Photo: CWSS/ Bostelmann. Container terminal in Bremerhaven (DE).

Wadden Sea Quality Status Report

Harbours and shipping

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1. Introduction

This thematic report, as a component of the Wadden Sea Quality Status Report (QSR), provides an overview on the statistical situation and development of harbours and shipping in the area. Conducted on a regular basis, QSR assessments are intended to raise awareness and facilitate a well-founded insight for stakeholders to initiate measures to enhance the safety and environmental sound condition of the universal but also vulnerable Wadden Sea World Heritage area.

Compared to the last QSR from 2017 shipping – as expressed in gross weight of seaborne goods – initially performed as predicted, with a steady global rise of about 3 % per annum. After the steady recovery observed since 2010, in the aftermath of the economic crisis, and the peak of activity reached in the second quarter of 2019, maritime transport observed a downwards trend until the second quarter of 2020 (Figure 1) (Eurostat, 2021).

Due to the outbreak of COVID-19 in February 2020, strong effects on maritime transport were observed (Figure 2), as 46 % of ship departures were cancelled on major Asia to Northern Europe shipping routes. Accordingly, ports have also been impacted by the adopted contingency measures, by delaying port clearance and refusing ships entry. As an overall annual change in terms of gross weight of goods handled in EU, a decrease of 9.5 % was thus observed in 2020 compared to the previous period.

Over recent years, this has resulted in an average of about 65 % of goods imported and exported and 35 % of exchanges within the EU transit through seaports. “At 547 million tonnes, short sea shipping tonnages to and from the main EU ports decreased by 3.7 % in the fourth quarter of 2020 compared to the corresponding period in 2019. Deep sea shipping tonnages also saw a fall of 6.6 %, to 270 million tonnes” (Eurostat, 2023). Regarding the overall annual change, short and deep-sea shipping decreased by 9.6 % and 9.5 % compared to the previous year. A partial recovery of the gross weight of goods was observed up to the second quarter of 2022. According to Eurostat 2023, the downwards trend observed in the rest of 2022 and beginning of 2023 can be attributed to the restrictions in freight transport with Russia due to its war aggression in Ukraine.

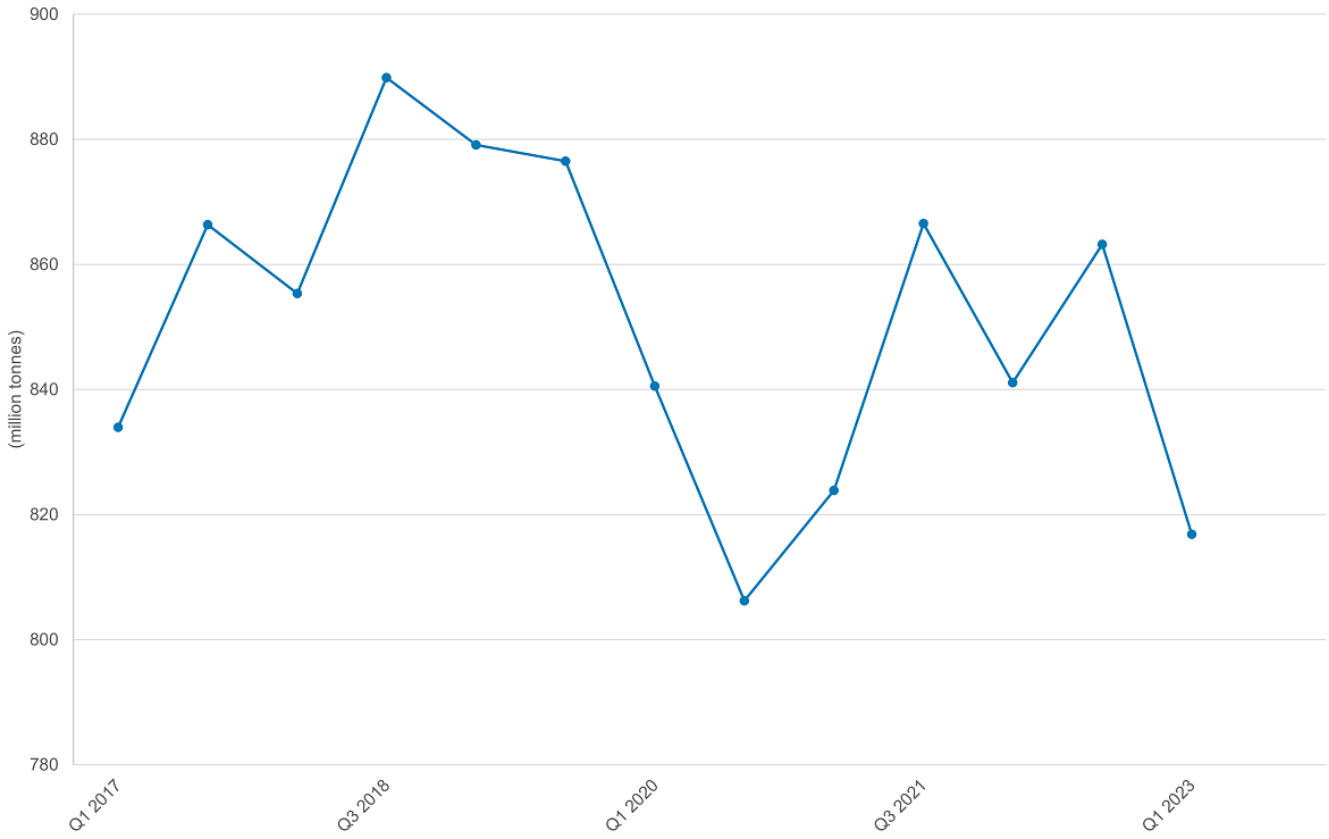

Figure 1. Gross weight of seaborne goods handled in EU main ports Q1-Q3/2017 – Q1-Q3/2023 (Eurostat, 2023).

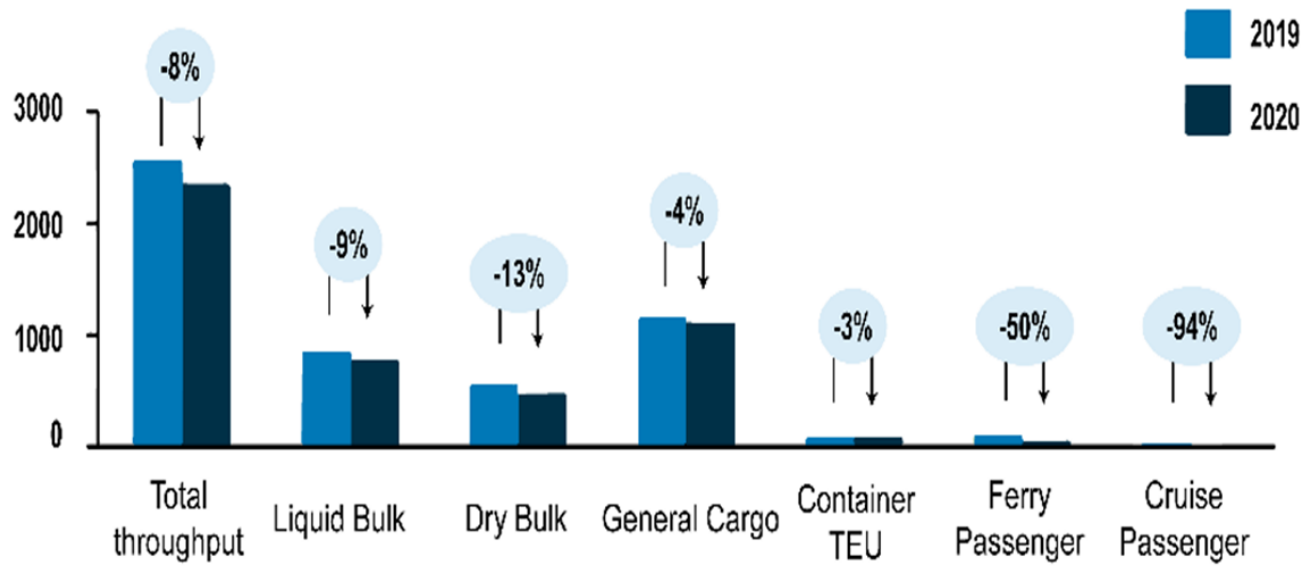

Figure 2. Total throughput in 2019/2020 (in million tons) (Deloitte & ESPO, 2021).

By addressing possible impacts of shipping on the Wadden Sea area, it must be distinguished between international and domestic shipping. International shipping navigates at the seaside of the Wadden Sea islands and uses estuaries to enter the inward ports of the Wadden Sea, whereas domestic shipping with ports of registry within this area, liaises islands, and the hinterland for the transport of passengers and goods. In this context, ferries and so-called “water-taxis”, port services, and leisure shipping are also considered.

Whereas hazards and possible impacts of the first category are probably to be assessed as more serious, the means to improve the situation are limited due to international constraints to applying improvements in a timely manner. Nevertheless, domestic shipping, which partly causes comparable but less serious impacts, must also be taken into account as they constantly ply in the area. These activities are within the reach of national legislation and, last but not least, paradigmatic for international shipping, especially in the case of the Wadden Sea, as they are important players in a marine World Heritage Site.

2. Status and trends

2.1 Status in shipping activities

As the drop due to Covid 19 is estimated to be marginal in the long term, the figures from counting traffic in the southern North Sea in 2019 (AqualisBraemar LOC Group, 2021) will provide a more detailed picture (Figure 3).

