PLASMAR

Bases para la planificación sostenible de áreas marinas en la Macaronesia

Finding the balance of Blue Growth sustainable development within Ecosystem approach (2.1.1 c&d) Analysis of Maritime Transport in Macaronesia under MSFD

ISABEL LOPES, NATACHA NOGUEIRA, JOÃO CANNING CLODE E PEDRO SEPÚLVEDA

UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA
ECOAQUA www.ecoaqua.eu
PROYECTO COFINANCIADO POR LA UNIÓN EUROPEA Investigación e Innovación
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[1] *Secretaria Regional do Ambiente e Recursos Naturais – Direção Regional do Ordenamento do Território e Ambiente*

[2] *Secretaria Regional da Agricultura e Pescas – Direção Regional de Pescas*

[3] *ARDITI – Agência Regional para o Desenvolvimento da Investigação, Tecnologia e Inovação*

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I. Context

1.1 Introduction

The target of the present study is the identification of relevant environmental issues related to the maritime transport in the Biogeographical Region of the Macaronesia, integrating the concepts of Blue Growth and MSFD to achieve Good Environmental Status for a sustainable development.

Following the European environmental legislation framework (Marine Strategy Framework Directive), the Decision 2017/848/EU lays down criteria and methodological standards on Good Environmental Status (GES) of marine waters and standardized methods for monitoring and assessment.

This report follows the 11 qualitative descriptors (QD) of GES, assessed by an overall of 42 criteria, namely:

- **Descriptor 1.** Biodiversity is maintained
- **Descriptor 2.** Non-indigenous species do not adversely alter the ecosystem
- **Descriptor 3.** The population of commercial fish species is healthy
- **Descriptor 4.** Elements of food webs ensure long-term abundance and reproduction
- **Descriptor 5.** Eutrophication is minimized
- **Descriptor 6.** The sea floor integrity ensures functioning of the ecosystem
- **Descriptor 7.** Permanent alteration of hydrographical conditions does not adversely affect the ecosystem
- **Descriptor 8.** Concentrations of contaminants give no effects
- **Descriptor 9.** Contaminants in seafood are below safe levels
- **Descriptor 10.** Marine litter does not cause harm
- **Descriptor 11.** Introduction of energy (including underwater noise) does not adversely affect the ecosystem

1.2 Characterization and regulation of the activity

Anthropogenic pollution poses a major threat to marine environment due to the harmful effect on biota, ecosystem structure and function. It also causes an economic, human health and aesthetic problems (STAP, 2011). The EU is highly dependent on maritime transport and seaports for both internal and external trade and shipping is an important contributor to the European economy and the quality of life to European citizens (HPCEU, 2014). Marine transportation includes cargo-carrying commercial shipping (e.g., merchant marine) and non-cargo commercial shipping (e.g., ferries, cruise ships). Also included in the marine transports are military ships, tugs, and fishing vessels.

Maritime transport contributes to multiple environmental pressures (Knights *et al*., 2011), which compromise direct and indirect socio-economic benefits derived from the goods and services of the marine and coastal ecosystems (Boteler *et al.,* 2012). High volume of maritime transport combined with other socio-economic activities, result in hotspots of environmental degradation and contributes to creating cumulative impacts on marine and coastal ecosystems (Boteler *et al.*, 2016);

Shipping is regulated by a combination of standard setting at the international level by the International Maritime Organization (IMO), a United Nations body established for improving safety and security of shipping and for preventing marine pollution from ships. IMO conventions become binding upon Governments who have ratified them, and enforcement depends upon the Government Parties. These conventions regulating commercial shipping will be influential to achieving GES (Salomon & Dross, 2013). Two

important International Maritime Organization (IMO) Conventions which will assist in achieving GES are the International Convention for the Control and Management of Ship´s Ballast Water and Sediments (BWM) and the International Convention for the prevention of Pollution from Ships (1973), modified by the protocol of 1978 relating thereto and by the Protocol of 1997 (MARPOL). More recently, policy and management tools to reduce environmental effects associated with marine transportation used long-term monitoring to determine the relative changes of impacts (Wooldridge, McMullen, & Howe, 1999). In recent years, marine transportation companies and port facilities have established numerous environmental performance indicator frameworks and European ports and maritime transportation have already adopted these frameworks aiming toward sustainable port management.
The frameworks include: European Sea Ports Organization (ESPO) (www.espo.be), EcoPorts (www.ecoports.com), Port Environmental Review System (PERS), PORTOPIA (www.portopia.eu), and the Green Marine Environmental Program (GMEP) (http://www.green-marine.org/) (Darbra *et al*.,2009; ECOPORTS Valencia, 2000; ESPO, 2012; Peris-Mora,Diez Orejas, Subirats, Ibañez, & Alvarez, 2005; Walker, 2016).

