European maritime transport and port activities: identifying policy gaps towards reducing environmental impacts of socio-economic activities

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Maritime transport and port activities contribute to multiple environmental pressures which compromise direct and indirect socio-economic benefits derived from the goods and services of the marine and coastal ecosystems. Concentrations of maritime transport and port activities, combined with other socio-economic activities, result in hotspots of environmental degradation. To ensure environmentally and economically sustainable ecosystems it is necessary to regulate socio-economic activities such as maritime shipping and ports. Concerns about cumulative pressures on the marine and coastal environment have led to a policy response from European policy makers to move away from sectoral measures which consider maritime activities in an isolated fashion to measures which use an integrated and ecosystem based management approach. Through the Marine Strategy Framework Directive (MSFD), targets for healthy and sustainable marine and coastal ecosystems are established and based on descriptions of Good Environmental Status (GES). However, while EU policy seeks to address the environmental status of marine and coastal environments, some pressures (e.g. underwater noise, ballast water, anchoring and shading) created by the maritime transport and ports sector go unregulated. This article highlights environmental pressures and impacts linked to maritime transport and ports and points to policy gaps which require further attention by researchers and regulators.

Keywords: maritime shipping, ports, socio-economic assessment, environmental pressures and impacts, ecosystem based management, Marine Strategy Framework Directive

1 Introduction

Shipping and ports are essential to the EU economy, as they facilitate the trade of materials and the import and export of goods to and throughout Europe. However, the European shipping and ports sectors cause multiple pressures on the marine and coastal environment [1-3]. Environmental pressures include abrasion (impact with the seabed), introduction of non-indigenous species, introduction of non-synthetic and synthetic compounds, smothering and sealing, marine litter, and underwater noise. At the same time other socio-economic activities (e.g. fisheries, energy production, recreation and tourism, etc.) also contribute to these environmental pressures, creating cumulative impacts on marine and coastal ecosystems. Concentrations of maritime transport and port activities combined with other socio-economic activities can result in hotspots for environmental pressures. Environmental degradation can consequently have negative impacts on socio-economic activities which depend on the goods and services provided by marine and coastal ecosystems [4-7].

In order to reduce the environmental pressures on marine and coastal ecosystems, European legislators have adopted policy responses. In 2008, the European Union (EU) introduced the Marine Strategy Framework Directive (MSFD) to protect and conserve the marine environment and is the environmental component of its marine water strategy set forth in the Integrated Maritime Policy (IMP). In addition to European policies, international agreements under the International Maritime Organisation (IMO) regulate the environmental performance of ships, as shipping vessels are mobile, regulation on pollution cannot be based on national boundaries. Furthermore, regional conventions (i.e. Helsinki Convention, Oslo Paris Convention, Barcelona Convention, Black Sea Convention) focusing on European marine regions also work to protect marine environments and support sustainable activities. Despite

efforts to reduce environmental pressures through legislation, multiple pressures on the environment created by the maritime transport and ports sector are currently not regulated, compromising EU policy goals as well as socio-economic activities.

Ecosystem based management is a key element of EU marine policy, and entails considering both ecological and anthropogenic dynamics within an ecosystem. Linking socio-economic pressures with ecosystem dynamics is also a goal of the research and reports of the European Environment Agency (EEA) [8] within the work of the European Topic Centre on Inland, Coastal and Marine waters (ETC-ICM) and European Topic Centre for Spatial Information Analysis. A number of research actions, such as those funded under the Seventh Framework Programme, (ODEMM, KNOWSEAS, MEECE, PERSEUS) also include a focus on the ecosystems based management approach and the link between anthropogenic and ecosystem dynamics to support policy decisions.

This article aims to 1) identify gaps in policy which allow environmental pressures to the marine and coastal environment to go unregulated. To do this, the article also seeks to 2) highlight environmental pressures created by maritime shipping and ports and 3) provide an overview of relevant policy, as well as highlight 4) hotspots where environmental pressures may be most significant and 5) the current state of the sectors. To complete this assessment, an in-depth literature review and a quantitative analysis using open statistical databases were conducted.

This article begins with a brief overview of the socio-economic state of European shipping and ports. The second section provides a look at the full spectrum of environmental pressures which result from maritime shipping and ports, as well as discusses cumulative environmental pressures and hotspots of environmental degradation. This is followed by a review of environmental policies for maritime

shipping and ports as well as environmental protection, focusing on international, EU and regional initiatives. Finally, a conclusion is provided to highlight key messages and areas for further discussion.

2 Overview of socio-economic benefits from European maritime transport and port activities

European maritime regions are highly active in terms of socio-economic activities. Maritime regions account for an estimated 40 % of the EU's GDP while the maritime economy represents 3 to 5 % of the EU's GDP [9][1]. At the same time, increasing evidence points to significant environmental degradation in European coastal areas [10]. It is estimated that shipping transports 90 % of Europe's trade and 40 % of all intra-EU trade in tonne kilometres [11]. In 2010, the EU 27[2] shipping industry contributed about EUR 26 billion added value to the economy, which equated to about 26 % of the value added generated by maritime activities [12]. Moreover, shipping is the largest European maritime sector with an estimated 10 000 companies forming the European market [13] making the EU the world leader in shipping with over 9000 merchant ships under EU flags and an additional 4000 vessels flying foreign flags [9]. In the EU 27 plus Norway, it is estimated that 254 119[3] seafarers[4] are employed in sea transport for 2010 [14].