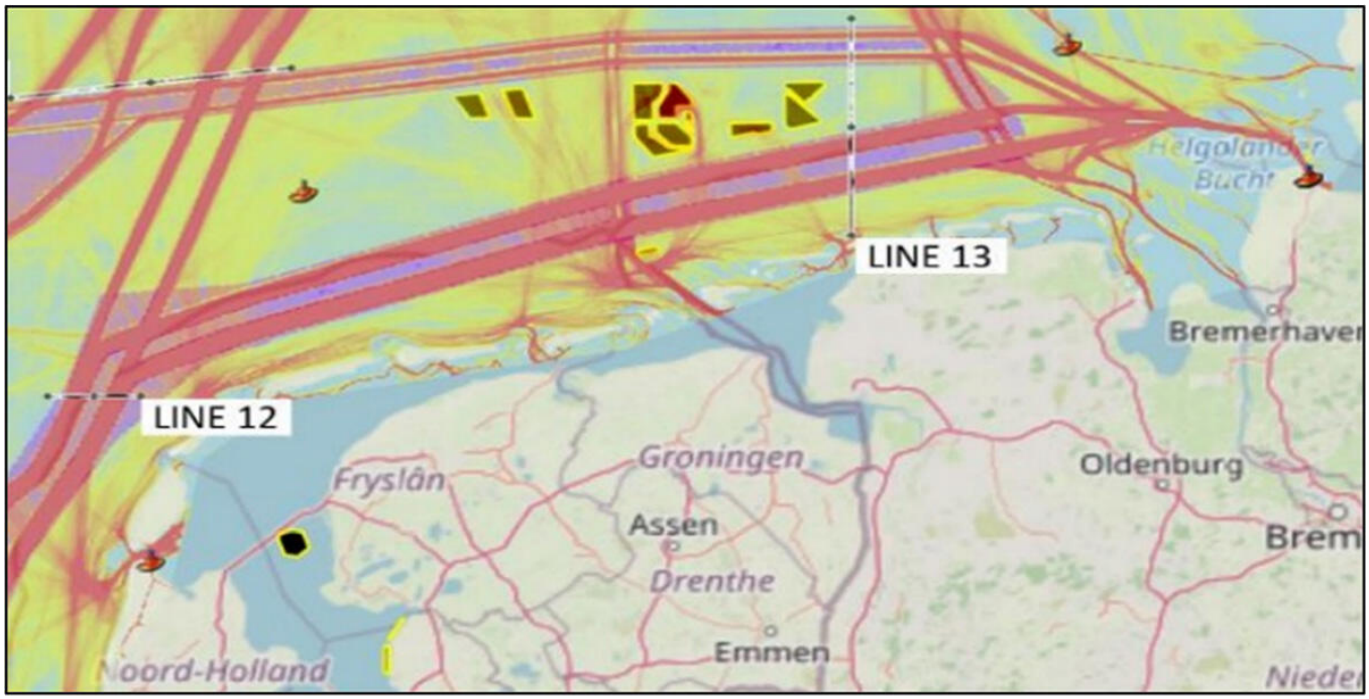

Figure 3. Traffic flow and counting lines in the German Bight (AqualisBraemar LOC Group, 2021).

The statistics provide three “counting lines” close to the Wadden Sea area. Counting line 12 is placed at the “Off Vlieland” Traffic Separation Scheme (TSS) to measure traffic before the split to the North Sea and east towards Bremerhaven, the Kiel Canal, and Hamburg. It thus represents the traffic in the area close to the Dutch and German Wadden Sea area (19,761 vessels northbound, 12,166 vessels southbound in 2019). Significant ship types in this area are medium size general cargo vessels, container carriers, Ro-Ro cargo, and small product tanker traffic. Counting line 13 covers the German Bight western approach and the Terschelling-

German Bight TSS corridors (15,440 eastbound and 9,196 westbound in 2019, including predominantly general cargo and container vessels, secondarily product tankers, and bulk vessels).

Of relevance for the Danish Wadden Sea is the counting line 14, with traffic from the port of Esbjerg to Danish offshore facilities, crossing the main NE-SW corridor in an area with high future offshore windfarm coverage (4,828 crossings; almost a third are support vessels).
When considering traffic, it is worth noting that there are two main distinct types of marine traffic in the southern North Sea – merchant vessels on one side and offshore work vessels on the other side which comprises construction vessels and all kinds of support vessels.

2.2 Trends in shipping activities

In 2019, the OECD expected a worldwide annual maritime freight growth rate of 3.3 % by 2030, and 3.6 % by 2050, ultimately leading to a 79 % increase in 2040. Compared to the global development, the projections for the North Sea are lower. Due to ship size and design optimisation, it is expected that the annual growth will be 1.65 %, with a total increase of 41 % by 2040. For offshore-work vessels, an increase of about 40 % between 2020 and 2040 (about 1.60 % annually) “appears to be a reasonable assumption” (AqualisBraemar LOC Group, 2021).

At the International Maritime Organisation (IMO), within the overall aim of decarbonisation, rather moderate targets were set for different time periods, with 2008 as the base year. Emissions intensity (emissions produced to transport unit goods per unit distance) is targeted to drop 40 % by 2030, with the aim of "pursuing efforts towards 70 % by 2050". At the same time, overall emissions are expected to peak "as soon as possible", alongside a specific target of "at least 50 % by 2050 compared to 2008".

The European Climate Law (Regulation (EU) 2021/1119) enshrines in law the goal set out in the European Green Deal for Europe’s economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas (GHG) emissions by at least 55 % by 2030, compared to 1990 levels.

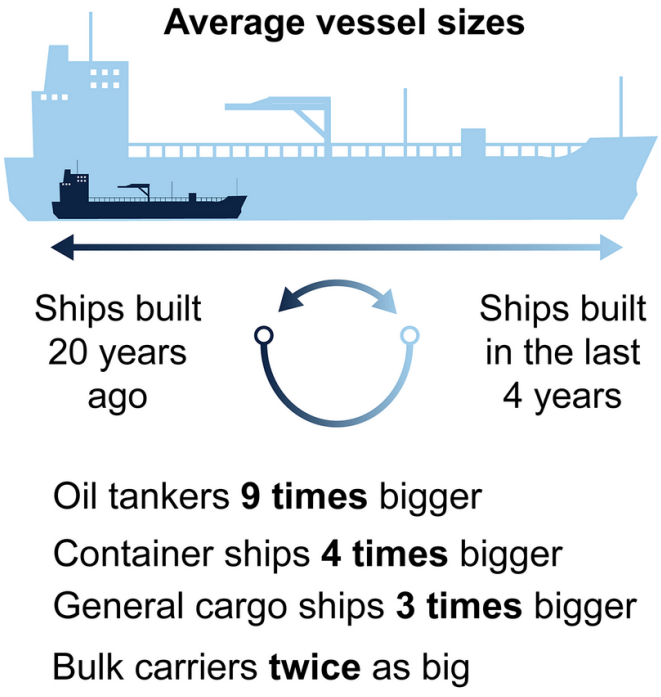

Figure 4. Average vessel sizes (UNCTAD, 2020).

The goals of the Nordic countries (e.g., net zero GHG by 2035 in Finland (OECD, 2020) are more ambitious and entail massive changes in the operation of ships. This would not only heavily reduce GHG but also sulphur oxides (SO_x), nitrogen oxides (NO_x), and particulate matter (PM) with related benefits for the environment. However, present initiatives to employ liquified natural gas (LNG) as a "bridging technology" could involve possible setbacks in terms of GHG reductions and should therefore be carefully observed and potentially rectified.

The recent installation of the "Floating Storage and Regasification Units" (LNG-terminals) following the shut-down of the gas-pipeline from Russia to Germany will thereby increase the traffic of gas tanker in the Wadden Sea and might especially affect the area close to Wilhelmshaven, Stade, Brunsbüttel, and Eemshaven.

With respect to the development of vessels plying along the coast of the Wadden Sea, it is important to be aware of the constant size growth across all ship types during the last 20 years (Figure 4). Additionally, there might be significantly more offshore supply vessels operating in the area.

Existing and possible impacts of shipping on the environment are thoroughly described in the European Maritime Transport Environmental Report 2021 (European Maritime Safety Agency, 2021). The most urgent ones to be considered for the Wadden Sea area are addressed in Chapter four.

2.3 Status and trends in harbour activities

There are about 40 smaller harbours in the Wadden Sea area, which have a variety of dimensions and functions (Wadden Sea Forum, 2020). All of them are members of in the European Sea Ports Organisation (ESPO), which issues an "Annual Environmental Report", based on the assessment of their members being part of the ECO Ports initiative. These reports provide a well-founded insight into the activities and future development plans. Generally, the development of harbours mirrors the development of shipping. They adapt to quantitative changes; for example, they are asked to provide the necessary infrastructure, e.g. to provide deeper access channels to the berths and/or bigger container terminal bridges, to supply bunker/energy or receive disposal.

Recent changes presently appear to be the need to comply with the demand to serve as hubs for offshore activities. In the Wadden Sea area, the main Dutch ports for offshore supply vessels are Den Helder and IJmuiden and, further north, Delfzijl and Eemshaven. To a lesser extent they operate from Wilhelmshaven, Bremerhaven, and Cuxhaven in Germany and from the port of Esbjerg for the Danish offshore sector (AqualisBraemar LOC Group, 2021).

Unlike shipping, port activities may be heavily affected by climate change and the resulting rise of the sea-level with the likelihood of an increased frequency and magnitude of extreme tides, waves, and storm surges. A high warming scenario (Christodoulou, Christidis, & Demirel, 2018) with a temperature increase of more than 3°C is expected to lead to sea level rise of more than 0.5 m by 2100, then affecting most European coastlines, while "more than 1 m increases will occur in the North Sea. The countries to be affected mostly include those with ports on the North Sea, i.e. the UK, Germany, Belgium, France, and the Netherlands." (Christodoulou, Christidis, & Demirel, 2018). Major European ports have therefore already taken protection measures against inundation and storm surges, such as specific barriers like seawalls and dykes.

3. Assessment

Harbour and shipping activities are vital for society; environmental impacts have therefore necessarily been "accepted" in the past. Next to accepted operational impacts, the assessment at hand addresses the safety of ships because shipping accidents are very often associated with major environmental damage.