Macaronesia is no different from the rest of the world and the maritime transport takes a relevant position, especially in these outermost regions, such as Madeira, Azores and Canary archipelagos. These regions possess an important external dependence from continental Europe (e.g. fuel, food, raw material, machinery, etc.), but simultaneously, Macaronesia is a key region in international maritime transport due to its strategic location.

Since the nineteen century, the strategic position of the Macaronesian archipelagos around the midpoint of the Atlantic trading routes, made them attractive as way stations between Europe and the rest of the world. They were used for resupplying water, fresh goods and coal to the earlier steamships (Bosa, 2013). The situation has not changed since then, and the islands are still considered as a convergence of shipping lanes where no significant commercial activity is taking place except in the Canary Islands.

In 2016, in the Madeira archipelago, the movement of maritime transport (containers, tanks, bulk carriers, general cargo ships and others) registered around 1,500 thousand of goods moved (Lopes *et al*., 2017; Fernández – Palacios *et al*., 2017). In 2015, the analysis of the evolution of maritime traffic of inter-island passengers registered around 267,541 passengers and regarding to the cruise ships in the same year it ended up achieving the national leadership when registering with 578,492 cruise tourists and 308 scales (Administração dos Portos da Região Autónoma da Madeira, S.A.).

The Canaries compared to the other archipelagos, present a higher rate of maritime carriage of goods due to its growing population that surpasses the two million and to its extreme dependence on the maritime transportation with mainland Europe to supply goods in order to meet the local demand. Besides, the Canaries hosts one of the major shipping ports in Spain, the port of Las Palmas. It is ranked 87th in the top 200 ports worldwide and it is an important trans-shipment point on international shipping routes with 433 linked port (Tovar *et al*., 2015). It stands out in fuel supplies, in passenger traffic and also in container traffic with a total transaction of more than one million Twenty-feet Equivalent Unit (TEUs) in 2010 (Orive *et al*., 2016; Menini, E., 2018). The cruise passengers showed a substantial increase in the last 16 years for the Ports of Santa Cruz de Tenerife (Tenerife), La Luz and Las Palmas (Gran Canaria) and Arrecife (Lanzarote). In 2016, according to the Canary Islands Institute of Statistics (ISTAC) these figures reached nearly two million thousand passengers across the Canaries.

In the Azores archipelago, the numbers of maritime transport (containers, tanks, passenger ships, bulk carriers, general cargo ships and others) remained more or less constant between 2000 and 2010 with a minimum of 3,335 movements in 2009 and a maximum of 3,829, in 2010 (Fernández-Palacios *et al.*, 2017). In recent years, movements have progressively declined to 2589 movements (in 2014), due to the economic crisis.

To ensure environmentally and economically sustainable ecosystems it is necessary to regulate socio-economic activities which includes maritime transport.

Definition and analysis of maritime transport in the present report was performed including the effect of the activity in harbors and marinas. Though negative events, such as oil spills, do not characterize the normal occurrence of the activity, they were considered in this report, as these events may have significant and last longing effects in the environment.

1.3 Methodology

The state of art of maritime transport in Macaronesia has been analysed in detail, with a view to identify environmental impacts and possible solutions through the review of specific publications and technical reports. The structure given by MSFD on GES (2017/848/EU) has been followed to assess the potential impact of the maritime transport on the aforementioned descriptors.

Additionally, specific tables have been filled for each applying QD and criterion, aiming to explain with more detail identified environmental impacts and likely solutions. The table field values are presented as follows:

1. **Environmental impact** values: **YES/NO** – if **YES** the rest of table fields were field and description of additional text below the table the following factors:
    - Description of the impact – significant adverse effect on the environment (if more than one, included the most relevant or all);
    - Direct/indirect impact;
    - Probability/intensity/complexity of the impact;
    - Expected onset, duration, frequency and reversibility of the impact;
    - Expected cumulation with other types of adverse effects linked to this maritime activity;
    - Currently relevant for the Macaronesia or expected to be relevant in the future (due to expected development of the maritime activity).

2. **Environmental impact spatial extent** values:
    - Impact area is lower than operative maritime activity area;
    - Impact area equal to operative maritime activity area;
    - Impact area broader than operative maritime activity area.

3. **Maritime activity (MA) pressure solution** values: **YES/NO** – if **YES** maritime pressure solution were described according to:
    - If solution is envisaged to avoid, prevent, reduce or offset the pressure;
    - If measure is a reasonable alternative in terms of technical complexity, cost and expected success in reduction of impact;
    - If the MA pressure solution is relevant for the Macaronesia.

