing easy to understand and concise reports through specific indicators. The right framework can also help assess competitive advantages, and thus promote collaboration and reduce tragedy of the commons-type situations (Di Vaio et al., 2019).

The physical practice of keeping logbooks is transitioning into the digital sphere, allowing for more easily transmitted data. However, this requires common data structures and data expectations, which need to be determined between a port and its docking ships.

Innovation is playing a big role in ports, especially relating to IT infrastructure to support all manner of port activities. Primarily, IT creates new ways to collect, integrate, and analyze data from a number of port activities. Especially prominent is the replacement of paper systems, and even digital but manual systems, with more automatic systems, which are less time-consuming, and in some cases less error-prone (Di Vaio et al., 2019).

Developing new software is considered an important part in increasing port efficiency, including in waste management, due to its ability to control and share information in an integrated and targeted way (Di Vaio et al., 2019). Sensors can also handle environmental monitoring in real-time, looking at different aspects of water quality (D'Amico et al.,

2021). Such monitoring is linked to waste management and pollution and can serve as very specific and reliable indicators for local environmental conditions.



Waste On Board Vessel Information Form

Republic of the Philippines
PHILIPPINE PORTS AUTHORITY
PMO _____

WASTE ON BOARD VESSEL INFORMATION FORM

Name of Vessel: _____
Gross Tonnage: _____ Port Registry: _____

Type of Vessel: ☐ Conventional ☐ Container ☐ Vessel
☐ Liquid Bulk ☐ Roll on-roll off ☐ Others

Name of company/liner/agent: _____
ETA: _____ ETD: _____

Berth Allocation: ☐ Anchorage ☐ Port/Wharf

Types of Waste for Disposal at the Reception Facilities: Volume/Weight:

☐ Bilge Water _____
☐ Sludge _____
☐ Garbage _____
☐ Noxious Liquid Substance _____
☐ Bilge Water _____

Is the vessel fitted with a liquid waste discharge connection? ☐ Yes ☐ No

If yes, what are the dimensions: outside diameter: _____ mm; inner diameter: _____ mm
bolt circle diameter: _____ mm; and flange thickness: _____ mm.

Accomplished by:

_____
Representative of Shipping Line/Agent/Company

Date: _____

Sample physical form for submission to Batangas Port, Philippines (PPA, 2022)

There are many models that can be used to evaluate technical, economic, environmental, and social impacts, and which can apply to different kinds of shipping-caused pollution. However, specific models for waste management processes remain lacking (Di Vaio et al., 2019),

and thus could be an important area for future research. Current models linking waste management to the environment tend to focus on large scale incidences of pollution or one-off events, consider very limited geographies, and miss links between environmental damage and related social and economic damage (Di Vaio et al., 2019).

Proposed waste management key performance indicators
PA in controlling functions for waste management from cruise ships.

e-KPIs
Effectiveness
1a. No. meeting on waste issues attended by port users involved in the waste collecting and management/ No, meeting on waste issues promoted by PAs
1b. No. hours spent listening to the cruise shipping lines by PAs linked to environmental topics
Efficiency
2a. No. hours to check the notifications/total hours planned for PAs activities
2b. No. waste deliveries/the tonnage of vessels
2c. The quantitative of waste retained onboard/the waste to be delivered
2d. No. notifications/No. hours spent for checking certifications/documents

(Di Vaio et al., 2019)

In general, more research into how port operations interact with different aspects of sustainability is needed (D'Amico et al., 2021). Inter-organizational relationships are important in generating correct performance. (Di Vaio et al., 2019). Management control systems are needed to measure port activities, allowing for decision-making processes to be supported and investments to have sustainability in mind (Di Vaio et al., 2019).

Understanding the specific responsibilities of all parties involved in port management is also crucial to effective port waste management. In Italy port authorities do not handle waste directly, but tender out management to companies which liaise directly with shipping companies. Instead, port authorities have overall control of port activities, and relationships between the various stakeholders is set out by national and European regulations. Currently, the waste

management company reports to the port authority using spreadsheets. Separate waste reports are required for before mooring, during mooring, and leaving the port, and reports are collated into annual summaries. External organizations can access such reports through a digital platform, allowing for assessment and monitoring, with specific indicators being collected on the digital platform (Di Vaio et al., 2019).

Ports need efficient and digitalized procedures to become modern, green, and competitive. However, such systems also help in incentivizing ship waste management to ensure ships deliver waste. Such incentives reduce the monitoring burden, by pushing more ships to feel compelled to dispose of waste adequately.

EXAMPLES OF GOOD PRACTICES AND IMPLEMENTATION

Large floating object collector (Martin Addison / geograph.org.uk)

Enabling ecosystems and digital transitions

Ports facilitate innovation as much as they do trade, and in many places, they have adapted to the new requirements and expectations that have developed. There are many examples of different legal and regulatory regimes; indeed, most situations are in some way unique. While this paper is not placed to give a comprehensive overview of each situation, some highlights may serve as guiding examples for the generation of new ideas.

Every port has a unique solution for waste management, based on its particular situation. The Port of Antwerp has set up a "zero-ton residual waste" goal, aiming to become fully circular in its waste management practices. It shares a waste-exchange platform with Amsterdam. The Port of Rotterdam has specific space set aside for use by waste companies (Karimpour et al., 2019).

The Port of Hamburg deliberately uses recycled materials in construction, which is an example of useful consumption. One challenge facing ports is a lack of businesses for a circular economy (Karimpour et al., 2019). As in other areas of sustainability, effective change will require concerted cooperation between ports and other stakeholders, such as industry and local and national government.

In general, port development works better when it includes cooperation between the various actors and stakeholders that interact with the port economically, geographically, or through regulations (D'Amico et al., 2021). A study on the Port Louis Harbor in Mauritius found that an environmental policy needed to include participation with the local government and the local community, as well as the port authorities (Sanches et al., 2020). Crucial considerations like data security (D'Amico et al., 2021) require cooperation from all involved stakeholders.

Australia has a national Marine Waste Reception Facilities Program which brings together regional and local governments with industry to reduce pollution by sharing best practices that can be adapted or replicated. Countries around the North Sea have set up a regional Green Port Project that facilitates transboundary cooperation (PEMSEA, 2022).

Good human stakeholder relations also improve the use of digital integration, as human logistics oversee, guide, and reinforce digital

strategies. Digital systems face initial challenges due to high costs of capital investment (D'Amico et al., 2021), as well as requiring high capacity to run and manage it. Developing manuals helps ensure operational management is effective, and provides a systematic overview of where responsibilities lie (Puig et al., 2022).

An important enabling factor is an effective ecosystem for development, with the port being part of a wider network of government, researchers, technology companies, logistics companies, and other relevant bodies. Ports are developing towards a more integrated fashion, as smart technologies provide greater interlinkages between different aspects of port management (D'Amico et al., 2021).

Solid waste to barge transfer station (Derek Harper / geograph.org.uk)