Ports represent the link and infrastructure for shipping in the transport chain and serve with their function as locations for shipboard supply and disposal. Through their operation as industrial sites, they also contribute to associated environmental impacts.

Their numerous potential safety and environmental impacts have been described before, some of them having been reduced, while others have increased their potential to harm the environment. The most urgent ones for the Wadden Sea area are addressed below.

In the PSSA Wadden Sea Operational Plans (Tønder Declaration, 2014), harbours and shipping are considered in various contexts. While the Operation Plans called for improvements, *inter alia*, regarding an overall enhanced ship safety level and, for example, the monitoring of invasive species through ballast water, the harmful impacts of underwater noise were noted as to "Support the development of guidelines … for the reduction of underwater noise currently under development within IMO".

Other items like "…stiffening of the regulations covering discharge of cargo-residuals …" e.g., addressing the problem of paraffin pollution ("2.3 Measures") have been rectified in the meantime. The activities and potential conflicts between impacts related to harbours and shipping activities and the key values derived from the Outstanding Universal Value of the Wadden Sea are presented in Table 1.

3.1 Assessment of safety in shipping

Shipping in the southern North Sea is quite safe when compared to other sea areas. However, accidents are still evident, shown e.g., by the loss of 342 containers in January 2019 from the "MSC Zoe", operating close to the Wadden Sea border (Figure 5), the fire on the RoRo "Freemantle Highway" off the coast of the Netherlands in April 2023, and the collision of two freighters north of the North Frisian Islands in October 2023. These accidents highlighted the potential risks and served as another reminder that the challenging environment, the growing number and size of vessels, the increasing constriction of free maneuvering surface in the southern North Sea, and the proximity to this unique area are continuously calling for enhanced protection measures, some of which are addressed below. The succession of these accidents led to several investigations by various institutes into the causes and feasibility of mitigation measures, resulting in recommendations and, in some cases, immediate operational requirements.

Figure 5. MSC Zoe loss of containers, 1st and 2nd January 2019 (Bundesstelle für Seeunfalluntersuchung, 2019 in NDR news).

The role of Particularly Sensitive Sea Areas

Since 1990, when the first PSSA was acknowledged (parts of the Australian Barrier Reef), 15 PSSAs have been recognized worldwide. In the majority, the applied Associated Protective Measures (APMs) consist of either (1) TSSs, (2) deep water routes, (3) precautionary areas, and/or (4) areas to be avoided.

In 2002, also parts of the Wadden Sea were acknowledged as a PSSA (MEPC 48/21), comprising areas in Denmark, Germany, and the Netherlands. Although APMs could possibly have been introduced, no specific one was implemented, mainly because this area was already deemed to provide a high level of safety, *inter alia*, due to the obligation for certain types of ships to use the German Bight Deep Water Route further off the coast.

Recalling the development of traffic and ship dimensions over the last 20 years, it should be assessed, whether the safety level is still appropriate today. The status of protection should consider aspects like new or improved technical and operational safety devices and measures, societal perception, etc.

An adequate approach in shipping would be the application of a Formal Safety Assessment (FSA) which also would allow identification of suitable APMs – if deemed necessary. These could be, for example, the identification of further ship types or dimensions which should firmly be bound to use a specified TSS, especially in the context of the German Bight Deep Water route.

Mandatory use of deep water routes

Ship routing measures are established in many congested shipping areas. Deep water routes are stretches within defined limits which have been accurately surveyed for clearance of sea bottom and submerged obstacles. Routing requirements are to be implemented according to the procedure determined at the IMO. A

recent example is the introduction of the routing scheme in Norwegian waters which regulates by law that tankers, ships carrying nuclear radioactive substances and waste, nuclear powered ships, and ships over 5,000 gross tons (gt) are to use the TSS ‘‘Off the Coast of Norway”. It is implemented on the argument that this requirement is a risk-reducing measure that gives the Norwegian authorities better response time which contributes to reducing the consequences of an oil spill in case an accident occur. Although the situation in Norway differs from the Wadden Sea in many respects, more risk-reducing measures could serve as APM under the PSSA regime.

Considering ship dimension developments since the recognition of the Wadden Sea as a PSSA, it seems reasonable to assess whether the requirements for the mandatory use are still appropriate. In particular, the incidents mentioned above, should advise an investigation of the present situation and a re-evaluation of the prescribed conditions.

Possible parameters for new requirements could be a permanent or temporal consideration of traffic conditions, ship specifics (ship-type, under keel clearance) as well as ambient conditions (weather, sea state, visibility). Possibly also used in combination (e.g. “from sea-state xy, ships with an under keel clearance less than xy metres are to use the deep-water route”).

The application of slow steaming

For many decades and until a few years ago, technical development triggered a constant rise in average ship speed levels with only occasional interruptions due to economic crisis, oversupply of ships, or excessive fuel costs. One of the ways shipping companies have responded in such cases has been to reduce the average speed, as this improves vessel utilization while reducing fuel consumption and the associated costs. It thus appears that there are few technical constraints to apply slow steaming.

As stated in “Regulated Slow Steaming in Maritime Transport” (Faber, Nelissen, Hon, Wang, & Tsimplis, 2012), a wide range of different implications of slow steaming on the shipping industry were thoroughly assessed. Accordingly, apart from an improved safety level, such a measure would provide additional benefits as it would reduce GHG, SO_x, NO_x, and PM emissions. Further, it would lead to significantly lower underwater noise levels, and it would reduce the threats of collisions with mammals. As engine power output is a third power function of speed (Gusti & Semin, 2018), it additionally would reduce fuel consumption with related cost savings for shipping companies. Thus, the introduction of a speed limit in or close to the Wadden Sea area appears to be reasonable and should be considered.

3.2 Assessment of environmental protection in shipping

With regard to the impact on the environment, shipping has been perceived in public in different ways over recent decades. Initially it was blamed for the irresponsible handling and disposal of household waste and cargo residuals at sea, thereafter for the application of toxic antifouling, followed by the harmful emission of SO_x, NO_x, PM, and the transfer and introduction of alien* species with ballast water. Although not totally cleared, the situation regarding some of these aspects has (partly considerably) improved in the recent years. Today, greenhouse gas emissions (GHG) of shipping, a possible discharge from exhaust gas cleaning systems (EGCS), and underwater noise are intensely discussed.

*In this text, the term ‘alien’ species is used; it is a synonym for ‘foreign’ or ‘non-indigenous species’.

Climate change: the role of shipping

The Paris Agreement from 2015 postulates to limit the rise of the average global temperature to well below +2°C compared to pre-industrial levels, in order to avoid the most severe consequences of climate change. This agreement has been signed by 195 nations.

Shipping contributes to about 2.8 % of worldwide GHG emissions (Figure 6) (Comer, Georgeff, & Osipova, 2020) and presently relies almost 100 % on the use of fossil fuels, mostly Heavy Fuel Oil (HFO) and Marine Diesel Oil (MDO). The IMO determines the obligation for worldwide shipping and the standards to comply with the Paris Agreement "to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50 % by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO_2 emissions reduction consistent with the Paris Agreement temperature goals" (Comer, Georgeff, & Osipova, 2020).

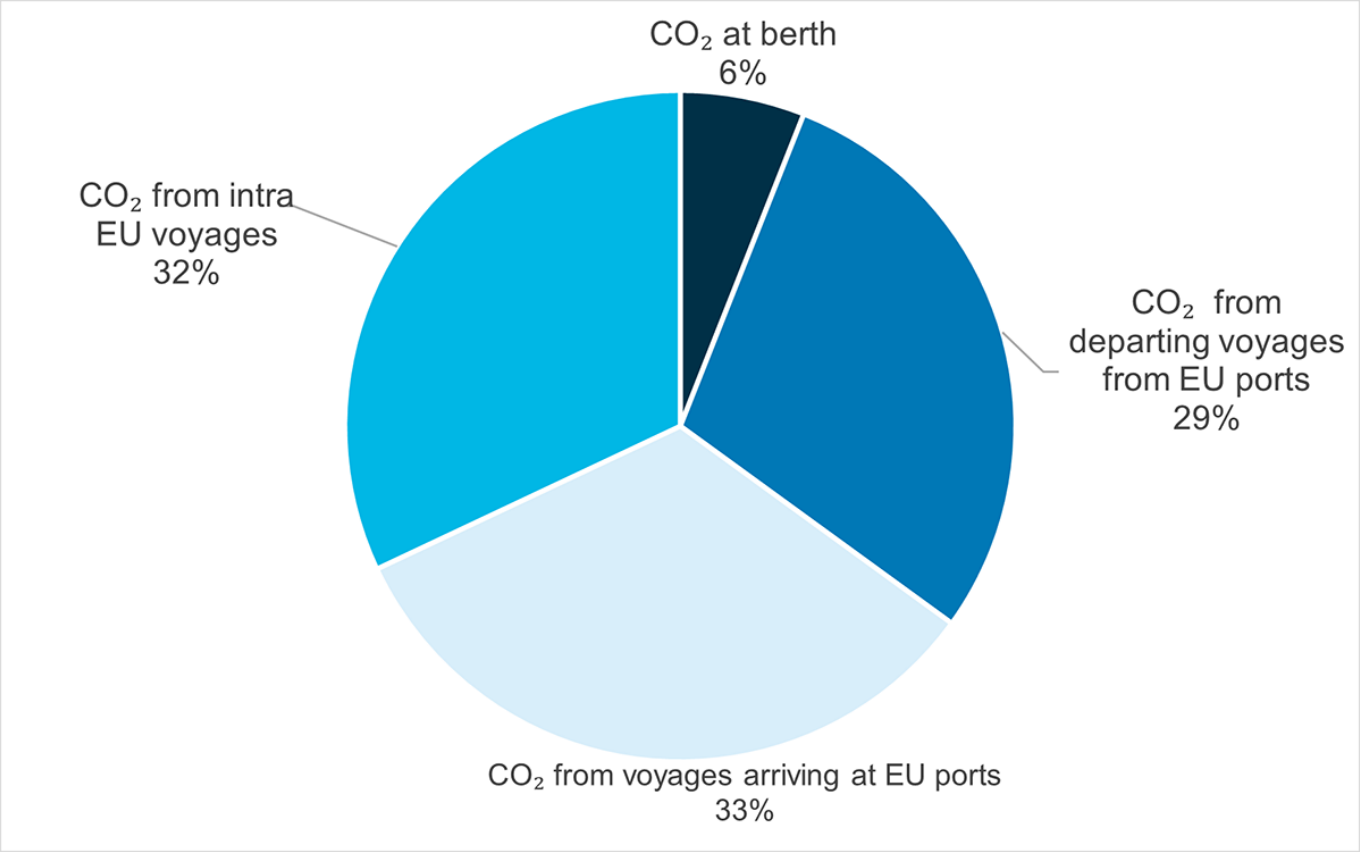

Figure 6. CO2-Emissions from ships calling at EU and European Economic Area ports in 2018 (European Maritime Safety Agency, 2021).