4. **Impact mitigation measures** values: **YES/NO** – if **YES** mitigation measures were identified:
    - If solution is envisaged to avoid, prevent, reduce or offset the impact/adverse effect;
    - If measure is a reasonable alternative in terms of technical complexity, cost and expected success in reduction of impact;

- If the impact mitigation measures is relevant for the Macaronesia.

5. **Monitoring method available** values: **YES/NO** – if **YES** monitoring methods were identified:
   - The viability of the monitoring method in terms of cost-effectiveness, complexity and relevance for the Macaronesia;
   - Should monitoring start before the construction phase or with the operational phase?

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II. QD on GES and maritime transport

2.1 Applying descriptors

2.1.1 D1. Species groups of birds, mammals, reptiles, fish and cephalopods (relating to Descriptor 1)

QD1 Species groups of birds, mammals, reptiles, fish and cephalopods (relating to Descriptor 1)							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD1	The mortality rate of birds, mammals, reptiles and non-commercially-exploited species of fish and cephalopods from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured.	D1C1	NO	-	NO	NO	NO
	The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. Member States shall establish a set of species representative of each species group, selected according to the criteria laid down under 'specifications for the selection of species and habitats', through regional or sub regional cooperation. These shall include the mammals and reptiles listed in Annex II to Directive 92/43/EEC and may include any other species, such as those listed under Union legislation (other Annexes to Directive 92/43/EEC, Directive 2009/147/EC or through Regulation (EU) No 1380/2013) and international agreements such as Regional Sea Conventions.	D1C2	YES	BROAD	YES	YES	YES
	The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures. Primary for commercially-exploited fish and cephalopods and secondary for other species	D1C3	YES	BROAD	YES	YES	YES
	The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. Primary for species covered by Annexes II, IV or V to Directive 92/43/EEC and secondary for other species.	D1C4	YES	BROAD	YES	YES	YES

	The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species. Primary for species covered by Annexes II, IV and V to Directive 92/43/EEC and secondary for other species	D1C5	NO				

D1C2: The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. Member States shall establish a set of species representative of each species group, selected according to the criteria laid down under 'specifications for the selection of species and habitats', through regional or sub regional cooperation. These shall include the mammals and reptiles listed in Annex II to Directive 92/43/EEC and may include any other species, such as those listed under Union legislation (other Annexes to Directive 92/43/EEC, Directive 2009/147/EC or through Regulation (EU) No 1380/2013) and international agreements such as Regional Sea Conventions.

D1C3: The population demographic characteristics (e.g. body size or age class structure, sex ratio and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures. Primary for commercially-exploited fish and cephalopods and secondary for other species

D1C4: The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. Primary for species covered by Annexes II, IV or V to Directive 92/43/EEC and secondary for other species.

Maritime transport is the backbone of the World Economy (Grote *et al.*, 2016). It is generally believed that more than 90% of world trade is carried by sea (Tsaini, 2011). In 2013, approximately 9.5 billion tonnes of goods were loaded for seaborne transport in ports worldwide (UNCTAD, 2014).

The occurrence and severity of vessel-strike threat to whale populations in a number of regions around the world has made strike threat an emerging conservation issue, particularly in those places where extensive vessel traffic and whales co-occur (Silber *et al.*, 2012). As maritime activities and associated vessel traffic increase, the rate of lethal vessel-strikes is also likely to increase (Silber *et al.*, 2012; Cunha *et al.,* 2017). Various whale-conservation initiatives have been designed to reduce the threat including vessel routing changes or vessel speed restrictions (Vanderlaan *et al*., 2009; Silber *et al*., 2012). Many of these changes were instituted by coastal states following their consideration and subsequent adoption by the IMO.

Macaronesia is home to an exceptional marine biodiversity. It has a unique diversity of sea mammals, with 29 species of cetacean observed in the Canary Islands. Azores archipelago also presents some 24 marine mammals, including beaked whales (*Mesoplodon bidens*), sperm whales (*Physeter macrocephalus*) pilot whales (*Globicephala macrorhynchus*) (European Commission[1]). Madeira amongst several other marine mammals presents a subpopulation of the critically endangered species of Mediterranean Sea monks (*Monachus monachus*) (Petit & Prudent, 2010).

[1] European Commission, The Macaronesian Region, available at: http://ec.europa.eu/environment/nature/natura2000/biogeog_regions/macaronesian/index_en.htm

In this way, it is necessary an assessment of the effect that marine traffic can have towards wildlife conservation measures, especially in Macaronesia, a region which has seen a growth in maritime traffic in recent years (Cunha, 2013).