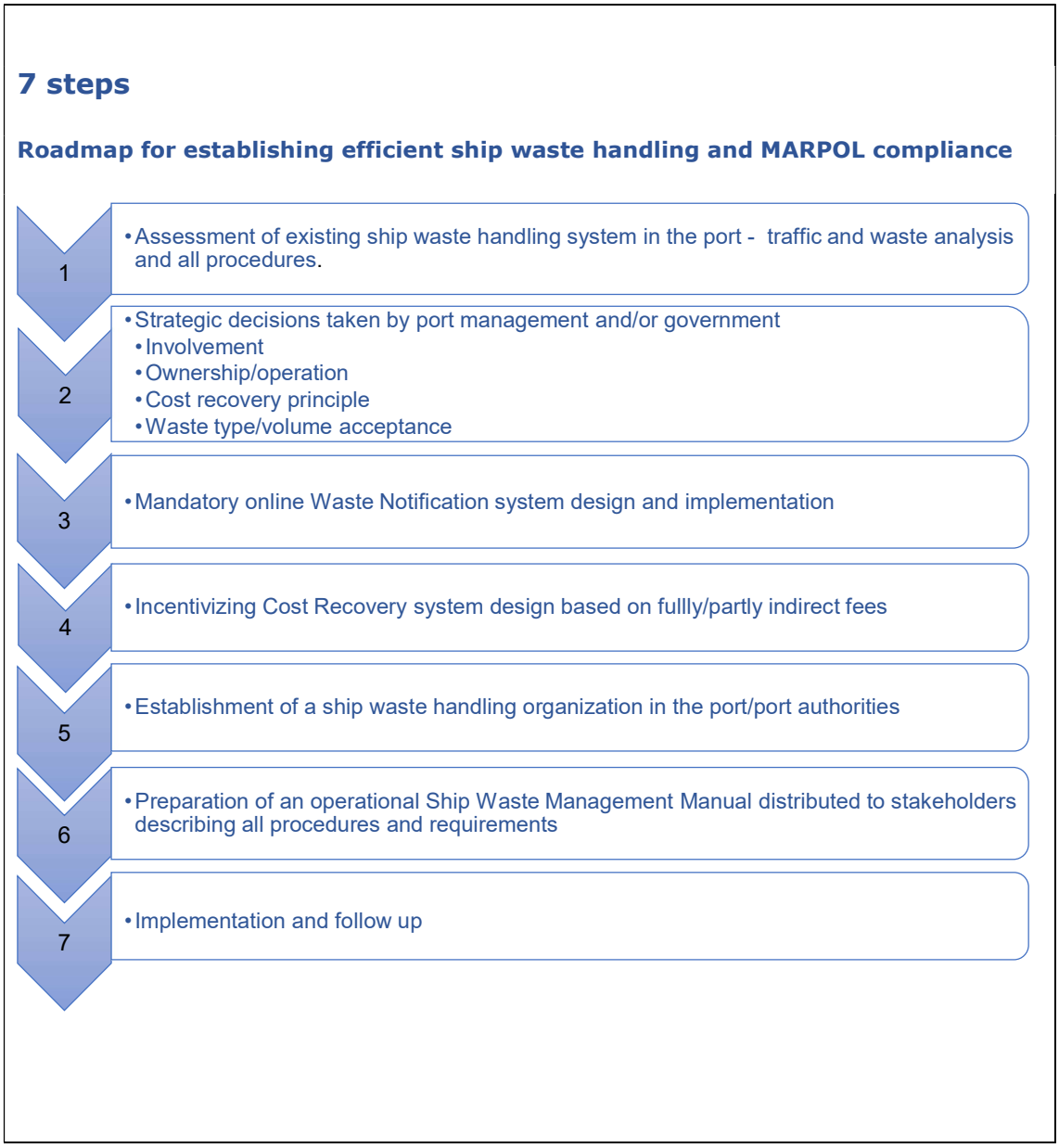
It is possible to design a better ecosystem, by finding forums for stakeholder interactions where ideas can be shared and developed. Ports can work directly with individual partners, and more loosely within this wider ecosystem of shared spaces. Identifying the goals desired from such areas requires ongoing and inclusive cooperation between various port stakeholders, establishing comprehensive frameworks and workplans to ensure such initiatives are successful.

Port cities play an important role in cooperation as well. For example, they have the ability to - either by themselves on in cooperation with national governments – establish special economic zones or zones of opportunity, which can allow innovation (D'Amico et al., 2021). This can spur investment, which can be very needed for systems such as waste management which can be heavily capital intensive. Such zones could also be tailored to incentivize particular waste management strategies.

The Port of Montreal has developed an innovation ecosystem, working with Concordia University to develop a port logistics hub. The Port of Rotterdam works directly with startups, and participates in an annual port hackathon (D'Amico et al., 2021).

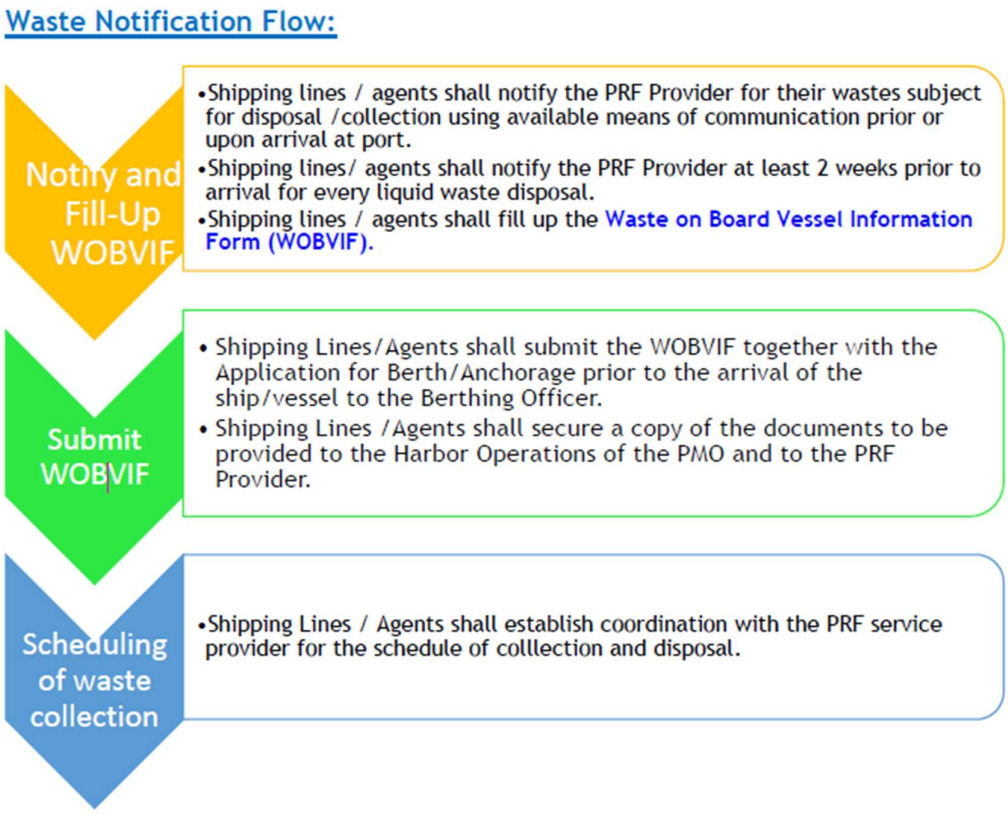
Port authorities can provide funding or grants to assist with technical compliance, or provide incentives for certain activities (although this is uncommon). Alternatively, specific tariffs and differentiated rates can be put into place based on externalities created. Voluntary regimes can supplement the formal legal and regulatory ones (Alamoush et al., 2021).

General Approach for the Implementation of an Efficient Ship Waste Management System in Ports based on EU Experience (Jens-Peter Oehlenschlaeger, pers. Comms. 2022)



The transition to digital remains nascent in many areas, with traditional paper-based waste notification systems still in use for many ports and ships. A shift to digital tools creates significant opportunities to increase efficiency. Digital tools ease waste notifications, as well as providing a more accurate picture of waste arriving and leaving. This can be of great advantage to setting up a more circular economy (D'Amico et al., 2021).

There are global systems for exchanging waste information, such as the Union Maritime Information and Exchange System (SafeSeaNet), and the IMO electronic database GISIS (Argüello, 2020). The Port of Hamburg has developed an integrated logistics platform that exchanges data between ships, trucks, and trains (D'Amico et al., 2021).



Waste notification process in the Philippines (PPA, 2022)

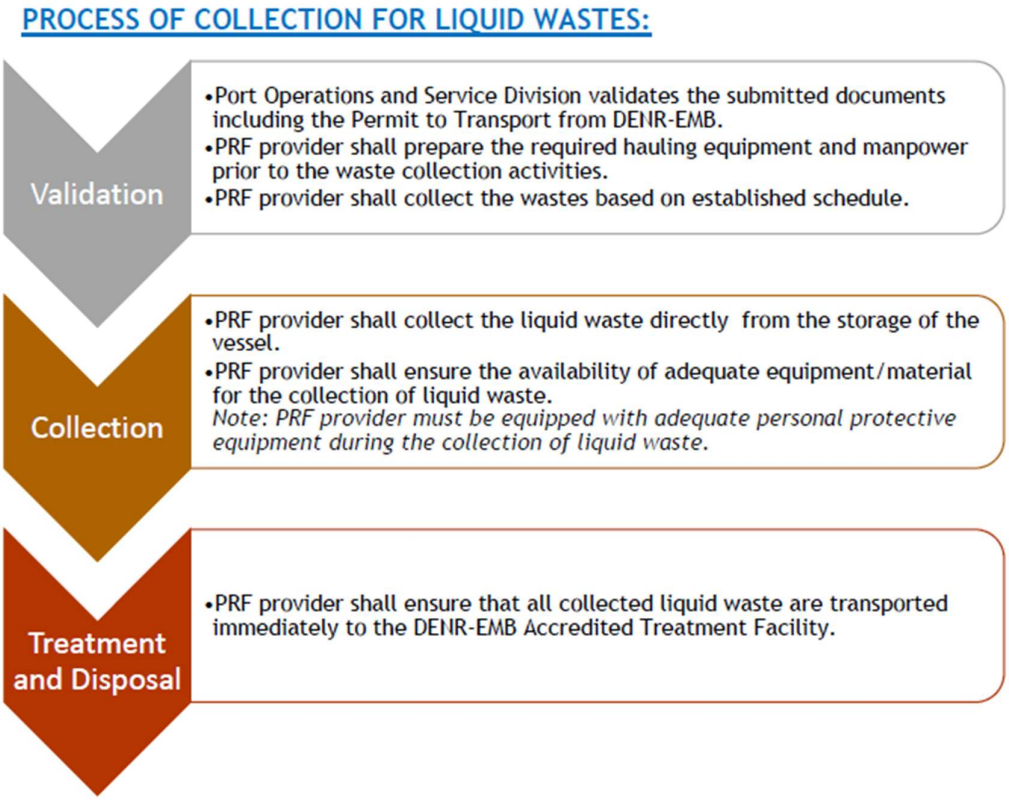
Encouraging on-board management

On-board ship waste management is less well researched than land-based waste management, and is strongly geographically biased (Vaneeckhaute & Fazli, 2020). Segregated waste is much easier to collect and process by ports. Segregation of on-board wastes thus benefits ships and ports, speeding up processing time when at the port, and reducing the complexity of the port's waste management tasks (Vaneeckhaute & Fazli, 2020).