In 2019, an alliance of more than 150 companies within the maritime, energy, infrastructure, and finance sectors committed to getting commercially viable deep sea zero emission vessels into operation by 2030 ("Getting to zero coalition"). Additionally, Denmark, Norway, and the USA took the lead on a Zero-Emission Shipping Mission in 2021, a global partnership which aims to develop, demonstrate, and deploy zero-emission fuels, ships, and fuel infrastructure by 2030.

Coastal states like Norway started additional initiatives, such as aiming to reach 100 % fossil free shipping in 2050 by promoting the implementation of electric propulsion for ferries along the coast. Coastal and offshore

traffic in particular could lead the way for a progressively decarbonized shipping industry. This appears constructive as electric or fuel cell-based propulsion systems not only reduce GHG but also SO_x, NO_x, PM, and noise – impacts which also have negative influences on the Good Environmental Status (GES) of the Wadden Sea as generally required by the EU Marine Strategy Framework Directive (MSFD) provisions.

As technical solutions for GHG reductions in world-wide shipping will take time to mature, it might be necessary to apply operational measures in the meantime. The implementation of a speed limit would reduce GHG emissions and, at the same time, would increase safety levels, especially in crowded areas close to the coast.

The use of exhaust gas cleaning systems

For the reduction of SO_x emissions, since 2020, shipowners have to choose one of several options to comply with MARPOL Annex VI, deciding either for (1) using fuel distillates (MGO/MDO); (2) using blended Very Low Sulphur Fuel Oils (VLSFO); or (3) installing Exhaust Gas Cleaning Systems (EGCS), so-called "scrubbers" which wash the sulphur dioxide out of the exhaust fumes. These scrubbers are either designed as "closed loop scrubbers", which discharge washing residuals to reception facilities on shore, or "open loop scrubbers" which dispose diluted washing residuals into the ambient water column, or hybrid versions thereof. In 2021, about 80 % of scrubbers installed on ships used the open loop type (Figure 7) (Comer, 2020).

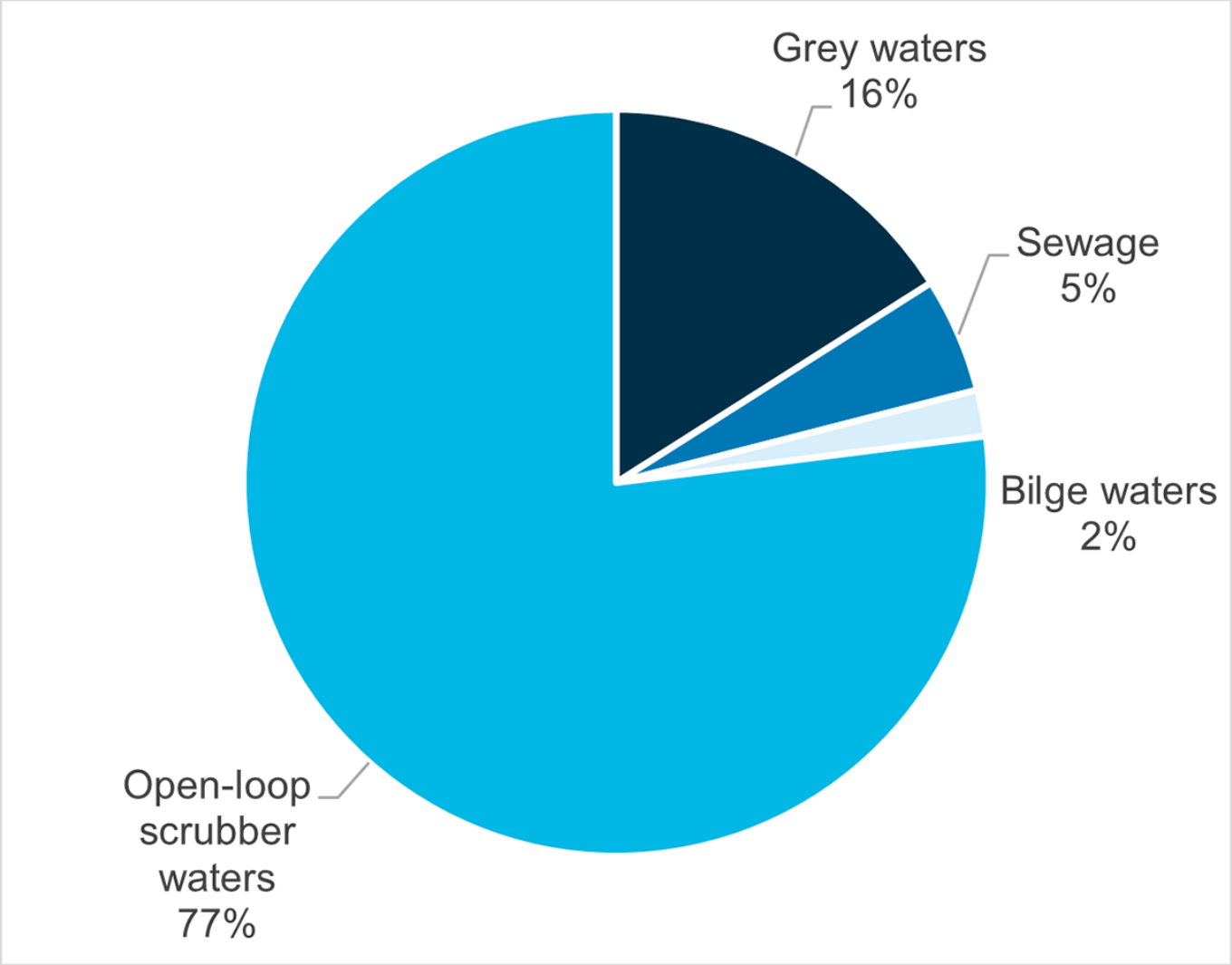

Figure 7. Share of estimated water discharges from ships in EU waters in 2019 (European Maritime Safety Agency,

2021).

Although the effluent initially sometimes was said to be harmless, an increasing number of regional governments deny the disposal into their territorial waters. In addition, ships fitted with scrubbers emit more carbon dioxide (CO_2) and PM compared to ships using low sulphur fuel (Dutch Safety Board, 2020).

In 2020 already, almost 50 countries put a regionally defined ban on the release of scrubber waste water (partly on inland waterways only). Norway, for example, imposed a ban to discharge waste water within their World Heritage Fjords. China's maritime authority banned the discharge of waste water "in all rivers and ports along China's coastline as from 01.01.2019 in the 12 nm area as from 01.01.2020".

Ballast water treatment and the introduction of alien species

In its World Heritage Outlook assessment from 2017, the International Union for Conservation of Nature (IUCN) identified the invasion of alien species as the number one threat to many natural World Heritage Sites. According to the International Council for the Exploration of the Sea (ICES) report from 2018 (ICES, 2018), "warm water" species are increasingly found in the southern German Bight, some of which are already considered to occur with a self-sustaining population. JadeWeserPort was identified as the area with the highest number of non-indigenous species in Lower Saxony (BSH, 2020). These findings were explained by the introductions by ballast water and biofouling. Figure 8 shows estimations of non-infigenous species introduced by ship ballast waters into EU waters. According to the EU Marine Strategy Framework Directive (MSFD) (Die Bundesregierung,2021), in the six-year period until 2018, 22 new species were identified.

The main vector for marine alien species is international shipping which connects marine areas worldwide and transfers the "unwanted" species – either in ballast water, attached to the ship's hull or nested on anchor chains or in sea chests – to areas where they may settle and possibly become competitors to or even predators of native species. Different to other negative impacts, these species are almost impossible to remove once they have become established (IOC/UNESCO, 2011). Thereby, the spread of species occurs not only through international shipping, but also through coastal shipping, currents, the tide, putting also small ports and the coastal areas at risk.