Associated to maritime transports are the possibilities to disaster in the marine environment. Oil spills have been proved to disturb the abundance of marine species and can provoke increased mortality (Abdulla & Liden, 2008). In Macaronesia the most serious record of oil spill occurred in 1990 in the Madeira archipelago.

1. **Environmental impact: YES.** Over recent decades, cetaceans have been victims of increased ship strikes all around the world (Carrillo and Ritter, 2008; Laist *et al.*, 2001; Silber *et al.,* 2012; Waerebeek *et al.,* 2007; Abdulla & Liden, 2008).The main causes are associated to recreational boating (excess speed); to the use of sonars in boats or military exercises (Freitas, 2004; Silber, Slutsky, & Bettridge, 2010; Cunha, 2013). When species such as cetaceans or turtles are threatened by anthropogenic actions, it may happen that they cease to use that territory (Faris *et al*., 2016). In other cases, it may also happen that the species continues to use the same territory because it is a place of feeding or rest. In these cases, shipping can bring long term harmful results (Walker *et al.*, 2017; Vanderlaan *et al.*, 2009). Ship collisions with cetaceans and turtles also cause different degrees of injury. A high proportion of dead whales show signs attributable to vessel strike, including severe lacerations, broken bones, internal bleeding and other lethal of blunt trauma (More *et al.,* 2002; Campbell-Malone *et al.,* 2008; Silber *et al.,* 2012). Other marine vertebrates, such as sea turtles, are also exposed to the risk of ship strikes (Hazel *et al*., 2007), though in rare cases, turtles show scars along the marginal scutes of the carapace that do not impede their movements or threaten their lives. On most occasions, however, a turtle does not survive an impact or is left seriously injured, with limited movement and diving ability.

In recent years Macaronesia has recorded some cetaceans strikes, although population impact (mortality) is not significant (SRA, 2014; SRMCT, 2014).
In the Madeira archipelago, the first registred throw occurred in 2000 whith 3 sowerby´s beaked whales (*Mesoplodon bidens*) coinciding with a naval exercise at NATO (SRA, 2014). A second event occurred in 2010, when three specimens of sowerby´s beaked whales washed ashore in Machico's beach (SRA, 2014), but without a clear and definitive reason.
In the Azores archipelago in July 2002, 3 sowerby´s beaked whales were also found washed ashore on the island of Pico (SRMCT, 2014). During 2003, new occurrences of dead sprung individuals were registered over several months. In 2009, more beaked whales, alive and dead (close to 10 individuals), were found in the Azores (Terceira, Faial, and S. Miguel) between the months of June and August, but the reason for these strikes has never been discovered.
In the Canary Islands collisions may be caused by the rise of maritime transport, namely the regional and international boats and the rise in the mean speed of ferries (Rodríguez *et al*., 2005; Soto *et al.,* 2000; Fais *et al.,* 2016). From 1991 to 2007, from a total of 59 strikes, around 11% were reported as showing signs of ship-strike (idem,ibidem), affecting several cetacean species like sperm whales, pygmy sperm whales, Cuvier´s beaked whales, short finned pilot whales (Carrillo & Ritter, 2010; Faris *et al*., 2016).

On the other hand, the maritime transports can also affect the species and habitats through oil spills. Normal activity of maritime transports does not contribute directly to not achieving GES in D1C3. Nevertheless, oil spills may occur and as described afterwards in D8, crude oil spills always mean the loss of species.

2. **Environmental impact spatial extent: Broad.** The strikes occur along the maritime space (EEZ), especially in the areas of maritime traffic (Carrillo & Ritter, 2010; Faris *et al.,* 2016; Cunha, 2017).
Relatively to the oil spills, the extent of impacts are wide, depending on the evolution of crude oil stains and coastal areas hit (e.g. the oil spill in 1990 affected the north coast of Porto Santo and a part of the north coast of the island of Madeira).

3. **Maritime activity pressure solution: YES**. IMO has developed several of initiatives to reduce the risk of collisions, namely:

- Instruments mounted on board to detect whales (such as sonar or night vision devices), acoustic alerting devices to warn whales of approaching boats, bottom anchored passive sonar systems designed to detect whale locations, and specially trained observers on board of ferries. Still, none of these solutions alone would seem to be effective or capable of achieving a significant reduction in ship strikes, since each of them either has undesirable side-effects (such as interfering with the whales' communication, or being too unreliable) or is only effective in particular situations (e.g. during day time, during specific weather conditions, only when the whales vocalize, only at short distances, or just within certain angles of the ship's bow) (Abdula & Liden,2008).
- Reducing ship speed when crossing areas of high whale density would both allow cetaceans more time to avoid the oncoming vessel and give the operator more time to react to the whales' presence (Abdulla and Liden,2008; Conn and Silber, 2013; Walker *et al.,* 2017).
- Alter shipping routes in different areas or at different times when whale concentrations are high (Panigada *et al.,* 2006; Walker *et al.,* 2017; Tejedor *et al.,* n.d.; Vanderlaan *et al.,* 2009).
- Creation of voluntary areas to be avoided when the risks of ship-strikes are high and altered speeds fail to protect (Walker *et al.,* 2017).