Unsegregated waste, in addition to causing issues with efficient and effective waste disposal, can damage waste management infrastructure. For example, mixing organic food waste in with grey water can damage sewage systems (Argüello, 2020). Ports can also have their own separation procedures, although these are relatively uncommon (Argüello, 2020). This waste segregation is crucial to efficiently handling waste. The mechanisms by which this happens will depend on the port and their agreements with various ship operators.

Existing volume saving measures on ships keep sewage storage more efficient than it is in most land-based situations (Vaneeckhaute & Fazli, 2020). Sewage can nonetheless cause similar nutrient issues to food waste if disposed into the ocean. Different practices exist with segregation, in some circumstances black water and grey water are stores together, in some cases they are separated (Vaneeckhaute & Fazli, 2020).

Waste processing facilities in ports might service black water and grey water together or separately. This would affect capacity and volume. Such choices may also influence ship treatment of waste, for example incentivizing or disincentivizing dumping at sea.



(PPA, 2022)

A significant type of waste often delivered in ports is food waste, with ships producing between 0.2 and 3.5 kg per person per day (Vaneeckhaute & Fazli, 2020). While this is often biodegradable, its potential role in exacerbating nutrient loading. This is especially the case in enclosed seas with limited exchange with the wider ocean. Ports, being often in enclosed bays, are at risk of water deoxygenation which can affect nearby areas. Such waste is often categorized into soft organic food waste, and hard waste (e.g., bones) and packaging (Vaneeckhaute & Fazli, 2020).

On-board storage of foods can be difficult, and bring about health concerns, often prompting cheap disposal at sea. As restrictions increase, ports may need to increase their capacity to handle food

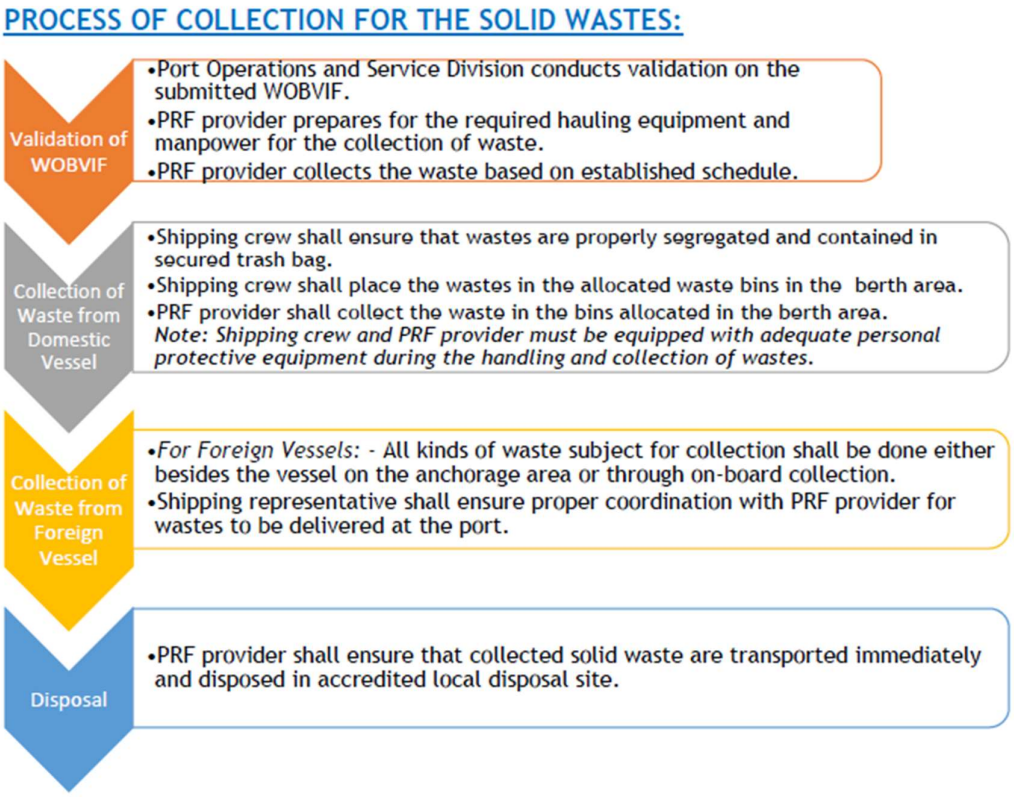
waste. Temporary on-board treatment includes grinding it into a smaller volume for storage. This makes it much easier both for ships to transport in terms of bulk and safety, as well as similarly simplifying port-side processing. Some ships also dry this waste, and keep it in cool rooms, reducing rotting and potential odors (Vaneeckhaute & Fazli, 2020).

Some ports may need to handle quarantine requirements for biological waste such as food and other organic leftovers. In particular, food waste that is considered to be a potential carrier of disease or pests needs to be covered (Vaneeckhaute & Fazli, 2020). This is especially true for international shipping, which has to account for regulations at all ports they enter. This may affect disposal possibilities, with the disposal of international waste being less flexible.

A sewage treatment plant near the port city of Hamburg (Matti Blume / Wikimedia Commons)

In the Baltic Sea, black water discharge is regulated with targets for various indicators and requirements for pre-processing, while grey

water discharge does not have specific limitations. Soft food waste can be missed into grey water after it has been processed, and then released at sea (Vaneeckhaute & Fazli, 2020). This means ports will have to be more attractive than this, or respond to future changing regulations. Mixed waste is intended to be handled with the most stringent set of precautions that would apply to any one part of the mixture.



(PPA, 2022)

The Port of Copenhagen-Malmo (CMP) has sought to use waste to play a role in improving its energy sustainability. This port lies at the junction of two cities and two countries, in an important shipping route leading to the Baltic Sea. It receives a wide variety of ships, not just those involved in global trade but also those involved in leisure such as tourism (Karimpour et al., 2019).

The Baltic Sea, which the CMP serves as a gateway too, became a special area for sewage under IMO regulations in 2013. This means that all sewage must be either treated in a certified on-board system or discharged at ports. Organic waste is also required to be kept on board in segregated waste facilities, to be discharged at ports. New ships were required to meet the requirements at an earlier date than old ships that needed to be adapted. For ships to meet the Baltic Sea IMO regulations, there must be adequate port facilities to handle the waste discharged from ships (Karimpour et al., 2019).

There are different options for disposing of waste. For example, black water can be treated chemically, which treats the waste to disinfect it but does not remove nutrients, or biologically, which uses natural processes to break down the material into something that is safe to discharge. There are many options for these, with 52 systems on the market that satisfy the requirements even for the very strict Baltic Sea area. (Vaneeckhaute & Fazli, 2020).

In the Port of Copenhagen-Malmo and the Port of Tallinn, wastewater from ships can be piped directly into municipal wastewater systems. These systems are adapted to deal with the different composition of ship-originating black water. In the Port of Helsinki and the Port of Stockholm, waste is collected by trucks which then move it to the appropriate treatment facilities. These trucks are required to keep their own record books, in addition to those carried by the ship and the port. In Helsinki, the port's treatment center is able to remove 95% of phosphorus and 90% of nitrogen from black water (Vaneeckhaute & Fazli, 2020).

Cruise ship at the Port of Tallinn (Ilya / Flickr)

Other potential actions for the treatment of solid waste on-board include incineration and gasification, or biological digestion. In some places there are regulations necessitating some treatment on-board, after which it is able to be dumped at sea (Vaneeckhaute & Fazli, 2020).