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[1] EC, 2008 does not define 'maritime region'.

[2] Excluding Bulgaria.

[3] It should be noted that it is extremely difficult to provide exact numbers for employment in the EU 27 shipping industry because of several of the industry's characteristics. This is due to a number of factors such as flag and registration status of ships, a lack of clarity over ship ownership and a lack of systematic data collection at a European level. Moreover, many European vessels sail between continents outside of Europe, using foreign crews with short-term contracts.

[4] EU seafarers working on board EU ships, non-EU ships and EU-controlled ships.

Over recent decades, globalisation, EU enlargement and the steady growth of trade with developing economies (i.e. China) have contributed to significant increases in both the import and export of raw materials and commodities. This resulted in unprecedented growth in shipping and its supporting industries [13]. While the global financial crisis led to a momentary substantial decline in economic growth and therefore production, trade and shipping activities, European ports (gross weight of seaborne goods handled in European ports) for 2011shows that shipping activities are rising [15].

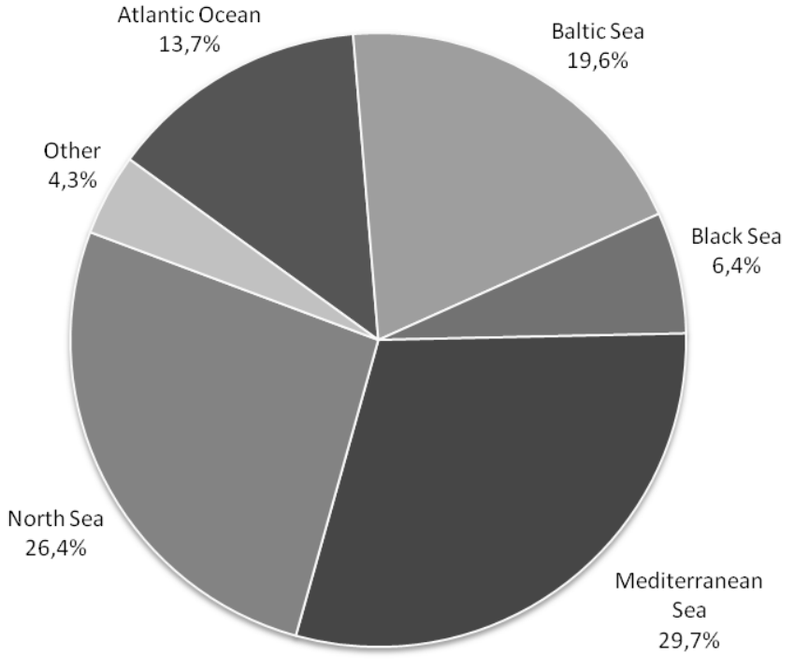
EU overall annual growth rates of maritime freight transport (weight of goods handled) averaged around 2.3 % between 1995 and 2008 (averaging 3.6 % between 2003 and 2006) [16]. Coinciding with the global financial crisis, shipping fell by 12 % in 2009 (to 3.4 billion tonnes) reaching levels similar to those in 2003 [17]. Nevertheless, statistics show that, for 2010, the shipping and ports sectors have begun to make a clear recovery as weight of goods handled climbed to levels comparable to 2005 (3.6 billion tonnes) [15].

EU Short Sea Shipping[5] represented about 62 % of the volume of maritime transported goods, i.e. 1.9 billion tonnes of freight in 2009 [18]. Short Sea Shipping experienced a similar impact to the 2008 financial crisis as overall shipping in the EU [18]. Based on the gross weight of goods transported, 29.7 % of Short Sea Shipping occurred in the Mediterranean, followed by 26.4 % in the North Sea. The Baltic Sea followed on third rank, and experienced a 19.6%, while other regions such as the Atlantic Ocean (13.8 %) and the Black Sea (6.2 %) were less prevalent [19], see Figure

[5] According to Eurostat (the statistical office of the European Union), Short Sea Shipping is defined as the "Movement of cargo by sea between ports situated in Europe as well as between ports in Europe and ports situated in non-European countries having a coastline on the enclosed seas bordering Europe."

1 below. This shows the concentration of shipping activities in the Mediterranean and the North Sea.

Figure 1 EU-27 Short Sea Shipping of goods by sea region of partner ports in 2009 (% based on gross weight of goods) [18]



In the Mediterranean, transport has been steadily growing, with a significant rise of 50 % between 1997 and 2006, mainly due to increased flows of energy products. The Mediterranean is crossed by 30 % of international maritime freight traffic and about 20 to 25 % of maritime oil transport each year [20].

Major European ports experienced overall growth of gross weight handled between 1997 and 2009, with growth being most significant between 2002 and 2008, before falling in 2009 due to the global financial crisis [21]. The three largest EU ports in terms of both gross weight of goods and volume of containers handled were Rotterdam, Antwerp and Hamburg, all located on the North Sea coast [21].