In Macaronesia some specific initiatives have been considered. For the Canary archipelago, IMO adopted some non-binding resolutions on a range of issues including the designation of Particularly Sensitive Sea Areas (PSSAs). The PSSA designation is linked with specific measures (Associated Protective Measures (APMs) designed to address the risk that shipping poses to each PSSA.

In the Azores archipelago implemented in 1999 the Azores Cetacean Striking Network (RACA), legislated by Resolution No. 72/2006, of June 29, with the following objectives:

- Minimize potential threats to mammals for human safety and health;
- Minimize the pain and suffering of living animals;
- Get the most out of scientific and educational benefits from living or dead bold animals.

In Madeira archipelago, the Regional Legislative Decree nº. 15/2013/M of May 14 amended by Administrative Rule nº. 46/2014 of January 14, which legally regulated all marine vertebrate observation activities and defined the capacity of inherent in the observation of this activity. These activities should follow a set of good practices, such as approaching and observing animals, so as not to cause any disturbance.

Related to the oil spills, several initiatives have been implemented to reduce impacts into the species and habitats. The European project "Reducing the Impact of Oil Spills – RIOS" had as objective the development of an Action Plan, focusing on negative impacts of oil spills on marine wildlife, such as marine and coastal birds, marine mammals and sea turtles, and how these effects could be minimised, e.g. through investments into research and development. In addition, to minimize the effects of accidents and leaks, there are several initiatives of the European Union, as the: Regulation (EU) 2016/1625 of the European Parliament and of the Council of 14 September 2016 amending Regulation (EC) No 1406/2002 establishing a European Maritime Safety Agency.

4. **Impact mitigation measures: YES.** With regard to strikes by vessels, the Autonomous Region of Madeira has developed some legislation. The Regional ordinance nº46 / 2014 of April 22 regulates the load capacity inherent to the activity of cetacean observation in the region and delimits an exclusion area for the observation of cetaceans. This area is characterized by being a preferential habitat of the bottlenose Dolphin (*Tursiops truncates*) to feed, socialize, rest and reproduce (Freitas *et al.,* 2013).

Related to the oil spills, several initiatives have been taken. The *International Convention for the Prevention of Pollution from Ships* (MARPOL), signed in 1973, is one of the most important international marine environmental conventions. It aims at protecting the marine environment through the minimisation or complete elimination of pollution by oil and other harmful substances. It is constantly updated in order to tackle new aspects of environmental pollution, which is performed by amendments and annexes to the convention (Grote *et al.*, 2016).

5. **Monitoring method: YES.** A number of projects have been developed to analyse the state of conservation of cetaceans, including the strikes in the Macaronesia, namely MISTICSEAS project and CETUS project.

Related to the oil spills, in the last years was developed in Macaronesia various studies, some of them related with the Marine Strategy Framework Directive (IEO, TRAGSATEC, 2012; SRA, 2014; SRMCT, 2014).
In the Madeira archipelago, taking into account the oil disaster recorded in 1990, the affected areas have been monitored. The monitoring that has been carried out over the last years has made it possible to see an increase in species (Araújo *et al.,*2005).

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2.1.2 D2. Non – indigenous species

QD2 Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems							
QD	Criteria (element)	CODE Criteria	Env. Impact	Env. impact spatial extent	MA pressure solutions	Impact mitigation measures	Monitoring method
QD2	Newly-introduced non-indigenous species.	D2C1	YES	BROAD	YES		YES
	Abundance and spatial distribution of established non-indigenous species, contributing significantly to adverse effects on particular species groups or broad habitat types	D2C2 — Secondary	NO				
	Proportion of the species group or spatial extent of the broad habitat type which is adversely altered due to non-indigenous species, particularly invasive non-indigenous species.	D2C3 — Secondary	NO				

D2C1: Newly – introduced non-indigenous species

Non-indigenous species (NIS) are species that have spread or have been transferred as a result of human activities, reaching environments in which they previously did not naturally occur (HELCOM[2]). Non-indigenous species are usually not dispersed by natural means, but arrive in new environments via some form of human-mediated transport, so called vectors. In this context, shipping (through ballast water and hull fouling) is considered the main vector for the introduction of marine non-indigenous species worldwide as they offer extended periods during which ships are stationary, and often offer suitable places for species to settle in shallow water or modified habitats (Canning-Clode, 2015; Lehtiniemi *et al.* 2015).