The Qingdao Qianwan Container Terminal has a fully automated system for emptying ships, which improves efficiency by 30% (D'Amico et al., 2021). Such saving might also help with waste management

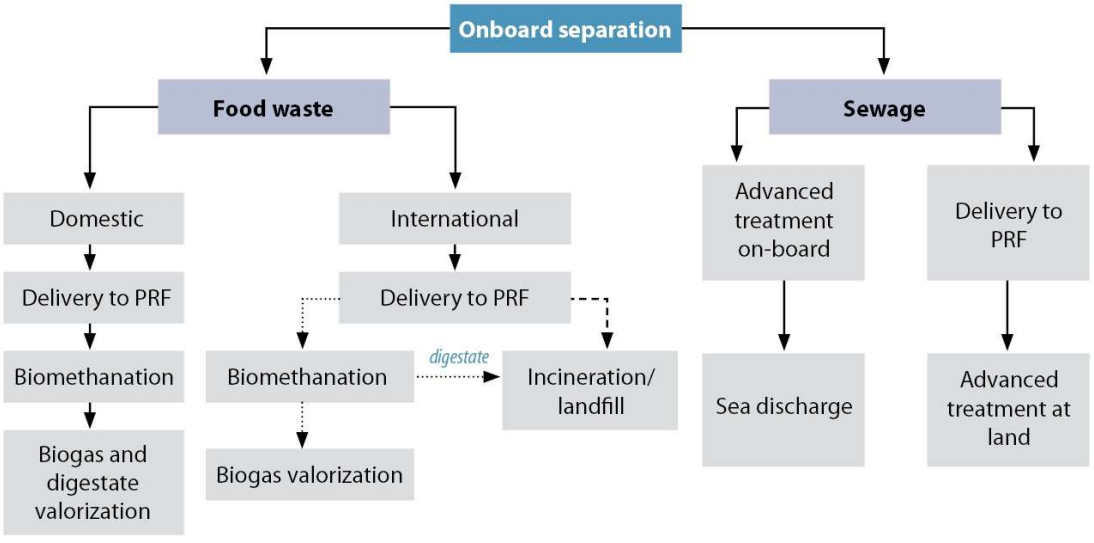
The European union has created legal provisions to allow ports to offer discounts to port fees for ships that can demonstrate on-board practices that reduce waste produced, although the lack of detail means that it is rarely utilized (Argüello, 2020).

Port infrastructure and services

The internal organization of ports needs to be able to prioritizing improved systems, and developing and empowering other relevant actors. The structure should allow for ideas to be created, studied, and when approved, implemented, allowing for innovation (D'Amico et al., 2021). Digitization allows for earlier notification, more cohesive reporting, and faster processing of records, leading in many ways to a more rapid turnaround for ships entering ports (D'Amico et al., 2021).

Given the regularity of shipping routes, there is great benefit to establishing long-term waste-related contracts between shipping companies and either ports or companies operating within the ports. Communication between the ships and the receiving bodies allows for the correct waste containers and waste logistics (such as trucks) to be ordered ahead of time (Vaneeckhaute & Fazli, 2020). This enhances planning, which will speed up overall processing at the port.

Overview of best management practices for ship-generated food waste and sewage management on the Baltic Sea



Note: striped line shows current practice, dotted line suggest a more sustainable future option.

(Vaneeckhaute & Fazli, 2020)

Waste management can be carried out along with cargo transfers (PPA, 2022), with time saved by having these processes run in parallel. Where complex waste management requirements exist, and where regulations allow for it, it may be possible for nearby ports to specialize in different forms of waste management, allowing joint efficiency without unnecessary and potentially expensive redundancy (Argüello, 2020).

In providing these services, it is helpful for ports to serve as centers of training and best practices. The Ports de la Generalitat de Catalunya has a training program for skills and motivation not only for its own staff, but for other stakeholders such as other administrations, NGOs, civil society, and private entities. Peel Ports Group in the United Kingdom provides staff and contractors environmental information, and communicates with regulators regarding environmental responsibilities. Copenhagen Malmo Port conducts three days of training twice a year (Puig et al., 2022).
Ports can help build capacity not only for their employees, but for those in attached companies working throughout their supply chain. This benefits from their central position within the overall supply chain, allowing ports to easily become a nexus of knowledge in addition to being a nexus of activity, with direct and indirect spillover impacts (Alamoush et al., 2021).

Some ports even involve outside stakeholders and non-governance port stakeholders into their structures, for example by having trade union representatives in a governance council (D'Amico et al., 2021). Improvement pilots started in one port can often be very useful for ports that lie within the same regulatory framework, and those who deal with similar sorts of shipping and thus similar waste profiles.

Responsibility and enforcement

While considerations for waste management are international, the IMO and other international bodies have no enforcement power. Instead, enforcement is a responsibility of signatory states to each particular convention.

In Europe, action was taken at the start of the century to deal with illegal ship waste. Hotspots of waste included the Baltic Sea, whose water is relatively isolated from the rest of the ocean, and the heavily transited English Channel. Because the Baltic Sea served a distinct number of countries, a "Baltic Sea Strategy" was developed through cooperation between the nine countries surrounding the sea. This joint strategy led to joint recommendations on cost recovery and waste notification; both are key to ensuring a consistent platform between ports and to ensure efficient collection and processing of waste.

Different ports have different systems, but all have overall responsibility for legal compliance in the EU. In the EU ship waste fees are mandatory under Directive 59/2000 EC on Port Reception Facilities (later replaced by Directive 2019/883 on Port Reception Facilities), meaning there is no advantage to dumping. This provided guaranteed cost recovery to ports, which collect the fees and pass them on to waste operators, ensuring there is no overcharging and an even ground.

Advanced mandatory waste notification is required on the waste that will be disposed at the port, notifying either the port of the within-port company responsible for collecting waste. 90% of EU ports outsource their waste handling activities, including reception, processing, and final disposal. However, they maintain ultimate responsibility, and manage the overall waste system. This clarity on ultimate responsibility ensured

ports were aware of what happened with waste rather than it being obscured by using a third party.

(Rhk111 / Wikimedia Commons)

This was linked to a requirement on the creation of port waste management plans (also referred to as ship waste management manuals) by every port, providing information on waste management procedures, cost recovery and prices, waste notification, contacts, and legal requirements. Ports are thus able to inform relevant stakeholders about how waste delivery and collection takes place.

The EU directive came into place in 2000, and began operating in 2002/2003. From 2004 to 2008 there was an almost 100% increase in oil waste deliveries. Indirect fees are mandatory for all waste under MARPOL Annex V, meaning most solid waste. Many ports in the EU, following the example of the Baltic, are further introducing indirect feed for other ship generated waste as well, including sewage and oily waste.

While all waste must be delivered to EU ports, there is uncertainty regarding how this provision affects the potential discharge of waste in international waters. Furthermore, there is an exception to EU rules for discharge if a ship has sufficient storage capacity for its waste, and it can opt to continue to store waste on board and discharge this waste at a later port of call. Details on how this is interpreted and enforced differ between states, and sometimes between ports (Argüello, 2020).

New regulatory standards are being developed around the world, and both ports and their host cities may need to adapt as circumstances change. Some international considerations relate directly to waste management, for example the International Telecommunications Union ITU-T Y.4209 standard includes waste management considerations in its standards for port-city interoperation (D'Amico et al., 2021).

Regional agreements can help provide common goals and common standards. Countries around the Baltic Sea, which faces particularly challenging pollution problems due to its relative isolation from the wider ocean, joined together in creating the Baltic Sea Action Plan (Vaneeckhaute & Fazli, 2020). This plan was specifically targeted at environmental challenges, including a reduction in waste dumped from ships into the ocean.

PRACTICES WITHIN EAST ASIA

(NSOC Thailand / TEI)

The East Asia seas is an important conduit for 90% of world trade through shipping, with these seas seeing an increasing portion of global trade routes and world shipping. Globalization and development have triggered an increase in global freight transport, both in terms of ship numbers and in ship size. This has necessitated innovation in infrastructure and practices.

Some ports in Asia are at the global forefront of port sustainability (Alamoush et al., 2021). Many policies have developed within this region to reflect varying challenges. Some regional standards have developed, such as the Port Safety Health and Environmental Management System (PSHEMS), which has certified ports in three countries, although there is significant room for further regional innovation.

Indonesia

Indonesia has specific laws on waste management which are related to their environmental protection laws, but also under health laws. Of particular concern to Indonesia is shipping waste relating to fishing, due to the important fishery sector in the country. The seasonality of fishing creates issues in these ports, as facilities which may be adequate for port activities in the off-season can be deeply inadequate during period of high activity (Dwiyanto et al., 2019).

The first official 'Green Port' in Indonesia was established in June 2016, at the Port of Krakatau Bandar Samudra (KBS) Cilegon. Indonesia partially views waste management through the lens of climate change, due to the link between waste and emissions. Improving waste handling is seen as a potential way to reduce the emissions of ports (Kristanto et al., 2020).