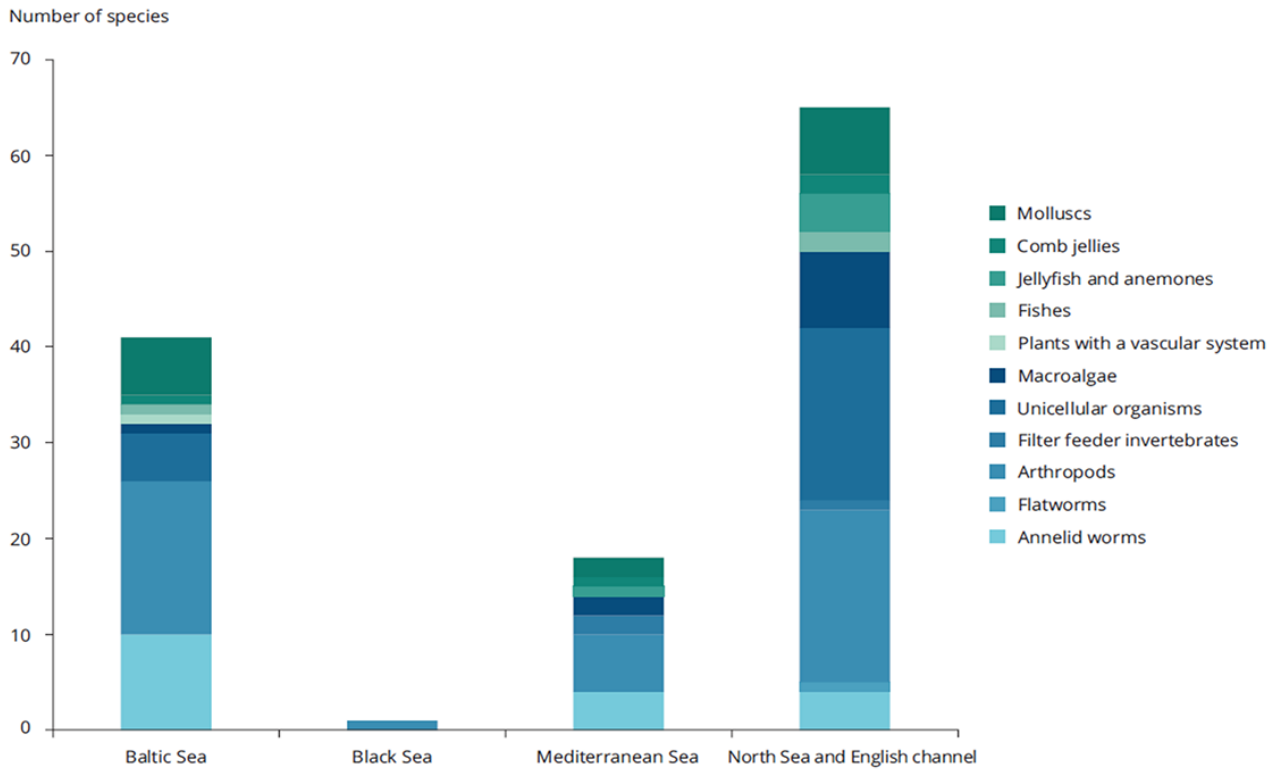

Figure 8. Estimations of the number of non-indigenous species introduced by ship ballast waters into EU waters (European Maritime Safety Agency, 2021).

The treatment of ballast water is a complex procedure as normally two or three different methods have to be successively applied. Therefore, from the adoption of the Ballast Water Management Convention (BWMC) in 2004, the efficacy was under discussion and tests revealed that some of the approved systems failed under certain conditions. In Jang et al., 2020 it was summarised that although the ballast water management systems (BWMSs) tested were a small subset of the large number of IMO-approved BWMSs only, "the results demonstrate that there is a significant gap between the technology currently available and the capacity to meet IMO and US Coast Guard standards". A technique only recently applied is the containerised shore-based treatment when a ship is in port.

Underwater noise

Anthropogenic underwater noise is increasingly recognized as a potential threat to marine fauna. The intensity and frequency of underwater sounds determine the level of the impact on marine species. Shipping has drastically increased the ambient marine sound and noise levels* over the past few decades. It can be classed as either acute (seismic surveys or military sonar) being high in intensity, but short in duration and often pulsed (e.g. from echo sounders) or chronic (commercial shipping propulsion) being long term, low intensity noise.

*Sound is referred to as 'noise' when it has the potential to cause negative impacts on marine life (OSPAR).

Marine mammals, fish, and other creatures communicate using sound to find mates, search for prey, avoid predators and hazards, and for navigation. Possible impacts depend on the nature of and exposure to the sound and the acoustic sensitivity of the affected organisms. They may cause hearing impairment, displacement, behavioural reactions, masking, or stress.

According to the European Maritime Safety Agency (EMSA) (European Maritime Safety Agency, 2021) next to

speed, the design parameters like the shape of hull and propeller are relevant for the radiation of underwater noise. Container ships and tankers radiate the highest noise levels. According to investigations the “noisiest 10 per cent of the global fleet is thought to generate 90 per cent of ocean noise, so there is a clear target group for noise-reduction measures” whereby a ship speed reduction of 10 % could reduce noise radiation by 40 % (and reducing collisions with marine mammals by around 50 %).

Coastal traffic in the Wadden Sea region

Generally, the managers of local shipping companies are aware of providing their services in a marine World Heritage Site and, therefore, are committed to maintaining the area and, *inter alia*, to also support it as tourist attraction. Thus, on average, coastal, and domestic shipping in the Wadden Sea area stands out to be superior in terms of safety and environmental performance compared to conventional shipping applying “merely” basic international standards.

On the other hand, the development of offshore wind farms entails new shipping services which permanently ply across the area, causing most of the usual different emissions and impacts of shipping on the environment, albeit on a smaller scale, but with the inherent risk that protection systems may fail.

Furthermore, in order to provide additional services to tourists and islands residents, for some years so-called water-taxis have increasingly been deployed. These boats are generally designed to carry up to 20 people, travelling at comparably high speed, with respective excessive emissions per person. They constitute a threat of collision with mammals, may emit significant high sound frequencies (under and above the water surface) and thus generate a new impact which is deemed controversial to the idea of a marine World Heritage Site.

3.3 Assessment of harbour activities

The policy and regulation framework of ports determines the capability of the port authority to set local rules regarding safety and environmental protection and to provide or control secondary services. It also governs the degree to which port authorities engage in partnerships with other clients, seaports, etc. Port authorities are responsible for the development and improvement of port operations, infrastructure development, maintenance, marketing, and management of facilities. As such, port authorities pursue public, commercial, and economic goals including the implementation of environmental regulations – also as a node for shipping activities and as a link to hinterland transport.

Whereas some of the challenges related to ship emissions are outside the direct control of port authorities, others are directly dependent on available port-based services, the most important of which are addressed hereunder.

Climate change and the use of renewable resources

When alongside, ships still require electricity to support loading/ unloading, lighting, heating etc. Today, this power is mostly provided by ship-board auxiliary engines which emit air pollutants and GHG. Onshore Power Supply (OPS) is one of the strategies recommended to reduce the environmental impact of vessels in ports which render ship auxiliary engine work at berth unnecessary. According to Darbra et al., 2020, the number of ports in Europe offering OPS increased from 32 in 2016 to 56 in 2020. According to the EU “Regulation on the Deployment of Alternative Fuel Infrastructure” (AFIR) from 2023, ports with a defined number of ship calls will have to provide OPS not later than 2030.

Meanwhile, in coastal shipping, battery-based e-mobility is becoming increasingly feasible. Investigations revealed, *inter alia*, that "7 out of 10" ferries, crossing the Norwegian fjords were assessed to be technically and financially feasible to be electrified. Consequently, a programme was initiated to continue the transformation, also including the necessary infrastructure in ports.

With regard to small ferry and port services as well as leisure shipping there are presently no binding regulations in place, however, the "Sylt Declaration" from 2010 postulates the aim for the Wadden Sea area to be climate neutral in 2030 (which would have to include emissions from ports, marinas etc.).

Reception facilities for scrubber residuals

The number of ships in the international shipping fleet fitted with scrubbers increased from 243 in 2015 to more than 4,300 in 2020 (Osipova, Georgeff & Comer, 2021). Due to economic reasons, a rapidly growing number of ships are being fitted with open loop scrubbers, which discharge polluted waste water overboard. As this practice is increasingly criticized due to the harmful impact on the environment, closed loop scrubbers are asked to be used as they generate contaminated sludge, which is to be disposed of at reception facilities on shore for further treatment (Osipova, Georgeff & Comer, 2021).

Reception facilities for ballast water

According to the IMO Ballast Water Management Convention, non-compliant ballast water should be, *inter alia*, given to a port reception facility ashore for further treatment. These reception facilities can either be fixed or mobile but should meet the IMO standards. In shipyards where cleaning or repair of ballast tanks occurs, sediment reception facilities should also be provided.

In order to reduce the transfer of invasive species, the provision of hull cleaning sites is increasingly being discussed which may be managed by robot systems. By cleaning the hull, these systems also would increase the energy efficiency of the ship and thus reduce fuel costs for the shipping company as well as GHG emissions.

3.4 Assessment of the policy and regulation framework in shipping

As international shipping is organised globally, ships are required and usually possess similar IMO features irrespectively of their flag. Apart from a few exceptions, flag states normally require their ships to merely comply with these harmonised standards. They, of course, may be outperformed by requirements which sometimes are imposed (1) on nationally flagged ships, (2) for certain areas within the territorial sea, or (3) when ships approach a national port. Thereby, the rules on "Innocent Passage", which address ships that merely pass territorial waters without calling a port, are to be observed.

PSSA status of the Wadden Sea

In December 2005 the IMO adopted the resolution on the "Revised Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas". The resolution is "intended to clarify and, where appropriate,

strengthen certain aspects and procedures for the identification and designation of PSSAs and the adoption of associated protective measures" (IMO, 2005). As the resolution is non-binding, the introduction of an APM requires a legal basis via existing laws already adopted under current conventions (Kim, 2021). Apart from International Convention for the Safety of Life at Sea (SOLAS) and MARPOL, a measure may also be based and adopted on another legal basis.

By revealing that "many PSSAs simply mirror existing national environmental measures, it has been suggested that states have underutilised the practical function of the PSSA due to their motives of promoting their national MPAs at the international level" (European Commission, 2021) to raise awareness with seafarers when passing such areas.

Mandatory use of the German Bight western approach deep water route

The Convention on the Regulations for Preventing Collisions at Sea (ColReg, Rule 10) stipulates that ships' routing, including TSS, recommended tracks, and deep water routes may be prescribed for the purpose of preventing or reducing the risk of pollution or other damage to the marine environment from ship collisions or groundings in or near environmentally sensitive areas.