Species that naturally increase their range are not taken into consideration, however, NIS that spread to neighboring areas by natural means following introduction (secondary dispersal), are still considered to be NIS (OSPAR[3]).

After their first introduction into a new sea area, non-indigenous species may spread further. The rate of spread is often determined by species specific factors, such as environmental tolerance or reproductive rates (HELCOM[3]). This pattern of establishment, and consecutive spread, is characteristic of invasive species. However, not all non-indigenous species are invasive, and may not spread widely nor become abundant. Established non-indigenous species may influence biodiversity and the ecosystem in different ways, and their effects are often difficult to foresee. However, the presence of NIS can exert pressures in the marine environment with possible social, economic or environmental impacts (Gestoso *et al.*, 2018). Invasive NIS are one of the most significant threats to global biodiversity both in terrestrial or aquatic systems. Removing NIS subsequent to introduction is very difficult, which means preventing their

[2] HELCOM, Non-indigenous species, available at: http://stateofthebalticsea.helcom.fi/pressures-and-their-status/non-indigenous-species/
[3]https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/non-indigenous/

introduction is the most cost-effective approach to management, thus avoiding costs and the need for eradication measures (OSPAR[4]).

1. **Environmental impact: YES.** The introduction of non-indigenous species (NIS) into new ecosystems is now considered a major environmental and economic threat and, along with habitat destruction, a leading cause of biodiversity loss at a global scale (Nentwig, 2007; Halpern *et al.*, 2008; Clarke Murray *et al*., 2014; Canning-Clode 2015; Gestoso *et al*., 2017). In fact, biological invasions were recently considered the second most significant driver of species extinctions (Bellard *et al*., 2016; Gestoso *et al.*, 2017). This fact could be even more severe in island ecosystems due to the relatively poor biological communities which are integrated by a great number of endemic species (Cronk, 1997; Ramalhosa *et al.*, 2017).

In the marine system, the most significant vector contributing to new biological invasions is commercial shipping, particularly through the movement of fouling communities on ship hulls or through ballast water (Cohen & Carlton,1998; Ruiz *et al.* 2000; Coutts & Taylor, 2004; Hewitt *et al.*, 2004; Mineur *et al.*, 2007; Davidson *et al*., 2009; Souto *et al.*, 2016; Gestoso *et al.*, 2016). The majority of such transfers are from harbour to harbour, due to the nature of shipping traffic, and thus typically involved are estuarine species with striking euryhaline and eurythermal adaptations (Ruiz *et al.*, 2000). Once introduced, many non-indigenous species flourish on the vast amount of artificial hard substrate (e.g. floats, piers, docks, pontoons, buoys, or seawalls) available in modern times in these environments (Bulleri, 2010), due in part to their physiological and behavioral abilities to outcompete native species.

Another vector of introduction of NIS is through research vessels or drilling platforms employed in offshore oil and gas exploration, serving as large artificial reefs and therefore pose a high risk of NIS transmission (Abdulla & Liden, 2008). 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.

A successful ship-introduced invasion is a complex process in which organisms must survive both the significantly selective transit (either via hull fouling or ballast water) and the conditions in the recipient port, and also, need to arrive in sufficient numbers to establish a self-sustaining population outside their native range (Abdula & Liden, 2008). The establishment of NIS in native communities induces a complex range of consequences, depending on the interaction between species, the ability of the introduced species to modify the habitat or the ecosystem energy flow in the new environment (Crooks, 2002; Wallentinus & Nyberg, 2007).

The consequences of an invasion are not often easily predicted based upon knowledge of a species in its native range (Ruiz *et al*., 1997). Moreover, the impacts of NIS are far-ranging and include the depletion of fisheries and other resources and secondary economic impacts stemming from human health effects and loss of biodiversity (Chapin *et al*., 2000; RN Mack *et al*., 2000; Raaymakers, 2002).

2. **Environmental impact spatial extent: Broader.** The area with highest probability to find NIS is near their point of inoculation (Abdulla & Liden, 2008). In this context, floating docks and other artificial substrates are very common in bays and estuaries, particularly in shipping areas and marinas are highly relevant for detecting new NIS arrivals (Carlton *et al.*, 1991; Wonham, 2005; Ramalhosa *et al.*, 2017).