Cilegon, Indonesia (Sammy Kris tanto / Panoramio)

The Philippines

Domestic shipping is a vital part of life in the archipelagic Philippines

(Lawrence Ruiz / Wikimedia Commons)

The Philippines joined the IMO on 2 October 1983, implementing a Policy on the Prevention and Control of marine Pollution in 1985. 1995 saw the passing of Anti-Pollution Measures within the Port Zone and the Policy on the Prevention and Control of Marine Pollution. 2001 saw the ratification of MARPOL 73/78, and in 2003 the implementing guidelines on MARPOL 73/78 for Shore Reception Facilities were put in place, to be implemented from 2005. 2018 saw new guidelines put into place, and further management frameworks and codes have continued to be developed in the years since then (Jens-Peter Oehlenschlaeger, pers. Comms. 2022).

Waste management at ports involves the cooperation of many government bodies, including multiple divisions within the Department of Environment and Natural Resources and the Department of Transportation. Over the maritime sphere alone, there is MARINA, the Philippine Coast Guard (PCG), and the Philippine Ports Authority (PPA), with their responsibilities being delineated in various legislative and executive acts (PEMSEA, 2022). The PPA is responsible for implementing MARPOL requirements, and is responsible for the issuing of permits and accreditation to relevant bodies which provide waste shore reception facilities (Jens-Peter Oehlenschlaeger, pers. Comms. 2022).

(Judgefloro / Wikimedia Commons)

It is mandatory that PPA ports have shore reception facilities (SRF), and mandatory that garbage is discharged from vessels. This is the only aspect of MARPOL that is currently compulsory, with there being a fixed

fee for SRF usage. Previously, fees were fixed per cubic meter. Foreign cargo vessels and domestic ones pay according to differing fee tables. Ship generated waste is usually collected on-board and then shifted to a truck, which delivers it to a sanitary landfill (Jens-Peter Oehlenschlaeger, pers. Comms. 2022).

SRFs are run using the Polluters Pay Principle, with a combined fee system that includes a fixed fee and a direct fee. Transactions are made upon presentation of waste delivery receipt. There are currently 8 accredited SRF providers by PPA, who operate different ports nationwide. Some ports lack a service provider, and in those SRF is handled by PPA management (Jens-Peter Oehlenschlaeger, pers. Comms. 2022).

The Philippine Coast Guard has a mission to enforce national and international maritime laws. A memorandum circular on oil marine pollution was issued in 7 October 2005, to meet MARPOL Annex I. Other circulars include: Marine Pollution inspection Apprehension Report from 18 June 2006, Inspection Guidelines for Domestic tankers from 25 June 2006, Accreditation of oil water separators and other equipment from 17 October 2005, Issuance of International Oil Pollution Prevention Certificates to Philippine Registered Vessels in 28 October 2005, and Prevention of Pollution from Garbage from 29 December 2014. The discharge of sewage into Philippine waters is prohibited within areas closed to shore, following a 19 December 2014 memorandum on pollution from sewage as well as a memorandum for the dumping of wastes in Philippine waters.

Port Reception facilities are defined as a physical system ashore or afloat for receiving discharges of oil refuse and other types of waste. The PCG definition is similar, and can be run by the port authority or a mobile service approved by the PPA. Mobile facilities include floating

facilities (e.g., Boats) or terrestrial ones (e.g., vehicles). The Philippines accredits local waste disposal services at each port (Jens-Peter Oehlenschlaeger, pers. Comms. 2022).

In 2020 the Philippines set out a new fee system for solid waste, oily liquid, and noxious liquid, which was later amended in 2021 due to the COVID-19 pandemic. There are separate fixed fees for domestic and foreign vessels to cover garbage under one cubic meter, with additional fees for larger volumes of waste. The basic fixed fee is mandatory for all ships, whether or not waste is delivered into the port (Jens-Peter Oehlenschlaeger, pers. Comms. 2022). In organizing new guidelines for port reception facilities, the Philippine Port Authority (PPA) engaged in wide stakeholder consultation, including opening it up to public comment (GIZ 2022).

Waste inspection at Batangas Port (PEMSEA)

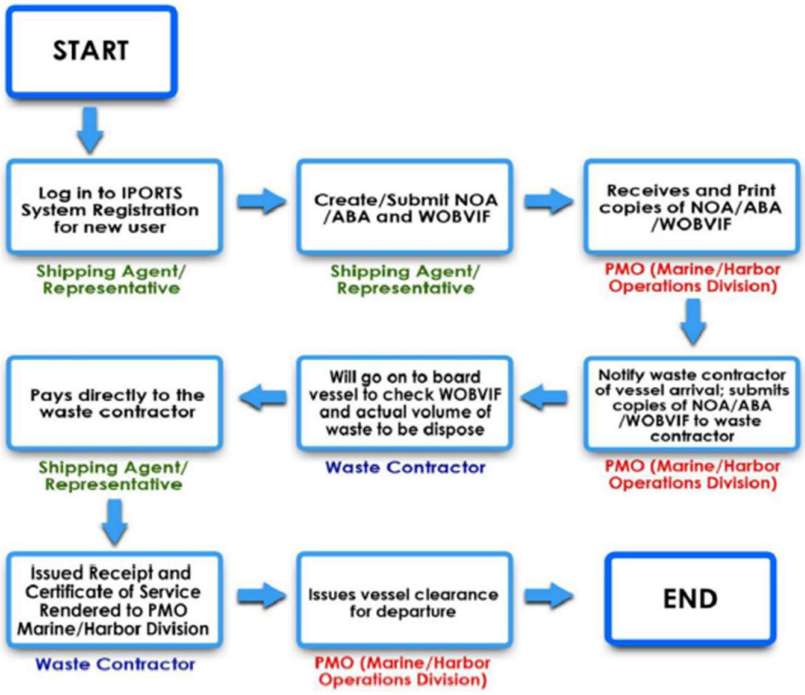
A pilot project in the Port of Batangas has tracked the impact of this new fee system. In this port there is an independent shore reception waste reception company. Waste reception fees are paid upon entry into the port, with a certificate being provided which is needed to clear

vessel departure from the port. A Waste on Board Vessel Information Form is manually submitted at the shore reception for regular domestic ferries, whereas for international shipping vessels the form is collected and the waste is manually observed by shore staff who board the ship when it is in port. The shore reception company submits copies of this paperwork to the Batangas port authorities, who then can authorize vessel departure. 5% of waste management port fees go the PPA (GIZ 2022).

The Port Management Office (PMO) of Batangas explicitly targets ship waste, port and terminal waste, and cargo residues. They have developed one waste management manual to cover all waste collections within their port, prohibiting waste being collected outside of this process (PPA, 2022). This provides an easier scope to monitor and manage waste management processes within the port. While solid waste is regularly collected, liquid waste requires advanced notification of two weeks, due to the need to get specific approval of this from the national environment agency. Furthermore, international vessels entering the country are required to dispose of oily and noxious liquid waste at the first port of call in the Philippines (PPA, 2022).

Ships at Batangas Port *(Andrea Albini / Panoramio)*

In the Philippines, the manual Waste on Board Vessel Information Form (WOBVIF) is standardized for all ports. It is to be filled up for ships and covers different types of waste. However, it is being integrated into a digital system, the Internet-based Ports Operations Receipting and Terminal System (IPORTS), which saw its use being in 2019. This is accessed by the ship operator, where the waste form is submitted alongside a notice of arrival and berthing applications. Initially voluntary, the electronic submission is expected to become mandatory. Currently, the indirect tariffs do not include sewage waste, which is still arranged directly with the shore companies (GIZ 2022). All roles and responsibilities for the port authorities, shipping companies, shipping agents, waste providers, and national authorities are clearly laid out in the published solid waste management plan (PPA, 2022).



(PPA, 2022)

While implementing these changes, it is thought impractical to simultaneously adjust existing rates, although it is expected that the implementation and scaling up of IPORTS will optimize waste collection. Mandatory online waste notification is expected to be implemented first for large commercial domestic shipping, as well as for international shipping. It is thought other vessels, including smaller domestic shipping and fishing fleets, will be able to directly organize an arrangement which will require less frequent submissions into the portal.

For very small ships, crews are allowed to dispose of waste from the ships themselves within designated areas. This provides flexibility for ships that make multiple calls in a day, or reliably delivers smaller amounts of waste than expected under the indirect fee system. Such considerations will also apply to the schedule of fee payments. It is expected that when implementation becomes more consistent and widely understood, that waste submissions can be given 24 to 48 hours in advance of arrival at port for all ships whose journeys last longer than a day and are above a certain size. Exceptions may be made for ships with dedicated on-board storage, and for specific ship categories such as tug boats and dredge boats (GIZ 2022).