It is estimated that the EU shipping industry will create an added value of EUR 30 billion in 2020 and EUR 36 billion in 2030 [12]. Industry forecasts until 2050 predict high growth rates for shipping, including both extra and intra-EU shipping at 150 % and 100 % compared to 2005 levels [22]. Growth is explained by technological, economic and globalisation trends, as well as weak decoupling of economic and transport activity. Improved ship technology is expected to increase ships' efficiency, making maritime transport even more economically viable, while at the same time other modes of transport are likely to become more congested (i.e. road and rail), making them less economically viable. This may be especially important in the case of Short Sea Shipping [23]. In economic terms, the impact of transportation costs is becoming less important because the unit value of goods transported is increasing (i.e. the ratio value-to-weight of goods transport is growing) [23].Therefore, even under high oil price scenarios, shipping will continue to grow and as such, environmental pressures from shipping will also likely grow.

3 Overview environmental of European shipping and port activities

Maritime transport is an environmentally and energy efficient form of transport, especially when compared to road and air alternatives, and is therefore often supported by government initiatives (e.g. Motorways of the Sea). However, shipping and port activities exert pressure on the marine and coastal environment and there is an increasing interest across different levels of government to address these issues. This section aims to provide a broad overview of environmental pressures and is divided into two sections, operational pressures and impacts and accidental pressures and impacts.

3.1 Operational pressures from maritime transport and ports

Operational pressures and impacts result from the sustained activities of the maritime transport and port sectors and are therefore often relatively well known. The subheadings used in this section are according to the pressures and impacts identified in the MSFD, Annex III Table 2 Pressures and impacts [24].

Abrasion

Ship anchoring and shading, when vessels sit for extended periods of time in one place, may have adverse affects on the marine environment. Though research conducted on these activities is limited, and completely lacking for commercial vessels, indications show that sensitive sea floors (e.g. sea grasses) are damaged from boat anchoring, by including by uprooting plants, which can lead to reduced shoot density and sea bed cover [1]. Therefore, anchoring poses a threat to seabed habitats and the species that depend on them. It could be assumed that anchoring by commercial vessels would have larger impacts than that of recreational or leisure activities, strictly due to the increased size of the anchor [1]. In addition, designated anchoring grounds such as in and around ports and harbours are likely to experience increased cumulative impacts from anchoring [1]. These may also include established areas for bunkering, ship to ship cargo transfers, or waiting grounds for ports. Additionally, ships spending long periods of time in ports and harbours (e.g. for long-term repairs or dismantling) increase the shade cover (i.e. reduce the exposure to the sun) of benthic biota underneath the vessel. Though research is limited, Struck et al. 2004 identified significantly lower abundance and diversity of estuarine macro invertebrates under low bridges, suggesting that ships may cause similar pressures [1].

Introduction of microbial pathogens

The discharge of sewage (e.g. human waste from onboard toilets) or food waste can lead to nutrient and organic matter enrichment. The amount of sewage produced on board ships ranges, depending on the type of ship, with the most being produced on passenger and cruise ships [2]. High concentrations of faecal coliform bacteria pose a significant risk to human health and can require bathing areas to be closed [1].

Introduction of non-indigenous species and translocations

Ballast water is needed to balance and stabilise ships. However, alien species are also transported in the ballast of ships (i.e. the sediments carried in water), and are then introduced into new marine environments when a ship discharges water [25]. Along European coasts, over 1000 non-indigenous aquatic species have been identified [26]. The risk from invasive species is associated with the amount of water transported, the frequency of ship visits and the similarity of environmental conditions for a species [27]. The number one path for the introduction of alien aquatic species in Europe is through vessels, followed closely by canals and to a lesser degree aquaculture [25]. Alien species place pressure on the environment by transporting diseases, altering ecosystem processes, changing biodiversity, disrupting cultural landscapes, and reducing the value of land and water for human activities [25] The result is that introduced alien species have harmful social (including health) and economic impacts [28, 29].

Introduction of non-synthetic substances and compounds

Air pollution is caused by ships which systematically emit engine exhaust as well as exhaust from other on-board operations such as incinerators and cooling installations. The main pollutants are nitrogen oxides (NO_x) and sulphur oxides (SO_x) as well as

carbon dioxide (CO_2) [2] and volatile organic compounds (VOC), which are mainly produced during tanker loading in ports [30]. NO_x emissions greatly contribute to eutrophication and SO_x causes acidification of terrestrial and freshwater ecosystems [2]. Eutrophication in marine waters can have significant effects on marine ecosystems and human health, thus impacting socio-economic activities such as fishing, tourism and leisure activities, by contributing to harmful algal blooms, murky waters, loss of aquatic vegetation and lifeless zones on the sea floor [2]. Furthermore, NO_x, SO_x and CO_2 contribute significantly to global climate change [2]. In 2008, total greenhouse gas emissions from maritime transport for the EU 27 were estimated at 192.7 million tonnes CO_2 equivalent [31]. In European marine regions, the majority of ship emissions come from large cargo ships with over 500 gross register tonnages. Of emissions in EU areas, around 20 % are released within 12 miles of the coastline and about 45 % stem from EU-flagged ships [27].