The provision of the German Bight western approach deep water route is laid down in the application for the PSSA status of the Wadden Sea area in MEPC 48/21, ANNEX 5. The measure is described as to "simplify traffic flows to reduce the collision hazard and to keep ships carrying certain dangerous or polluting goods away from the Wadden Sea coast". For specific ship types over 5,000 gt which carry certain kinds of dangerous cargo, the use is mandatory.

The MSC Zoe accident in January 2019 was investigated and described by different organisations (Panama Maritime University et al., 2020), some of which proposed an urgent examination of this topic. A list of six recommendations, other actions, and the progress on the recommendations from a Dutch parliamentary paper was published by the Lower House of the States General (Tweede Kamer der Staten-Generaal, 2023). One immediate outcome was the broadcasting of warning signals, especially to large vessels in case of extreme weather / sea conditions. A precept for large container vessels to use the TSS was also integrated into the MSFD (UZ2-08) (Die Bundesregierung, 2021) and stipulated by different national administrations (Niedersächsischer Landtag, 2019).

BOX 1. PSSA Wadden Sea Operational Plan

1.2 Current status & challenges 2030:

"Establishment of Traffic Separation Schemes (TSS) with a firm regulation for certain vessels e.g. vessels carrying dangerous goods or deep draft vessels, where relevant"

Slow steaming in or close to the Wadden Sea area

The speed of vessels at sea is not generally limited but, for certain situations, it may be based on IMO collision regulations, which may oblige ships to reduce speed "whenever it is required in order to ease an unclear situation" (ColReg Rule 6) depending on traffic, sea-state, visibility, etc. Regionally or locally, the speed of

ships may be regulated, *inter alia*, for ice covered waters, for example on the Northern Sea Route with 6 to 13 knots or on access channels to ports, etc. In this way, slow speed is used as an adequate measure to enhance the overall safety.

Speed limits have also already been introduced to protect whales: in 2008, the US government introduced speed-limit zones known as Seasonal Management Areas (SMAs). The rule is valid for all vessels more than 20m in length. It requires, that ship traffic in SMAs around major ports as well as close to feeding, calving, and nursing grounds must not travel faster than 10 knots.

Inside the Wadden Sea conservation area, covering the Dutch Wadden Sea Conservation Area, the German Wadden Sea National Parks of Lower Saxony and Schleswig-Holstein, and most of the Danish Wadden Sea maritime conservation area, speed limits have been imposed as described in the Implementation of the Esbjerg 2001 Declaration and the Trilateral Wadden Sea Plan (CWSS, 2005). Hence, in the three member states, speeds of 8 knots in general and 16 knots on navigation routes are applied (CWSS, 2005).

In 2023, the German Federal Ministry for Digital and Transport enacted an amendment to the regulations on the use of federal waterways in national parks in the North Sea area. This regulation contains rules for all vessels operating in the German area of the Wadden Sea national parks and thus the World Heritage Site. For commercial shipping, there are corridors with a speed limit of 24 knots. These corridors are designed to concentrate shipping traffic in order to reduce traffic and underwater noise in other areas. In the inner part of the Wadden Sea, speed limits are lower (16 knots in fairways, 12 knots outside fairways) (Verordnung über das Befahren der Bundeswasserstraßen in Nationalparken im Bereich der Nordsee, 2023).

Reducing of GHG emissions in shipping

In order to improve energy efficiency, the IMO adopted, under MARPOL Annex VI, the Energy Efficiency Design Index for new ships (EEDI, 2013), the Ship Energy Efficiency Management Plan (SEEMP, 2013), and the Energy Efficiency Design Index for existing ships (EEXI, 2023), all of which are intended to reduce the carbon footprint per haulage capacity. In 2018, the IMO adopted a strategy aiming to reduce the carbon intensity as an average across international shipping by at least 40 % by 2030, pursuing efforts towards 70 % by 2050, compared to the level in 2008.

As from 2018, in the European Economic Area (EEA) ships over 5,000 gt are obliged to “Monitor, Report and Verify” (MRV) their related CO_2 emissions and other relevant information. This, in turn, triggered the IMO to implement an equal guidance (Data Collection System, 2019) in order to provide international level playing fields.

Apart from legal regimes, initiatives have emerged on voluntary basis. Incentive systems like the Environmental Ship Index (ESI) or the Blue Angel Award for Environmental Sound Shipping also consider GHG emissions.

BOX 2. PSSA Wadden Sea Operational Plan

2.3 Measures:

“The three countries will support appropriate IMO initiatives with the goal to further reduce ship emissions both on sea and in the ports as already stated in the Wadden Sea Plan 2010”

The Wadden Sea will increasingly be affected by serious consequences of climate change, namely the surge of extreme weather and sea state conditions and the rise of the water level – to mention only the most adverse impacts. Against this background, the trilateral partners agreed to strive to achieve climate neutrality by 2030 (Sylt Declaration 2010).

According to the Leeuwarden Declaration from 2018 (§ 30), ports and ferry companies working in the Wadden Sea Area are encouraged to "develop codes of conduct to further demonstrate their willingness to work towards environmentally sound standards in accordance with best available technology".

Exhaust gas cleaning systems and sulphur scrubber waste water

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL Annex VI requires worldwide shipping outside emission control areas to reduce the sulphur content in fuel oil from former max 4.5 % until 2012 to 0.50 %* as from 2020. The 2015 IMO Guidelines for Exhaust Gas Cleaning Systems (MEPC.259(68)) include criteria for monitoring and recording levels of pH, polycyclic aromatic hydrocarbons (PAHs), turbidity / suspended particle matter, nitrates, additives, and other substances in wash water from open loop scrubbers. However, studies (Comer, 2020) revealed increased values of such substances in the marine environment, which have increasingly met with resistance and prompted coastal states to implement local regulations which partly or totally restrict the discharge of waste water from open loop scrubbers. This approach was based on the argument that Regulation 14.1.3 of MARPOL Annex VI limits the sulphur content of fuel oil at 0.50 % and residuals are to be delivered to reception facilities.

* In SECAs (inter alia, North Sea and Baltic) the maximum sulphur limit is 0.1 % as of 01.01.2015.

BOX 3. PSSA Wadden Sea Operational Plan

2.2 Current status & challenges 2030 emissions:

"Regarding the expected increase in the overall fuel consumption, the IMO released regulations to stimulate continuous technical development of fuel-efficient ships. The implementation of these measures will lead to a significant decrease of emissions like CO_2, NO_x, SO_x, and PM."

In (Osipova et al., 2021), the amount of scrubber waste water disposed of into the sea was calculated for the 15 PSSA existing worldwide. Regarding the amount of waste water, the Wadden Sea area occupies the seventh place. This seems to be conservative as it merely considers waste water inside the borders of the PSSA and thus does not consider the very close Terschelling-German Bight TSS.
Considering the possible shift by the current and tidal stream along the Wadden Sea, greater distance from the borders of the PSSA seems thus to be appropriate.

Due to the harmful effluent, (1) ships should use fuel as laid down in MARPOL Annex VI and new scrubber

installations should be prohibited, (2) open loop scrubbers should be converted to closed loop scrubbers, (3) ships should be obliged to operate in zero discharge mode in or close to MPAs, especially PSSA, and (4) existing scrubbers should be phased out over time (Osipova et al., 2021).

Ballast water management

The Ballast Water Management Convention (BWMC) was adopted in 2004 and has been globally in force since September 2017. A grace period allows certain kinds of existing ships to use the ballast water exchange method (D1) until 2024. This allows ships to change ballast water at least 50 nm from the nearest land with at least 200m in depth if not possible otherwise. When these requirements also cannot be met, suitable areas may be assigned where ships may conduct a ballast water exchange. After 2024, all ships will have to apply the treatment method (D2). D2 specifies system standards to be met including the number of viable organisms per ml/m3 in the effluent as well as defining other limits.

BOX 4. PSSA Wadden Sea Operational Plan

2.3 Measures:

"Apply/implement IMO Marine Environment Protection Committee 2011 guidelines for control and management of ships' fouling and consider measures indicated in the trilateral Strategy for Alien Species"

The level and the environmental impact of invasive species is one of the descriptors for assessing GES under the MSFD. At the EU level, Regulation 1143/2014 recognises the BWMC as one of the possible management measures to address invasive species. At the Trilateral Governmental Wadden Sea Conference in 2014, it was decided to commission a report which was the basis for a workshop on this subject in 2017. The Alien Species Management and Action Plan (MAPAS) was finalised in 2018 and presented at the Leeuwarden Conference in May 2018 (ICES CM 2018/HAPISG, 2018).

Underwater noise

In 2014, the IMO approved "Guidelines for the Reduction of Underwater Noise from Commercial Shipping" (MEPC.1/Circ.833) to address adverse impacts on marine life. The guidelines focus on possible measures that can be applied to propellers, to the hull form and hull cleaning, on-board machinery, and operational aspects. According to investigations, large ships emit lower frequency with possible impacts over a wider area, while small pleasure craft with high frequencies may be loud, especially at high speed. Speed reduction is identified to be the most effective way to reduce noise.

At the European level, the MSFD and the rules on underwater noise (EU, 2017a) are set to define GES of marine waters. Descriptor 11 states that GES is qualitatively achieved when the "Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment" (European Maritime Safety Agency, 2021). A technical group of EU member states initially focused on monitoring aspects

in order to identify values for underwater levels. It is presently assessing the impacts and developing thresholds for the indicators for the MSFD.

Underwater noise is specifically addressed by the International Whaling Commission (IWC) which adopted a resolution on anthropogenic underwater noise in 2018. This resolution is also part of a paper submitted to the IMO in 2018 (MEPC 72/INF.9).