Waste should be discharged before or during cargo transfer, unless this interferes with other port operations. Furthermore, biodegradable solid waste is expected to be separated from other waste when deposited into the port, and waste from international vessels is expected to be disinfected. For docked vessels, the indirect fee covers only the early collection, with later collections having direct fees without a fixed charge (PPA, 2022).

Recommended Waste Management Structure

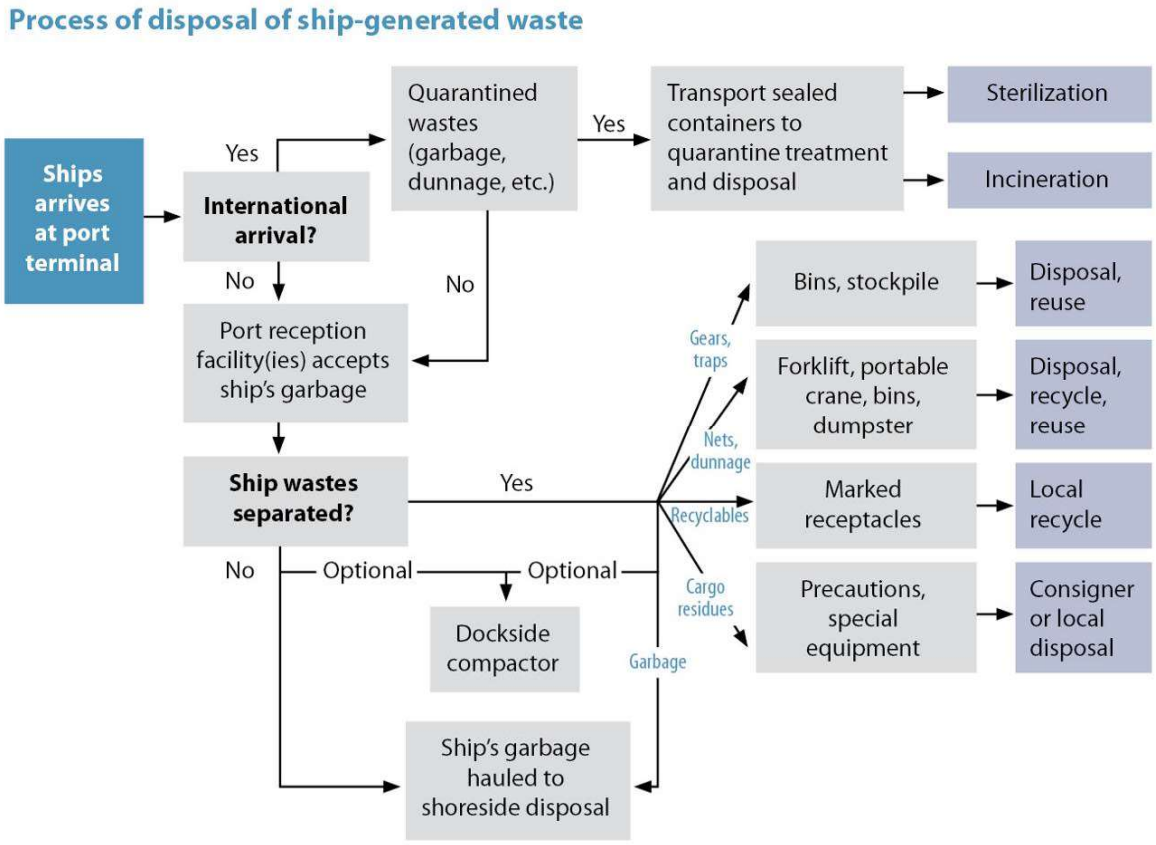
Waste management activities \ Ships categories calling Batangas port	Larger commercial ships (domestic/ international)	Larger ferries	Smaller tourist ferries	Port and fishing vessels
Waste notification	Mandatory through the i-port system	Exempted annual agreement with port	Exempted quarterly agreement with port	Exempted quarterly agreement with port
Waste fee payments	Mandatory through the i-port system	Based on annual negotiations/ monthly payments	Based on quarterly negotiations/ weekly payments	Based on quarterly negotiations/ quarterly payments
Waste collection	Individual by waste operator	Individual by waste operator	Daily at special designed area	Daily at special designed area

(GIZ, 2022)

Such pilots are occurring alongside the Maritime Industry Development Plan (MIDP) 2019-2028, crafted by MARINA authorities to provide a joint understanding on the maritime sector's development. It seeks to increase domestic ship production and repair capacity under the expectation of continuing global growth, while also seeking to better enhance the safety, efficiency, and sustainability of the industry in the Philippines (PEMSEA, 2022).

The Philippines specifically lists some port services that fall within the sphere of ship waste management. These include cleaning services, environmental services, laundering, port terminal services including cargo handling, and the collection of ship-board waste. Waste management is included within the ten-year MIDP plan, with an initial focus on institutional strengthening to more clearly identify

responsibilities, both for implementing specific activities and for overall coordination (PEMSEA, 2022).



(PEMSEA, 2022)

Vietnam

In Vietnam, only the largest posts (Ho Chi Minh City, Vung Tau Province, Da Nang City, Hai Phong City) have adequate facilities to receive and manage ship-sourced wastes. The national government is seeking to address this, developing regulations (e.g., Circular 41 from 14/11/2017) that aim to improve the waste reception facilities used throughout the country's ports (Jens-Peter Oehlenschlaeger, pers. Comms. 2022).

Under the 2015 Vietnam Maritime Code, ships and seaports must have environmental protection equipment installed as part of construction,

among other stipulations. For ongoing activities, that law along with the 2014 Law on Environmental Protection and the 2015 Law on Natural Resources and Environment of Sea and Islands oblige ships and ports to dispose of waste in line with international treaties. Some local areas, such as Ho Chi Minh City, have their own regulations for ships at their ports (GIZ, 2022).

Hai Phong Port (RSOC Viet Nam / PEMSEA)

Ports in Vietnam fall under the jurisdiction of The Maritime Administration (VINAMARINE), which is part of the Vietnamese Ministry of Transport (MOT). This MOT is responsible for implementing MARPOL within Vietnam, including working towards full compliance with the MARPOL regulations on ship and port waste management through a complete legal framework.

Currently, waste management is included both as part of maritime law (through the Maritime Code of 2015) and environmental law (through the Law on Environmental Protection of 2014), which are further clarified through specific government decrees and circulars (Jens-Peter Oehlenschlaeger, pers. Comms. 2022). Waste that exits shipping leaves the jurisdiction of MOT, falling under the jurisdiction of the Ministry of

Natural Resources and Environment (MONRE) (GIZ, 2022). This means cooperation is needed between both bodies.

A pilot project in the Cai Lai port of Vietnam produced recommendations for operational issues and regulatory amendments. They are seeking to develop a better online mandatory waste notification system for the port, and shift the way they charge waste management port fees to better incentivize the conveying of waste to the ports and thus cost recovery for the ports (Jens-Peter Oehlenschlaeger, pers. Comms. 2022). This port is part of the Saigon New Port System (GIZ, 2022).

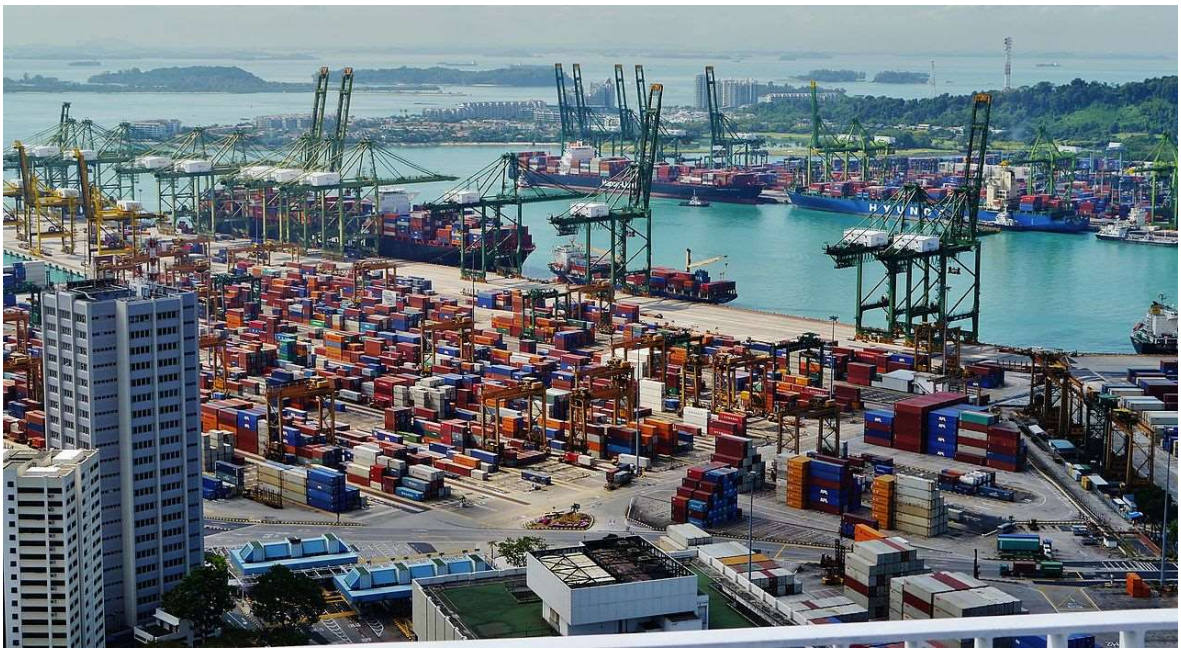
Nha Trang Port (calflier001 / Flickr)