Oil spills which result from daily operations may be considered small when compared to, for example, spills caused by shipping accidents; however, they are also repetitive and may concentrate in ports and along shipping routes. Therefore, these spills will impact local marine habitats, including physical disturbances, toxic inputs to sensitive species and organic enrichment to sediments. Ships of all kinds discharge oily residues into water under normal daily operations. In addition, they must clean their ballast and bilge water tanks, which results in considerable pollution [20]. The impact of oil and toxic substances on the environment depends on the size of the spill and the type of oil or substance as well as weather conditions, location and a number of other factors [2]. Operational oil spills pose a serious threat to the environment, especially because attention and mitigation measures tend to be focused on accidental spills, which can be highly visible and intense [1]. Globally, most oil spills are the result of routine

operations, most often occurring in oil or port terminals [1]. Indeed, the International Tanker Owners Pollution Federation Limited (ITOPF) reports that small and medium sized spills account for 95 % of all the incidents recorded. Of these, a large percentage, 40 % and 29 %, occur during normal operations, such as loading and discharging in ports and oil terminals [32].

Introduction of synthetic compounds

Antifouling paints, paints which protect a ship's hull from biological fouling, have been used for several decades, and their toxic effects are widely recognised and discussed [1]. Antifouling paints are based on tributyltin (TBT), which is highly toxic for marine organisms [33]. TBT is often found in high concentrations in areas such as ports and shipyards, usually accumulating in sediment [33]. Moreover, TBT is found in high concentrations in marine species: molluscs are very sensitive to the chemical, while it also accumulates in the tissue of top predators such as bottlenose dolphin, blue fin tuna and blue sharks [1].

Marine litter

The intentional, illegal or accidental disposal of waste and discharge of sewage into marine ecosystems can have severe effects on marine life and water quality deterioration [1]. Although land based sources of waste and sewage are significant, shipping is considered a major source of marine inputs. The most damaging form of marine waste is considered plastics, which makes up to 80 % of all marine debris [1]. Plastic bottles and particles can lead to the death of marine species (e.g. especially fish catching birds) [2]. Waste can also have consequences on the entire food web by entering and accumulating in animals such as mussels [2]. Moreover, marine plastics can have significant economic costs, for instance on tourism through fouled beaches and

litter removal; on fishing through contaminated catches, restricted catch or damaged gear; to aquaculture due to damaged propellers on workboats; to ports and harbours because of fouled facilities, vessel damage; and to coastal agriculture due to damaged machinery and harm to livestock [34].

Sealing

Port construction and expansion of port facilities involves land reclamation and land use to accommodate loading and unloading of goods. Construction may entail sealing or smothering coastal land as well as the destruction of marine and terrestrial habitats. It may also involve the filling of wetlands to acquire land for port development. Port construction can greatly contribute to the fragmentation of natural habitats along coasts and therefore threaten beach dwelling species. The construction of marinas, breakwaters and shoreline developments can also cause changes in a currents sediment supply and consequently cause coastal erosion [35].

Changes in siltation

Dredged materials are categorised as mud and silts or sand and gravel, and often contain some form of contamination such as heavy metals or oil. Materials are either disposed at sea or used for beach nourishment [36]. Dredging can mobilise contaminated materials, such as TBT, which are often locked in sediment over extended periods of time. Disturbing the contaminated materials can pose threats, depending on the amount of contamination, to the environment and water quality in port areas and shipping channels [37].

Underwater noise

Ships are a dominant source of low frequency noise in coastal zones with high vessel traffic [27]. Noise pollution from ships can be wide reaching and can impact fish

behaviour by distracting them and impairing their ability to retrieve vital information from reef noises. Underwater noise can also influence the predator-prey relationship, hindering prey from detecting and avoiding predators [38]. However, noise may also restrict predators that use sound for hunting [38]. Exposure to artificial noise hinders specifically juvenile fish, from finding suitable habitats and protection, making them more susceptible to predators and other threats [39]. At the same time, research suggests that exposure to noise can cause stress in fish and potentially influence reproduction [40]. There is also increasing concern that noise from shipping puts increased pressure on marine mammals, particularly along migration routes. Estimates suggest that background marine noise has doubled each decade since the 1950s in some areas due to the development of faster and larger ships alongside an increase in vessel traffic [27].

3.2 Accidental pressures from maritime transport and ports

Accidental pressures and impacts from maritime transport and ports are the result of unanticipated incidents. Thus, ship and port procedures and regulations, often regarding safety, are intrinsically linked to marine water pollution. Planning and legislation can help to avoid accidents and prepare for the timely mitigation of the impacts of accidents, while improving education, training and employee procedures also plays a role.