BOX 5. Wadden Sea Operational Plan

2.3 Discharges:

"Support the development of guidelines and technical and operational measures for the reduction of underwater noise currently under development within IMO"

Being aware of growing shipping and offshore activities with related noise levels, the ship classification society DNV launched a class notation "SILENT" with different levels addressing specific items, *inter alia* "SILENT S" for seismic vessels dependent on acoustic research or "SILENT E" which is intended to document noise performance "for authorities or others demanding proof of noise emission for transit through vulnerable areas".

In certain areas, seasonal voluntary slowdowns are already in place. The Vancouver Fraser Port Authority-led ECHO Program defined "target speeds" for bulkers, tankers, and government vessels at 11 knots and for vehicle carriers, cruise ships, and container vessels at 14.5 knots, which reduced the noise level by 50 %.

3.5 Assessment of the policy and regulation framework in harbour activities

The legal obligations on ports are largely based on the respective national shore-based rules. Most valuable information on environmental related issues for ports is provided by environmental reports of the European Sea Ports Organisation (ESPO) (M. Darbra et al., 2020). They provide the status and the projections for ports in general and for members of the ECOPort initiative in particular. The aim is described to "increase awareness about environmental challenges, deliver compliance with legislation and to demonstrate a high standard of environmental management". The more ambitious internal Port Environmental Review System (PERS) was introduced by the Wadden Sea ports of Groningen, Den Oever, and Den Helder in the Netherlands and by the JadeWeserPort, Bremen/Bremerhaven, and Niedersachsen Ports in Germany. Especially to be mentioned is the "Trilateral Wadden Seaports" initiative (https://waddenseaports.com/) which provides different best practices to stimulate similar activities.

Ports may play an important role in encouraging and supporting shipping in applying advanced technologies by, *inter alia*, granting rebates on port dues. Presently these are only provided on voluntary basis, and they are not harmonised which is a disadvantage as they do not provide a reliable incentive for ship owners.

Nonetheless, they indicate specific necessities which have to be addressed.

Climate change and the use of renewable resources

On average, about 15 % of the total energy consumption per ship voyage arises in ports. OPS may thus serve to connect vessels at berths to the use of renewable energy in order to lower the respective GHG emissions.

BOX 6. Wadden Sea Operational Plan

2.2 Current status & challenges 2030:

"Many ports invest in basic infrastructure to address insufficient land based electricity supply to decrease fuel consumption and corresponding emissions. The Green Shipping initiative is an example of efforts by the shipping sector to lower environmental impacts. Port authorities founded initiatives like Ecoports and the World Port Climate Initiative (WPCI) to improve the environmental situation in ports, surrounding areas, and the transport chain. European Ports are engaged in the field of environmental "

The AFIR-Directive 2014/94/EU on "Deployment of alternative fuels infrastructure" establishes a common framework of measures for the deployment of alternative fuels infrastructure in the EU. The European Green Deal also "highlights the great need for decarbonisation in shipping" (ESPO, 2021) in order to achieve the 55 % Climate Target Plan for 2030. Thereafter, "hydrogen or hydrogen carriers, such as ammonia, as well as bio-LNG, electricity, methanol and e-fuels" (ESPO, 2021) are expected to attain a larger share.

ESPO claims to want to be "a partner in implementing Europe's ambition to be the first net-zero emission continent by 2050 …" (EU, 2021) but, of course, points out that an area-wide provision of OPS needs funding and will be time-consuming.

Reception facilities for scrubber waste water residuals

Directive 2019/883 of the European Parliament on port reception facilities for the delivery of waste from ships (Port Reception Facility Directive) considers "all waste … unloading and cleaning operations … which falls within the scope of Annexes I, II, IV, V and VI to MARPOL Convention". It postulates in (6) that MARPOL Annex VI introduced discharge norms for new waste categories, in particular for the residues from EGCS which are also to be considered in the Port Reception Facility Directive and, furthermore, encourages the introduction of "appropriate measures in accordance with Directive 2000/60/EC of the European Parliament and of the Council (5), including discharge bans for waste water from open loop scrubbers in their territorial waters" (WSB, 2019).

In (S.Schmolke et al., 2020) it is emphasized that, for the discharge of scrubber effluents, the application of APMs within the framework of PSSAs could be particularly important. "A short-term strategy could be a discharge prohibition for internal waters and territorial seas as a unilateral measure or in concert with the

other EU Member States".

Reception facilities for ballast water

Generally, ships at sea comply with the Ballast Water Convention by following the D1 or D2 standard (ballast water exchange versus ballast water treatment). If this is not feasible before they reach the next port, they may need to discharge untreated water while at berth. As this is often prohibited, the use of reception facilities must be offered.

As, ultimately, all types of ships will have to comply with the D2 standard in September 2024, reception facilities for residuals and sediments may be required in ports. According to the Ballast Water Convention for sediment reception facilities (Guideline 1), they shall provide a uniform interface to be connected. The sediments are to be tested for active biological agents, alien species, and chemical composition which may pose risks before they are stored in appropriate landfills or the like.

Provision of incentives to promote sustainable shipping

Constructional and operational measures which provide a superior safety level and/or enhanced protection to the environment may cause a commercial disadvantage against possible competitors. Thus, in order to enhance the respective level, shipping companies need to be funded or otherwise financially supported.

Ports may contribute to motivate further improvements by, *inter alia*, granting rebates on tariffs or fees. Deductions are usually linked with specified environmental impairments to be reduced or avoided – mainly they are intended to improve the local environmental situation.

The Environmental Ship Index (ESI) is a suitable system, it presently addresses the emissions of SO_x, NO_x, PM, and CO_2. Ports are invited to voluntarily participate and to grant rebates in accordance with a score system. However, as possible rebates are provided on a voluntary basis only, they are not very capable of inducing substantial financial commitments into improvements. Other environmental labels (e.g. the Blue Angel Award) address additional and different factors, also including safety aspects. However, so far they just acknowledge superior performance by issuing a respective certificate.

Dredging and dumping for harbour access

Dredging in estuaries, entrances, and in ports is carried out to maintain a required water depth for shipping to access the ports. To a certain degree, this is necessary to maintain the functionality of ports and society as a whole. However, following the constant increase of ship sizes, the related dredging activities negatively impact the environment along almost all navigational waters with differing damaging effects meanwhile. Additionally, the dredged sediments also create impairments as they may be contaminated by different substances and as they may cause turbidity when disposed further at sea.

The resulting damage to the environment and habitats can be manifold. It may include impairments to the geomorphology of the area, changes in currents and sediment transportation, changes to extreme weather or sea state conditions, changes of turbidity, water salinity, and suspension of contaminants, all of which may result in habitat loss as well as loss of flora and fauna.

According to the State of Conservation Report (CWSS, 2024) the amount of dredged material for ferry traffic in the Dutch Wadden Sea has doubled within the past 15 years. Especially the fairways to Ameland (almost 50% of the total dredging volume) and from Harlingen to Terschelling and Vlieland are affected.

3.6 Assessment of conflicts of harbours and shipping with the OUV of the Wadden Sea World Heritage Site

This chapter summarises the possible conflicts between existing and potential impact factors arising from harbour and shipping related activities in or adjacent to the Wadden Sea and the key values derived from the Outstanding Universal Value (OUV) of the Wadden Sea World Heritage Site.

A rapid assessment matrix of conflicts is given in Table 1. This matrix includes a variety of specified aspects of possible impacts to the Wadden Sea property. Based on an expert assessment, the matrix also shows if the effect of the identified (potential) impacts are/would be insignificant, minor, significant, or major. The rapid expert assessment intends to represent the overall situation for the Wadden Sea World Heritage Site.

The evaluation/description by choosing one of three colours and vectors is sometimes quite inaccurate due to the large spatial area to be considered and the range of different possible impacts. For example, the "introduction of alien species" may be sometimes almost neglectable, whereas in other cases disastrous. The effect of an accident always depends on the amount and the property of the lost cargo or other substances. In some cases, the specific effect is still quite unclear (underwater noise, GHG emissions).

Table 1. Matrix of (potential) conflicts between impacts related to harbours and shipping activities and the key values derived from the Outstanding Universal Value of the Wadden Sea World Heritage Site.

Possible conflicts	Activity related to energy production	Impact	Criterion (viii): Outstanding geological processes			Criterion (ix): Ongoing ecological and biological processes				Criterion (x): Vital habitats for in-situ biodiversity conservation		
			1	2	3	4	5	6	7	8	9	10
			Unbroken tidal flat and barrier system	Typical geomorphological diversity	Ongoing natural geomorphological processes	Intact natural intertidal ecosystems	Linked geomorphological, biophysical and biological processes	High biomass production typical for the Wadden Sea	Key site for sustaining abundant wildlife beyond its borders	High typical biodiversity	Staging, moulting and wintering area for migratory birds	Essential stopover for the East Atlantic Flyway
Introduction of invasive alien species	Operational pollution											
Underwater noise	Operational pollution											
Greenhouse Gas Emissions	Operational pollution											
Dredging and dumping of sediments in estuaries	Maintenance											
Pollution due to Accidents	Accidental pollution											
Pollution due to unlawful Acts	Unlawful acts											

The following table shows the symbols used in the rapid assessment matrix (taken from Periodic Reporting, the trilateral science-policy matrix).