Currently, vessels need to submit appropriate waste declarations at least 24 hours before arrival at the port to a local agent, who then passes it on to regional maritime Port Authorities. It is the responsibility of the port, or a company contracted to the port, to have appropriate waste collection facilities ready to receive ship-sourced waste. Upon

receiving the waste, the waste operator must provide a standardized receipt to the ship master. Waste companies are required to be approved by MONRE and collect waste in a responsible manner preventing leakage and adhering to national regulations. There are some inconsistencies between domestic law and definitions under MARPOL that make waste classification complicated for incoming ships, and while most hazardous waste is strictly controlled other waste has more diffuse responsibility (GIZ, 2022).

Singapore

Singapore's small size and heavily integration into the global shipping network leaves it acutely cognizant of the importance of long-term shipping sustainability. It has a specifically established Inter-agency Taskforce on Marine Litter, which brings together multiple government agencies to both coordinate existing efforts on marine pollution and to invest in research towards the future (MSE, 2022).



Port of Singapore (Zairon / Wikimedia Commons)

The Marine and Port Authority of Singapore carries out active monitoring for shipping pollution in Singaporean waters, and checks waste logs for both domestic and foreign vessels. Waste disposal sites are located at the port for individuals from ships to directly deposit waste at. For ships at port, the port authorities carry out daily waste collection through five dedicated ships. This collection is complimentary up to a certain level of waste, and ships wishing to dispose of waste in excess of this amount can pay an additional fee (MSE, 2022). Thus, Singapore uses a base indirect fee as part of general anchorage with direct fees added on top where applicable.

The port authorities also directly act to remove waste from the ocean. There are nine ships dedicated to removing floating waste from the ocean, which in addition to its environmental impacts serves the benefit of removing potential hazards for boats. Singapore has also explored the use of 'seabins', floating waste collection platforms which passively collect waste from the sea surface. They are also investing in creating autonomous waste collection vehicles (MSE, 2022).

RO Korea

Ports have been a crucial part of the economic development of the Republic of Korea. The 1967 Act of Ports devoted specific attention to port expansion, and the volume of cargo they have handled has continued to grow since (Kim et al., 2011).

RO Korea has Rules on the Prevention of Pollution on Ships, which are managed by the Department of Maritime Industry Technology within the Ministry of Oceans and Fisheries (MOF) (MOF, 2021).

The Prevention of Pollution from Ships strategy includes explicit acknowledgement of areas of more strict regulation, namely the Baltic Sea, the English Channel, North American Waters, and the Caribbean Sea (MOF, 2021). This inclusion of external models suggests a desire to keep higher benchmarks in mind, and reinforces recent moves to create reduced emissions area within Korean waters.

Busan Port *(Busan Metropolitan city)*

Requirements covering different sorts of waste production and discharge. Specific rules regarding the oil content of discharged liquids, as well as to the rate at which waste can be discharged at sea. There are specific requirements for the storage of sewage and its discharge to shore facilities, both in terms of implementation and in terms of record-keeping. Similar requirements exist for other types of waste, whether it is discharged or incinerated (MOF, 2021).

Ships involved in international voyages are required to have hazardous liquid substance discharge forms in English and Korean, and some tasks require professionals and/or equipment that has been approved by MOF. Cargo hold washing water must be transferred onshore (MOF, 2021).

Plastic products are explicitly included as a substance that needs to be collected and properly managed, including specific notes of fishing nets, ropes, garbage bags, and plastic incineration products (MOF, 2021).

Many of the regulations focus on requirements for ship management, with documents relating to ship energy efficiency, oil consumption and supply, ship plans, ozone-related facilities, and engine logs needing to be submitted to the regional Ocean and Fisheries Administration office. Regular inspections are needed for all ships in order to be certified for marine pollution facility compliance (MOF, 2021).

For the development of ports, there has been a longstanding policy of integrating private and public capital through Public-Private Partnerships (PPP). This was made explicit in the Act on Promotion of Private Capital in Social Overhead Capital shortly before the turn of the century, an Act which specifically included ports as a target area for increased private funding (Kim et al., 2011).

Historically, most PPP projects were Build-Transfer-Operate schemes focused on the berthing needs, while other improvements to port facilities remained funded exclusively by the ports (Kim et al., 2011). This is likely due to that being the area where revenue felt most secure to private entities. The challenge for the future is extending such partnerships into other areas of port management.

CONCLUSION AND RECOMMENDATIONS

Container ships at Incheon Port (Incheon Port Authority)

It is increasingly clear that on many levels, be it local, national, or international, it is vital to consider sustainability as part of successful and long-term planning. Sustainability needs to be considered within port activities actively looking towards the future.

A key part of this sustainability is going to be the aspects that relate to waste management. Waste management is a broad topic, including waste produced through port activities and waste handled from ships. Ports in this role play as significant a role in waste logistics as they do for cargo and passengers.

This role also provides influence. Ports are part of a system, meaning that the path to increased sustainability does not rely fully on their individual efforts. Ports wield influence in supply chains, regulations at various levels of government, and transboundary concerns. Cooperation is key to effective achievement of any port sustainability targets. It also

allows for a considered approach that minimizes risk and improves economic sustainability, especially if that cooperation extends to other domestic ports or ports nearby within the region.

In general, there are recognized barriers relating to cost, capacity, and complexity. Overcoming these both individually and in cooperation with stakeholders should be short-term priorities towards the wider long-term goals. Furthermore, over the long term it is worth any particular plan be flexible, able to adapt to new technologies and innovations. Digitization has shown huge potential in transforming port operations, both for waste management and otherwise, and may continue to do so.

This is particularly true within the specific circumstances of Incheon Port, for which any plan would need to be tailored. The Ministry of Ocean and Fisheries Rules on the Prevention of Pollution on Ships has been regularly revised and updated since its creation, with new aspects added, current aspects revised, and outdated aspects removed. This presents a challenge in creating unknown variables relating to future regulation, but also opportunities in that any changes and innovations that the port may want to adopt might be considered within future regulatory revisions.

With its considerations of innovations in regions elsewhere in the world, along with an already advanced marine waste management framework, it is likely that the Rules on the Prevention of Pollution on Ships will continue to be revised with an aim of achieving global leadership. Its provisions are likely to exceed the minimal requirements of international regulations, even as those minimal requirements may themselves shift. MARPOL may be updated in further years, so there will be a need to be forward looking and able to adapt when needed. Notably, a sulfur Emissions Control Area has already been created in an area covering

Incheon Port, highlighting national government ambitions towards pollution reduction.

Incheon Port lies along a convoluted coastline with many bays, and is itself within a bay that is part of the Yellow Sea. This means local pollution is going to be a key consideration for waste management. This management needs to consider not just the port, but the ships and land transport that sustain port activities. It should also be holistic, integrated into wider waste streams and accounting for the various waste types created by port and ship activities.

To create an efficient system that works, all key stakeholders need to be involved. Ensure waste definitions and classifications match international standards where possible to ease international shipping, taking into account domestic law and needs.

The port should continue using standard waste notifications, and consider electronic systems which can ease submission and analysis, as well as monitoring and assessment. There should be clear procedures for communications within the port, as well as for incoming and outgoing ships. Ship waste manuals and guides should be readily available in Korean and English, and perhaps other relevant international languages.

To further ease waste transfer, notification forms should as much as possible match and be compatible with both domestic and international waste definitions and standards. A push for full electronic reporting could both increase efficiency and reduce costs, and as such it may be worth making support available to ships and stakeholders who do not currently possess appropriate digital capacity.
Promoting segregation is likely to be key to effectively and rapidly handle waste transfer from ships, so segregation should be promoted

both on incoming ships and in shore reception areas. For some waste types, it may be beneficial to developed offshore facilities, which can absorb some waste before the ship is docked and taking up limited berthing space. Different facilities can be targeted to different ship types, such as cruise ships.