[4] OSPAR, Trends in New Records of Non-Indigenous Species Introduced by Human Activities, available at: https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/non-indigenous/

3. Maritime activity pressure solution: YES. Several policy instruments and regulations were created to address the problem of NIS introductions requiring the implementation of prevention measures, mainly through the management of introduction pathways and vectors. In Europe, the European Strategy on Invasive Alien Species (EC, 2008a) encouraged the development of a pan European inventory of NIS and required information about NIS taxonomy and biology, propagule characteristics, dispersion properties and risk assessment predictions. The European Marine Strategy Framework Directive (EU-MSFD), published in 2008, requires Member States to take the necessary measures to achieve or maintain Good Environmental Status in marine ecosystems by 2020 (EC, 2008b). The EU-MSFD descriptors for environmental status assessment include criteria addressing the abundance and state of NIS, in particular invasive species and their impacts. These regulations have triggered the compilation of data on NIS and the development of research projects funded by the European Commission (Occhipinti-Ambrogi *et al*., 2011). Several NIS inventories have been published for European countries in the last decades, such as the national lists for France (Goulletquer *et al*., 2002), Norway (Hopkins, 2002), Great Britain (Minchin and Eno, 2002; Minchin *et al*., 2013), Greece (Pancucci-Papadopoulou *et al*., 2005), Denmark (Jensen and Knudsen, 2005), the Netherlands (Wolff, 2005), Germany (Gollasch & Nehring, 2006), Belgium (Kerckhof *et al*., 2007), Ireland (Minchin, 2007),Italy (Occhipinti-Ambrogi *et al.*, 2011) and Portugal (Cardigos *et al*., 2006 (Azores), Canning-Clode *et al*., 2013 (Madeira); Chainho *et al*., 2015 (Portugal mainland and islands).

The Convention on Biological Biodiversity (CBD) recognized the need for the “compilation and dissemination of information on alien species that threaten ecosystems, habitats, or species to be used in the context of any prevention, introduction and mitigation activities”, and calls for “further research on the impact of alien invasive species on biological diversity” (CBD 2000). The treaty requires all internationally operating vessels to manage their ballast water and sediments which will include maintaining a ballast water record book and International Ballast Water Management Certificate (IMO, 2016b). Other management programs, such as Green Marine, encourage ship-owners to test or install treatment systems on their vessels (Walker, 2016). The GloBallast partnerships (GBP), an IMO-initiated ballast water management tool, was implemented in 2007 to aid developing countries with national policy, legal, and institutional reform aimed at reducing the harmful transfer of aquatic organisms in ships’ ballast water (GloBallast Partnerships, 2017). The Ballast Water Management Convention entered into force on 8 September 2017 which requires each relevant vessel to carry an International BWM Certificate, issued by the flag state.

The objective set by Aichi Biodiversity Target 9 is that “by 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment”.

This reflects Target 5 of the EU Biodiversity Strategy (EU, 2011). In Europe, the Marine Strategy Framework Directive (MSFD; EU 2008) recognizes alien marine species as a major threat to European biodiversity and ecosystem health, requiring Member States to develop strategies to reach the Good Environmental Status of the marine environment (Katsanevakis *et al.*, 2014).

There are also some European and national legislation (Madeira, the Azores and the Canary Islands) which aim to avoid accidental introductions, as well as control or eradication of species already introduced:

- Council Regulation (EC) No 708/2007 of 11th June, concerning use of alien and locally absent species in aquaculture.
- Regulation (eu) no 1143/2014 of the european parliament and of the council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species
- The Decree-Law no. 565/99 – Republic Diary no. 295/1999, Series I-A of 1999-12-21 - Regulates the introduction into nature of non-indigenous species of flora and fauna.
- Regional Legislative Decree No 27/99 / M of 28th August, It governs the arrest, import and entry into the territory of Autonomous Region of Madeira of non-indigenous species of fauna
- Decree Law no. 40/2017 of 4 April, related to the aquaculture.

There are also some international Directives and Conventions that advocate the adoption of measures that condition intentional introductions and avoid accidental introductions, as well as the control or eradication of species already introduced, namely:

- Decree-Law No. 95/81 of 23rd July, Convention on the Convention on the Conservation of European Wildlife and Natural Habitats.
- Decree No. 103/80 of October 11, Convention on the Convention on Migratory Species of Wild Animals
- Decree No. 21/93 of 21nd June, Convention on Biological Diversity

4. **Impact mitigation measures.** As mentioned earlier, there are only measures currently in place that try to mitigate the impacts of invasive species.