Shipping accidents (e.g. caused by groundings or collisions) significantly increase the chances of oil spills and leaks [2] as well as the loss of other substances, whether liquid, solid or gas. Most polluting accidents (which may be extremely small) occur in ports during mooring, loading and unloading operations [20] and cause localised impacts and disturbances. In the Baltic Sea area, there were about 120-140 shipping accidents in 2009, which has increased since 2006 due to a 20 % rise in vessel traffic. This growth illustrates the relationship between transport intensity and environmental pressures. The number as well as size of oil spills in the Baltic Sea has

decreased considerably from 763 spills in 1989 to 178 spills in 2009, with no major spills occurring since 2006 [2]. In the Mediterranean, the majority of shipping accidents occurs in the eastern region due to the many islands in the area [20]. Shipping accidents have varying impacts on the environment depending on the specific characteristics of the accidents. Therefore as shipping intensity increases it is essential that precautionary measures are taken to reduce shipping accidents and their environmental impacts.

3.3 Spatial considerations and cumulative environmental pressures

Europe's oceans and seas are heterogeneous, both in terms of their environmental or ecosystem characteristics and by what they provide in terms of socio-economic uses. The MSFD separates European waters into four regions: the North-East Atlantic, the Baltic Sea, the Black Sea and the Mediterranean Sea, and each of these regions have distinct characteristics and considerations.

Spatial considerations

The multiple marine waters of Europe and its Member States require that shipping and port activities are considered in regard to spatial characteristics and potential conflicts with nature. For example, in areas of high vessel traffic, such as the Mediterranean Sea, high levels of background noise plays a significant role in collisions with marine animals. It is reported that the majority of accidents (e.g. 76.6% in the Mediterranean Sea) with whales and dolphins occur during the summer months, when these animals congregate in feeding grounds that align with the areas where vessel traffic is the highest [1]. Marine animals may be injured or killed due to accidental impact with shipping vessels or propellers. Noise levels can make it difficult for marine animals, such as whales, to communicate with one another or receive acoustic cues, therefore impairing their ability to avoid collision [1].

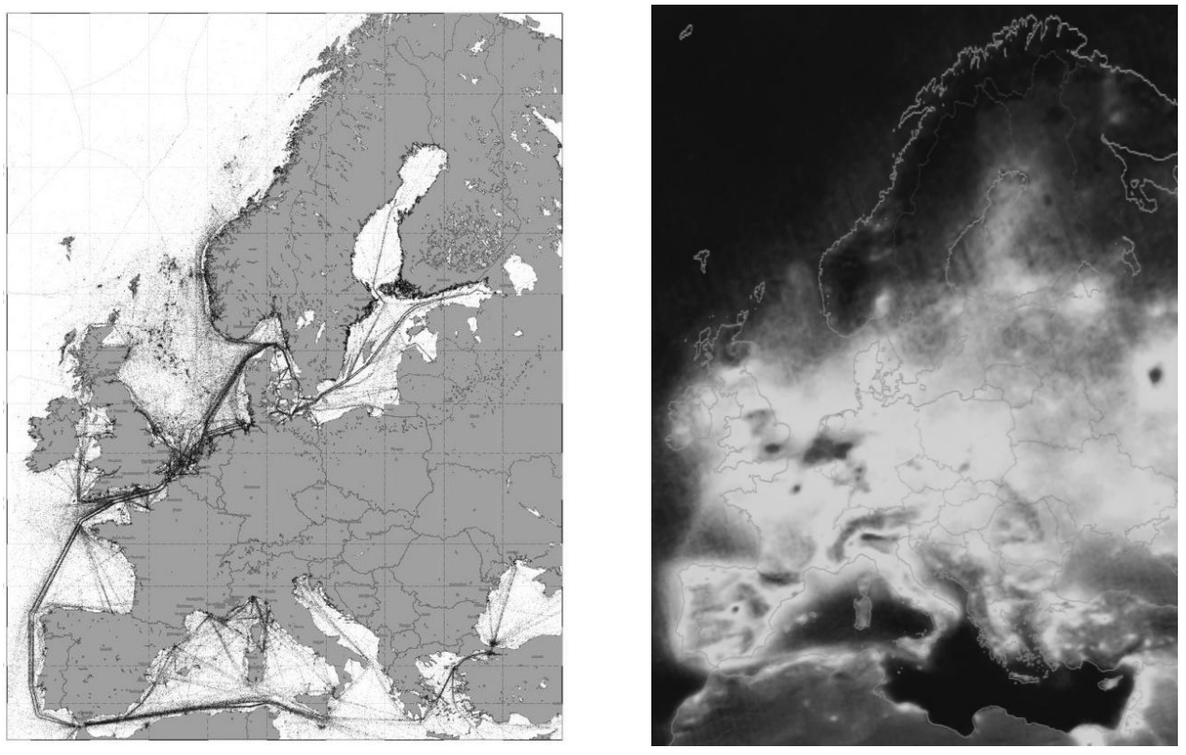
Cumulative environmental pressures

Cumulative pressures on the marine ecosystems can result from several marine or land-based activities and creates hotspots of environmental impact. The North East Atlantic, for example, including the North Sea, is highly relevant for European trade and shipping [27]. The region is also central to a number of other socio-economic activities, such as fisheries, aquaculture, tourism, bio prospecting and oil and gas. More recently the offshore wind energy industry is gaining as a significant and growing sector in the region. Offshore wind capacity in Europe is expected to grow by 17 fold between 2010 and 2020 [40]. The growth in offshore wind energy in the North East Atlantic suggests that planning tools and environmental policy will need to consider shipping and offshore wind energy in a combined manner. This is needed, not only to address potential disputes over the use of marine space (i.e. wind farm locations and shipping routes), but also because growth in offshore wind energy and shipping suggests that environmental impacts resulting from cumulative environmental pressures will also increase. For example, both offshore wind energy production [41] and shipping vessels are a source of underwater noise [1]. Increased underwater noise from both activities leads to greater cumulative impacts on the ecosystem, e.g. fish behaviour, which may have negative effects on the fishing industry.