Impact		Origin		Trend		Temporal scale	
	positive		inside	→	stable		one off or rare
	negative		outside	↗	increasing		intermittent or sporadic
	current			↘	decreasing		frequent or on-going
	potential						

Degree of concern (negative)			Spatial scale		
	Insignificant	The (potential) impact has no effect on the OUV key value.		Widespread	affecting between 91-100% of the property's area at any one time
	Minor	The (potential) impact produces/can produce a minor disturbance of the OUV key value.		Extensive	affecting between 51-90% of the property's area at any one time
	Significant	The (potential) impact produces/can produce a significant disturbance of the OUV key value.		Localised	affecting between 11 and 50% of the property's area at any one time
	Major	The (potential) impact is/can be a major cause of disturbance of the OUV key value.		Restricted	affecting less than 10% of the property's area at any one time
	Range	The (potential) impact is/can be from insignificant to a major cause of disturbance of the OUV			

4. Recommendations

Many improvements have already been made for the protection of the Wadden Sea against possible harbour and shipping impairments, but there are also many proposals for gaps to be closed (Parsons, Erbe, Parsons, & Meekan, 2021) which are still in discussion or to be implemented. The list of recommendations hereunder picks up some of the most important ones, while others address new topics. The proposals are intended to raise awareness and encourage deliberation in order to update the necessity to act in this day and age.

4.1 Summary of targets

Harbour/ Shipping: Generally, the overall safety level in the German Bight is, compared to the situation worldwide, considered to be high, as, *inter alia*, acknowledged reporting and monitoring systems, contingency

planning, etc. are in place. However, a 100 % safety level can never be accomplished, especially in a complex and changing working environment. Possible risks may be reduced by organisational or technical improvements but, as the pattern of shipping and the specific situation on board of ships are constantly changing, the safety level and the suitability of measures to maintain or enhance the safety level or environmental protection need to be continuously checked and potentially adapted.

The last two decades in particular have yielded remarkable progress regarding (possible) environmental impacts from shipping, *inter alia*, with respect to accidental pollution, air emissions, and harmful antifouling. The Wadden Sea area took advantage of the strengthening or introduction of regulations, also regarding the duty of ports, for example, the requirement to handle tank washing residuals ("persistent floaters") according to the Port Reception Facility Directive which was introduced only recently. Last but not least, the recognition of the Wadden Sea as a PSSA needs to be mentioned. This status highlights the constant need to observe and improve the prevailing protection level and could be a trigger to implement further improvements.

4.2 Recommendations for ships

PSSA / APM utilisation for the Wadden Sea area

Management: IMO member governments with PSSAs are encouraged to bring forward concerns and proposals for additional APMs or modifications to existing APMs or to the PSSA itself. Adequate APMs for further improvement of the Wadden Sea protection have already been discussed, *inter alia*, an extension of the PPSA, limited ship speed in the area and waste water disposal. Also, underwater noise was recognised as a threat to be possibly tackled within a PSSA regime.

Monitoring: Assess and document ship speed, discharge of waste water and underwater noise levels, in order to evaluate potential risks to derive possible mitigation measures / APMs (if applicable).

Research: Apply an FSA to identify parameters which could serve as a basis to utilize the potential of the PSSA/APM regime in order to find the most effective solutions to improve the safety and environmental protection level. Conduct ship noise level assessments to identify adverse effects on the marine environment and living resources of the sea.

Use of the German Bight deep water route

Management: Due to the specific risk potential, the use of the German Bight deep water route is mandatory for certain types of tankers. Based on accident statistics and investigations, it may be suggested that other ship types (large container ships, high risk due to the type of cargo or bunker on board or based on e.g. PSC records) should consider using the mandatory deep water route as they may pose high risks.

Monitoring: Monitor weather-based recommendations and proper adherence when using the German Bight western approach deep water route. Assess whether ship-types apart from specified tankers should be obliged to use the German Bight deep water route.

Research: Present management practise should be evaluated by applying a FSA in order to identify parameters which could serve as basis to oblige certain types of ships to use the German Bight deep water route.

Speed limitation

Management: The introduction of a speed limit would provide different benefits for the Wadden Sea area. As a sectoral confined speed limit would provide various benefits without causing long delays. A proper voyage planning would consider possible speed reductions in order to avoid anchorage anyhow.

Monitoring: Observe traffic speed pattern on the access to large ports and especially to the Terschelling-German Bight TSS. Observe speed limits of new services such as offshore supply shipping and the deployment of water taxis to and from the islands and enforce existing speed limits.

Research: Conduct a FSA to identify different implications in connection with ships speed, best practice, and possible exemptions – taking into account, for example the voluntary noise reduction scheme and analysis using in-situ noise measurements according to the ECHO Program in Canada.

Climate change mitigation

Management: Promote the provision of incentives to support local and regional initiatives to shift from the use of fossil fuels, especially with ferries and in coastal shipping. Support the use of systems like the ESI or the Blue Angel Award to promote sustainable techniques in shipping.

Support local initiatives to transfer from fossil-fuelled shipping to regenerative energy. Raise awareness among actors in the context of port services and leisure shipping and consider to help to provide e-charging facilities for small shipping services and boating.

Monitoring: Monitor and support initiatives to promote fossil free shipping. Carefully consider initiatives to establish LNG as a ship fuel as this may not be productive in reducing GHG emissions.

Research: Investigate further opportunities to move from the use of fossil fuels in shipping, *inter alia*, also in context with coastal/leisure shipping.

Handling of exhaust gas cleaning system discharge

Management: Promote the use of low sulphur fuels and the use of fossil free fuels in coastal and offshore shipping. Consider a ban on the release of scrubber discharge in the vicinity to the Wadden Sea border.

Monitoring: Monitor ships operating open loop scrubbers. Investigate the amount of scrubber discharge disposed of in, or close to the Wadden Sea area and initiate the monitoring of the proper function of installations and online monitoring systems such as calibration to ensure that the concentrations of PAH, turbidity, and the pH are within the defined limits.

Research: Apply an environmental risk assessment on the discharge of scrubber waste water into protected areas like the Wadden Sea and support investigations on the use of closed loop scrubbers and reception facilities in ports.

Introduction of invasive species mitigation

Management: In order to prevent hull fouling, promote the provision of hull washing services in ports.

Monitoring: Support inspections to verify the proper functionality of ballast water treatment systems. Monitor the magnitude of introduction and spread of neobiota by shipping into the Wadden Sea area.

Research: Support the improvement of ballast water treatment systems as well as the identification of possible introduction of alien species.

Underwater noise mitigation

Management: Consider adequate speed limits to reduce underwater noise (refer to ECHO Program, chapter 3.2.3). Consider re-routeing of specified ships to shipping lanes to avoid biologically important areas, or the establishment of acoustic buffer zones.

Monitoring: Assess the traffic and related ship based noise levels close to the Wadden Sea border in order to derive possible mitigation measures / APMs (if applicable).

Research: Investigate the actual impacts caused by shipping activities on marine species. Identify possible means to reduce the noise level (slow speed, shift of (specified) traffic, use of classification notation systems for coastal shipping).

4.3 Recommendations for harbours

Climate change mitigation

Management: Identify possible additional climate neutral application opportunities for ports and initiate and support the timely introduction of OPS and the introduction of electric and fuel cell driven ships.

Monitoring: Following the Sylt Declaration (§ 24), leading communities of the signatory states of the Wadden Sea World Heritage committed themselves to be climate neutral by 2030. Track the respective development including the emission of ships, port services and leisure boating and omit the use of LNG, where possible.

Research: Identify additional means to support climate neutrality, for example the transition to fossil free fuels in offshore, leisure, and port service shipping.

Reception facilities for sulphur scrubber waste water

Management: Encourage the use of low sulphur or fossil free fuels in shipping. Be prepared to provide reception facilities for exhaust gas cleaning residuals. Prohibit all scrubber discharges in or close to the Wadden Sea area. If closed loop scrubbers are used, they are to be operated in zero-discharge mode.

Monitoring: Assess the present situation and the respective developments in order to evaluate proper and legal implementation of a prohibition of the use of open loop scrubbers. Conduct ongoing water and sediment monitoring for acids, PAHs, heavy metals, nitrates, and nitrites (Comer, Georgeff, & Osipova, 2020)

Reception facilities for ballast water / provision of hull cleaning sites

Management: Be prepared to provide ballast water treatment or reception facilities and offer hull cleaning sites.

Monitoring: Assess the present situation and the respective developments in order to evaluate a proper and

legal implementation.

Dredging activities for ferry fairways

Management: For cases, the avoidance of dredging is not possible, the government of the Netherlands has started a process to “ensuring accessibility while minimizing the impact on nature” meanwhile (CWSS, 2024). Possible measures identified include the environmentally sound dredging and use of the material, the operation of suitable ship types or even the repositioning of harbours.

Monitoring: Assess the present situation and compare the necessity for dredging activities with ongoing and predicted traffic development. Encourage and observe options to adapt the ship design to the specific environmental surrounding.

5. Summary

By addressing possible impacts of harbour activities and shipping on the Wadden Sea area, it must be distinguished between international and domestic shipping. International shipping navigates at the seaside of the Wadden Sea islands and uses estuaries to enter the inward ports of the Wadden Sea, whereas domestic shipping with ports of registry within this area, liaises islands and the hinterland for the transport of passenger and goods.

Risks and (possible) impacts of international shipping are probably to be estimated more serious, the means to improve the situation are limited due to international constraints on applying quick improvements. Domestic shipping, which partly has the potential for similar but less serious impacts, are nonetheless to be considered as they constantly ply in the area. They are within the reach of national legislation and, last but not least, paradigmatic for international shipping, especially when they are important players in a marine World Heritage Site like the Wadden Sea. This offers the opportunity to address existing deficits at local or regional levels and, thereby, interfuse international legislation.

The assessment above is intended to delineate pending challenges, for some of which measures have already been put in place but should be strengthened, like the consideration of air emissions or the introduction of measures to prevent the introduction of alien species. Other issues need more attention in the future, such as the consideration of the harmful effluent of scrubber waste water, the implications of GHG emissions and underwater noise. Whereas some impacts efficiently can be controlled at a regional or trilateral level, others, like global warming, need to be tackled additionally at the international level.

Due to the special circumstances and the imminent environmental challenges, the stakeholders in marine World Heritage Sites are constantly requested to monitor and act as front-runners to maintain the site’s specific OUV as well as being exemplary actors for an ambitious advancement for the protection of the marine environment.

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