When considering fee systems, it is likely some form of indirect fee would be useful. Working together with regulatory authorities, such fee creation should consider the twin targets of cost recovery and disincentivizing dumping, the considerations of which may differ. Such fees can therefore be differentiated for different ship types and origins as is optimal.

Meanwhile, in-port procedures to service ships should be designed as environmentally friendly as possible. Contingency plans should exist for failures in waste management systems, and there should be full clarity as to the extent of responsibility for all actors involved in the port, such as port authorities and private waste companies. Procedures for information sharing between these various actors for information transfer and verification should be clear and established. Reporting, monitoring, and enforcement mechanisms similarly should be developed and included in standard regulations and practices.

Most importantly, to see improvement in port sustainability, and with this the various related ancillary socioeconomic benefits, there must be a willingness to change!

Recommendations for Incheon Port

Within the region, Incheon Port has readily engaged in questions surrounding sustainability, leading initiatives to improve both practice and future innovation. Continued development means both an awareness of global trends and ideas, and an effective local understanding of the situation regarding an individual port. Emphasis should continue on digitalization, augmenting existing port and ship waste management measures. E-notifications in shareable and understandable formats should become standard, and used to refine cost incentive recovery schemes.

The port should continue to sponsor and co-organize relevant trainings, such as on new cost incentive recovery schemes, using new digital tools, changes to international, regional, and domestic reporting standards, and other relevant port waste management skills. These complement existing annual conferences on innovation and research which PEMSEA has collaborated in, which can be expanded to include other shipping and port stakeholders throughout the region. Reports such as this one can be disseminated domestically and regionally.

Similarly, already ongoing projects and initiatives in the region can be further augmented. These include the EU-GIZ project on shipping emissions, partnerships with PEMSEA, KOEM, and KIOST, and domestic policies and best practices for managing ship waste. Other ports should be encouraged to share their experiences, best practices, and lessons learned, as part of commitments to UNSDG14.1 and MARPOL.

Given the regional location, domestic support, and importance within a maritime-based economy, Incheon Port has the potential to expand its global leadership in port sustainability. Such an opportunity should not go to waste.

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Incheon Port Authority was established in 2005 to develop Incheon Port as a competitive logistics base and thereby contribute to the national economy. The goal of IPA is to develop port facilities and hinterland, as well as to improve expertise and efficiency in port management and operation, so that Incheon Port establishes itself as a leading base station for exchange in the Yellow Sea region. With the establishment of IPA, Incheon Port's competitiveness has been enhanced with reinforced marine transportation, port and logistics functions. Incheon Port is continuously developing, strengthening its position as the core logistics center of Korea and contributing to the national economy.

In public recognition of IPA's achievements, the agency was certified with the public agency management result evaluation class A among national port authorities. Existing resources and capabilities have been improved through tremendous efforts leading to an increase in asset valuation (2.8 trillion KRW) by 35%, six-fold growth of sales revenue (126 billion KRW), and expansion of manpower from 118 personnel to 200 personnel compared to the figures at the time of establishment. Incheon Port Authority will strive to make Incheon Port a top-notch port with cargos, passengers, logistics, and tour business coordinated through the Golden Harbor Development Project focused mainly on constructing Incheon New Port, the New Incheon International Ferry Terminal, and other terminals.

PEMSEA (Partnerships in Environmental Management for the Seas of East Asia) is a regional organization dedicated to fostering and sustaining healthy and resilient coasts and oceans, communities and economies across the seas of East Asia. It builds sustainability through holistic and integrated management, and partnerships both in the region and internationally.

COUNTRY PARTNERS

Cambodia, PR China, DPR Korea, Indonesia, Japan, Lao PDR, Philippines, RO Korea, Singapore, Timor-Leste, Viet Nam

NON-COUNTRY PARTNERS

- ASEAN Centre for Biodiversity
- Coastal Management Center (CMC)
- Conservation International (CI) Philippines
- International Center for the Environmental Management of Enclosed Coastal Seas (EMECS)
- IOC Subcommission for the Western Pacific (IOC/WESTPAC)
- International Ocean Institute (IOI)
- International Petroleum Industry Environmental Conservation Association
- International Union for Conservation of Nature – Asia Regional Office
- Korea Environment Institute
- Korea Institute of Ocean, Science and Technology
- Korea Maritime Institute
- Korea Marine Environment Management Corporation
- Marine Biodiversity Institute of Korea
- Norwegian Institute for Water Research
- Northwest Pacific Action Plan
- Ocean Policy Research Institute
- Oil Spill Response Limited
- Plymouth Marine Laboratory
- PEMSEA Network of Local Governments for Sustainable Coastal Development
- UNDP/GEF Small Grants Programme
- UNDP/GEF Yellow Sea LME Project (YSLME)
- UNEP Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (UNEP/GPA)

Maritime Collaborators

PEMSEA is a unique regional coordinating mechanism that operates at the local, national, and regional levels. It works on a range of coastal and marine management programs such as biodiversity conservation, climate change and disaster risk reduction, marine pollution and solid waste management and cross cutting programs on ocean governance, capacity development and knowledge management and blue economy and sustainable financing under the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA).

The seas of East Asia support 30 percent of the world's coral reefs, and include six large marine ecosystems areas. At the same time, they supply 40 million tons of annual marine capture fisheries, produce more than 80 percent of the world's aquaculture output, and are home to nine of the world's 10 busiest seaports.

For three decades PEMSEA has provided solutions for effective management of coasts and oceans across the seas of East Asia. PEMSEA works with national and local governments, companies, research institutions, communities, international agencies, regional programs, investors and donors.

Thomas Bell is a Programme Manager at PEMSEA, working on marine pollution and related topics, following a broader interest and understanding of coastal and marine ecosystems. Mr. Bell has a MRes in Ecological, Environmental, and Conservation Science from Imperial College London.

Projects PEMSEA is currently undertaking with regional and international partners include:

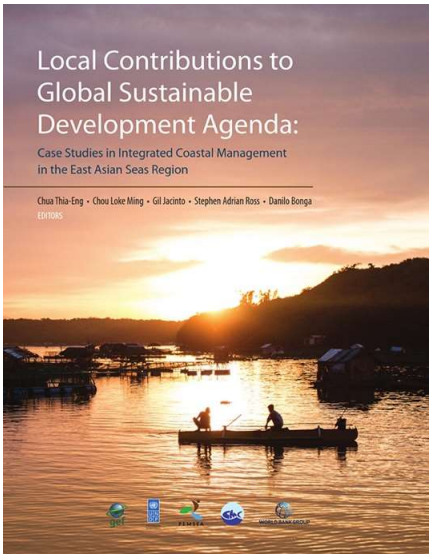
The GloFouling Partnerships Project is a global collaboration towards better responses to the issue of marine biofouling, where invasive species are moved via international shipping.

The Blue Solutions maritime decarbonization project is focused on the challenge of reducing the climate change impact of maritime shipping, taking a whole-systems approach to the port and logistics network.

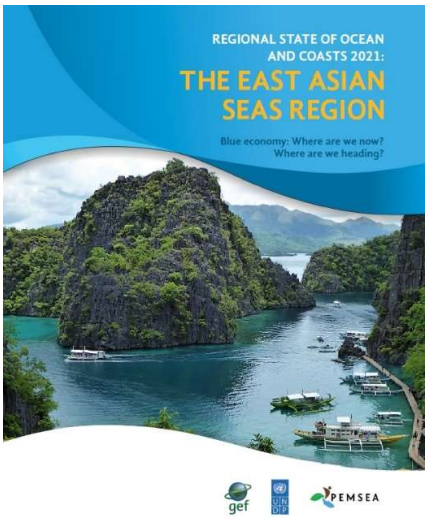
PEMSEA is a partner to the Rethinking Plastics: Circular Economy Solutions to Reduce Marine Litter project, whose work includes finding better solutions for plastic waste in ports.

Recent PEMSEA publications include:

The **PEMSEA Story**, covering 28 years of collaboration for the seas of East Asia.



Local Contributions to Global Sustainable Development Agenda: Case studies in Integrated Coastal Management in the East Asian Seas region, sharing examples and ideas for the many sectors involved in Integrated Coastal Management (ICM) based on two decades of practical experience throughout the seas of East Asia.



The **Regional State of Ocean and Coasts 2021** report compiles up to date information on the state of the oceans and coasts around the seas of East Asia.

PEMSEA maintains the SEA Knowledge Bank, a collection of accessible resources on the seas of East Asia.

More information about PEMSEA can be found at the following locations:

The PEMSEA website

(www.pemsea.org)

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