Shipping also contributes to the eutrophication of marine waters through emissions, and is intensified through cumulative activities. Algal foam is caused by the churning of highly concentrated dissolved organic matter, nitrogen, and phosphorous in waves and ocean water which can be amplified by oil discharges from ships as well as pollution from land-based activities (e.g. sewage, detergents). Emissions created by shipping activities are concentrated along shipping routes as well as near port areas. For example, high concentrations of NO2 emissions are along narrow straights and channels of shipping routes such as through the Strait of Gibraltar and the English Channel.

Figure 2 below shows European shipping routes and concentrations of NO2, which is also the result of land-based activities. In the Baltic Sea, for example, eutrophication represents a significant challenge to human well-being and socio-economic activities such as tourism [2]. The ocean turns a red or green colour (depending on the kind of algae) which can be unpleasant to see and smell for tourists and local residents as well as pose risks to human health. Ultimately, swimming needs to be banned when an algal boom is present. On the Swedish island of Öland, it was estimated that algal blooms cost the tourism industry EUR 27 million in 2005 [2].

Figure 2 Cumulated NO2 from European shipping (2002 -2009) [42]



Cumulative pressures arise when spatial aspects, i.e. location, and environmental pressures from several activities align. The results of cumulative pressures can impact both the environment and socio-economic activities, and therefore require a management approach which takes a holistic approach to environmental pressures.

4 Policy overview

The international nature of maritime shipping and ports means that multiple levels of governance are used to regulate the sectors. Thus a mix of agreements, conventions, policies, and regulations exist across different levels which manage the sectors. The following section aims to identify policy gaps and therefore also highlights the most relevant governing mechanisms for the European waters, and focuses on international agreements, EU policies (including sector policies), and regional initiatives.

4.1 International agreements

The International Maritime Organisation (IMO) is the United Nations' agency responsible for the safety and security of shipping and the prevention of marine pollution from ships. The IMO's MARPOL Convention is the main international convention on shipping and the environment. MARPOL's six annexes pertain to different forms of marine pollution; oil (Annex I), noxious liquid substance carried in bulk (Annex II), harmful substances carried in packaged form (Annex III), sewage (Annex IV), garbage (Annex V) and air pollution (Annex VI) [43].

In addition to the MARPOL convention, several other conventions relate to the prevention of marine pollution from ships. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LC) entered into force in 1975, and in 1996 the London Protocol was adopted. This latter convention prohibits the dumping of certain hazardous materials, and requires permits for the dumping of a number of other identified materials. Annex 4 of the convention provides a list of exempt materials [44]. The Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS Convention) which came into force in 2008 bans the use of TBT paints on ships. It was transposed into EU legislation as EC No 782/2003 [45] and, consequently, all ships that have TBT antifouling paints are banned from entering EU ports [46]. EU Directive

95/21/EC establishes procedures for ports to enforce the ban within the jurisdiction of Member States [47]. Furthermore, the IMO convention for the control and Management of Ships' Ballast Water and Sediments (BWM Convention) was completed in 2004, but as of this writing has not yet entered into force [48]. The IMO has also adopted regulations regarding the energy efficiency of shipping vessels, namely the Energy Efficiency Design Index (EEDI), to reduce emissions from ships [49]. However, this effort is arguably too little to combat the significant contribution of emissions by shipping, and the effects will only be seen after 2019 [50]. Even though the IMO sets out a number of standards, are not sufficient to protect the environment. Furthermore, they show severe gaps, especially in terms of GHG emissions, underwater noise and abrasion or shading.

4.2 Regional initiatives

Regional initiatives are also working to develop environmental protection measures targeted towards shipping and port activities. These include the Oslo Paris Convention (OSPAR) which is the mechanism to protect the marine environment of the North-East Atlantic [51] and the Helsinki Convention (HELCOM) which works to protect the marine environment of the Baltic Sea [52]. Further regional initiatives include the Barcelona Convention which aims to protect the environment and to foster sustainable development in the Mediterranean basin [53] and the Bucharest Convention which works to protect the Black Sea Marine Environment [54]. Regional conventions often facilitate the regional implementation of environmental policies as well as the monitoring of the environmental status. However, they rarely implement additional standards beyond those set at IMO or EU level.

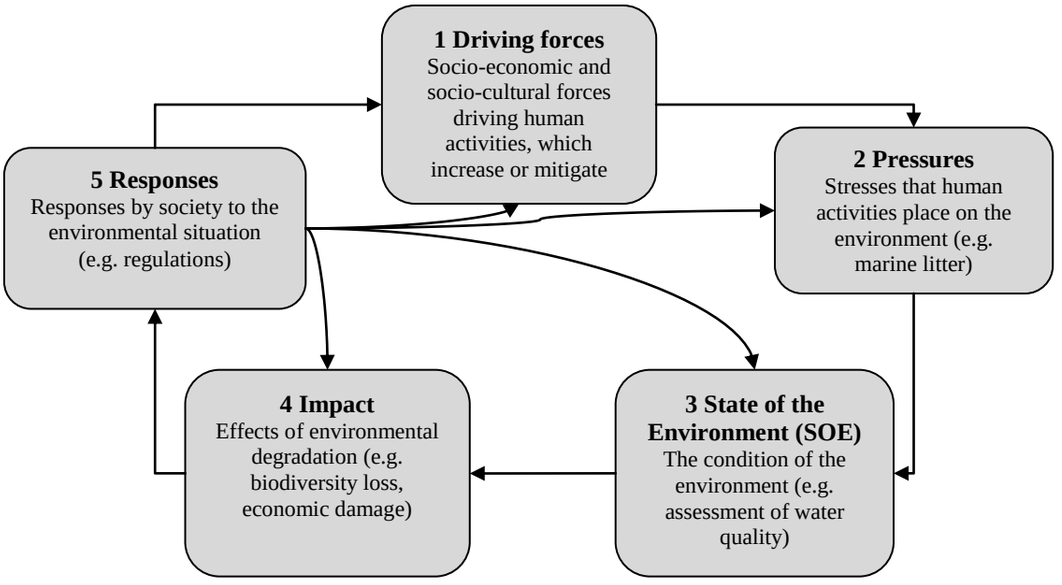
4.3 European measures

The European Union not only implements IMO regulations and agreements, but also adopts further standards and policies relevant to the shipping and ports sector. The Integrated Maritime Policy (IMP) is the EU's overarching maritime policy which applies a holistic, integrated approach to resource management using the concept of ecosystem based management [55]. The MSFD constitutes the vital environmental component of the EU's IMP. The MSFD aims to reduce the pressures of human activities on the marine environment to sustainable levels and provides a clear regulatory framework requiring that environmental targets are met in an effort to obtain GES, defined as the ' environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations (...)' [24]. Key planning instruments are Integrated Coastal Zone Management (ICZM) [56] and Maritime Spatial Planning (MSP) [9], which seek to provide a stable planning framework for coastal and maritime activities, and include considerations for environmental aspects such as marine protected areas.

Ecosystem based management is a key element of the EU marine policy. The ecosystems based management approach entails considering both ecological and anthropogenic dynamics within an ecosystem [5]. The Driver Pressure State Impact and Response (DPSIR) framework, see Figure 3, is a structured way of considering the interaction of humans and the environment [57]. A DPSIR framework is used to organise information about the state of the environment and requires that sectors, or data, are considered in terms of cause and effect relationships. By applying this concept, it is possible to track anthropogenic pressures, which develop into environmental impacts, and may ultimately impact socio-economic activities. Links between pieces of

information are provided, and with them the consequences of actions can be determined [58].

Figure 3 The DPSIR Framework [57]



A variety of other EU measures also play a role in marine and coastal environmental protection and are therefore relevant to the shipping and port sector. The Biodiversity Strategy, published in May 2011, seeks to halt biodiversity loss in Europe. Targets included in the strategy are: maintaining and enhancing ecosystems and their services; ensuring the sustainability of fisheries, combating invasive alien species; and addressing the global biodiversity crisis [59]. The EU Waste Framework Directive comes into play regarding the disposal of dredged materials, and dictates that materials should first be re-used, and if this is not possible they should be recycled, or recovered, and finally disposed as a last option [60]. The Water Framework Directive (WFD) establishes a framework for the protection of inland surface waters, transitional waters, coastal waters and ground waters. Transitional waters are bodies of water in the vicinity of river mouths, but influenced by freshwater, whereas coastal waters refer to waters

extending to one nautical mile from the nearest point of the baseline from which the breadth of territorial waters are measured [61]. Under the Birds and Habitat directives and Natura 2000, EU Member States establishes special protected areas, which make up the Natura 2000 network. The directive covers the marine environments such as open sea areas, estuaries (near ports), coastal lagoons and reefs. Once an area is selected as a Natura 2000 site, Member States are required to develop management plans to ensure the 'favourable' status of natural habitats and population dynamics of species [62]. The Environmental Liability Directive requires that when measureable damage occurs to the environment, such as pollution in sediment, damage to protected areas or adverse affects to water quality, remedial measures must be taken in accordance with the polluter-pays-principle [63]. While there are a number of EU regulations focusing on the environmental status of marine and coastal ecosystems with a link to socio-economic activities, not all pressures which result from the shipping and ports sector are addressed by EU regulations.

Shipping is also relevant within EU policies such as the Trans-European Transport Network (TEN-T) as well as the Marco Polo II programme. These aim to assist the freight transport system and strengthen its environmental and economic performance. Strategic goals and recommendations for the EU's maritime transport policy until 2018 (COM(2009) 8 final) suggest improving the environmental performance of the shipping industry and that it should work towards 'the long-term objective of 'zero-waste, zero-emission', by reducing greenhouse gas emissions (GHG) from international shipping; actively working with the International Maritime Organisation (IMO); ensuring that Member States achieve 'good environmental status', as required by the MSFD; strengthening EU legislation regarding port reception facilities; following up on proposals from the Commission on an EU strategy for better

ship dismantling; overseeing the smooth implementation of the amendments to MARPOL Annex VI to reduce sulphur oxides and nitrogen oxides emissions from ships; promoting alternative fuel solutions in ports such as the use of shore-side electricity; re-launching the Commission's Quality Shipping Campaign; and promoting a European Environmental Managements System for Maritime Transport (EMS-MT). The 2011 White Pater, Roadmap to a Single European Transport Area also set a number of goals for the maritime sector, such as developing and deploying new and sustainable fuels and propulsion systems to ships to reduce CO_2 emissions. The Roadmap also includes optimising the performance of multimodal logistic chains as a goal. In this regard, it aims to make greater use of more energy efficient modes therefore increasing the efficiency of transport and infrastructure. This means shifting transport away from road and air and towards rail and shipping by utilising information systems and market based incentives as well shifting towards the full application of a user pays and polluter pays principles for sector management [64]. This shows the contradicting nature of EU policies, which aim for an increase in shipping and port activities while simultaneously improving the environmental status of marine and coastal waters. It also shows that current environmental regulations do not address all relevant pressures, omitting underwater noise as well as ballast water, abrasion, shading and GHG emissions by ships.

5 Conclusion and discussion

Maritime transport is a key driver for growth and employment in Europe. At the same time, shipping and port activities lead to a number of direct and indirect pressures on marine and coastal ecosystems caused by both regular operating activities as well accidents or incidents. Evidence suggests that shipping contributes to environmental pressures, which may significantly impact other key socio-economic activities within

Europe. A wide number of mechanisms across multiple levels of governance regulate shipping and port activities and their resulting environmental pressures. As both benefits and negative impacts occur due to maritime transport, it is essential to protect the environment without excessively restricting economic activity. This assessment has identified several gaps where environmental issues are either entirely or partially unaddressed by policy mechanisms: underwater noise, ballast water and greenhouse gas emissions are so far insufficiently covered. These policy gaps compromise EU environmental objectives, such as in the MSFD, and potentially have negative impacts on other socio-economic activities.

Though the impacts of underwater noise are recognised and discussed by the IMO [65] and EU (in the MSFD), no mechanism exists by which to reduce or eliminate the pressure. Additional research, especially in regard to temporal and spatial aspects, could be undertaken to develop regulation to decrease this pressure. Because these pressures take place during shipping operations, the IMO should seek to address them. Otherwise, it may become necessary for the EU to take actions.

Further, there is also a gap in policy in the case of ballast water and invasive species. The BWM Convention has not yet been ratified. The EU Biodiversity Strategy 2020 and the MSFD consider the environmental impact of non-indigenous species but do not regulate ships. EU Member States are encouraged to ratify the BWM Convention [66] adopted in 2004, but as of writing this, it has only been ratified by France, the Netherlands, Spain, and Sweden, as well as Norway [67]. This issue should be addressed as soon as possible, i.e. Member States should move to ratify the convention.

In regard to shipping greenhouse gas emissions, the EU is proposing to develop its own mechanisms to combat this environmental pressure if the IMO fails to develop regulations. The EU has taken similar steps in the past, for example with the airline

industry. To date, market based measures, such as a CO_2 levy, are at the heart of discussions [68].

The issue of anchoring and shading is also not addressed by international or EU regulation. While little research has been conducted regarding these pressures, there is a potential that these shipping and port activities impact the integrity of the seafloor [1]. Seafloor integrity is covered within the MSFD as an environmental pressure but specific policies are lacking. In this regard, additional research is needed to more completely understand the implications of anchoring and shading, as well as the potential impact of policies. These issues could potentially be developed at the EU level, as this does not involve trans-boundary activities.

The adoption of the AFS convention banning the use of antifouling paints which use TBT means that it will need to be removed from ships hulls. The toxic waste will most likely be produced and concentrated near shipyards. The IMO has developed a guidance document for best practices for the removal of antifouling paints [69]. Yet, several advanced techniques for TBT removal and treatment have also been developed which could improve the removal of TBT from shipyard waste and the sediment surrounding ports and harbours, reducing the environmental impact [33]. Advanced techniques for the removal of antifouling paints should be explored to ensure that contaminants in ports and harbour ecosystems are minimised, and potentially made mandatory by EU regulation.

The health of marine and coastal ecosystems is highly dependent on the socio-economic activities which depend on their resources and the mechanisms developed to govern human activities. It is therefore important that government policies and regulations address environmental pressures which compromise ecosystem health. In this respect, additional research should be conducted in order to determine whether the

policy gaps identified in this paper in regard to environmental pressures should be addressed with new regulations or by adapting already developed measures.

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