5. **Monitoring method: YES.** In Macaronesia, to the best of our knowledge there were not many studies that conducted standardized monitoring surveys for non-indigenous species detections (but see Cardigos *et al*.; 2006, Canning-Clode *et al.;* 2013; Chainho *et al*.; 2015). Particularly for the Madeira archipelago, the MSFD initial assessment reported 39 NIS (SRA, 2014). However, the number of marine NIS detections in Madeira archipelago has increased significantly in recent years due to ongoing monitoring surveys, particularly in marinas on the southern coast of both Madeira and Porto Santo. Consequently, several records of different taxa have been detected (Canning-Clode *et al*., 2013), such as Annelida (Ramalhosa *et al*., 2014), Crustacea (Ramalhosa & Canning-Clode, 2015) Bryozoa (Wirtz & Canning-Clode, 2009; Ramalhosa *et al*., 2016; Souto *et al*., 2016), including bryozoan species previously undescribed for science in Madeira Island (Souto *et al*., 2015) and Porto Island (Souto *et al*., 2016).

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2.1.3 D10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment

QD10 Properties and quantities of marine litter do not cause harm to the coastal and marine environment							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD10	The composition, amount and spatial distribution of litter (excluding micro-litter, classified in the following categories : artificial polymer materials, rubber, cloth/textile, paper/cardboard, processed/worked wood, metal, glass/ceramics, chemicals, undefined, and food waste) on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.	D10C1	YES	BROAD	YES	YES	YES
	The composition, amount and spatial distribution of micro-litter (particles < 5mm) on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment.	D10C2	YES	BROAD	YES	YES	YES
	The amount of litter and micro-litter classified in the categories 'artificial polymer materials' and 'other' ingested by marine animals (birds, mammals, reptiles, fish or invertebrates.) is at a level that does not adversely affect the health of the species concerned.	D10C3 — Secondary	YES	BROAD	YES	YES	YES
	The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.	D10C4 — Secondary	YES	BROAD	YES	YES	YES

D10C1 The composition, amount and spatial distribution of litter (excluding micro-litter, classified in the following categories : artificial polymer materials, rubber, cloth/textile, paper/cardboard, processed/worked wood, metal, glass/ceramics, chemicals, undefined, and food waste) on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.

D10C2 The composition, amount and spatial distribution of micro-litter (particles < 5mm) on the coastline, in the surface layer of the water column, and in seabed

sediment, are at levels that do not cause harm to the coastal and marine environment.

D10C3 The amount of litter and micro-litter classified in the categories 'artificial polymer materials' and 'other' ingested by marine animals (birds, mammals, reptiles, fish or invertebrates.) is at a level that does not adversely affect the health of the species concerned.

D10C4 The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.

Along with chemical pollutants such as heavy metals, nutrients, and hydrocarbons, marine debris contaminates beaches, water surface, water column and seabed levels of the oceans worldwide. Marine debris consists of items of synthetic organic polymers, called "plastics", wood, metal, glass, rubber, clothing and paper. In some locations, plastics make up most of the marine debris, making up 90% of marine debris (OSPAR, 2014). Substantial quantities of plastics have accumulated in the marine environment since the first reports of plastics occurrence in the early 1970s (Moore, 2015). It is estimated that more than 150 million tons of plastics have accumulated in the world's oceans, while 4.6-12.7 million tons (from Jambeck *et.al, 2015*) are added every year (European Commission). It is broadly documented that entanglement in, or ingestion of, marine litter can have negative consequences on the physical condition of marine animals and even lead to death. The list of species that have been reported to suffer from entanglement or ingestion of marine debris includes seabirds, marine mammals, fish, crustaceans, mollusks and turtles. Ingestion of microplastics is also of concern as it may provide a pathway for transport of harmful chemicals into the food web. Additionally, marine litter is known to damage and degrade habitats (e.g. in terms of smothering). Furthermore, recent research indicates that **marine debris** is now being considered a growing vector for the introduction of non-indigenous species, with transoceanic rafting already likely intensifying species invasions worldwide (Barnes & Milner 2005; Gregory, 2009; Mouat *et al*., 2010; CIESM 2014; de Tender *et al*., 2015; Carlton *et al*., 2017). Despite global efforts to reduce inputs and remove plastics from the marine environment, their abundance will likely increase due to its resilience to environmental degradation and they will continue to exert a detrimental impact on marine biota, pose a navigational hazard for shipping, and cause negative economic and financial impacts to fishing, transportation and tourism, as well as governments and local communities (STAP, 2011).

1. **Environmental impact** values: **YES.** The discharges of ship-generated waste and cargo residues into the sea contribute to the estimated 20% and 40%, respectively, of the total amount of the marine debris originated from sea-based sources. Waste generated on ships include sewage, domestic and operational waste (garbage) and cargo residues generated during the service of a ship. When ship-generated waste is not disposed of or delivered legally it contributes to pollution of the marine environment and may have adverse effects on ecosystems, including the effect of microplastics (EMODnet). Historically, ships were a major source of plastic pollution of the oceans due to the maritime tradition of dumping garbage at sea (Hagen, 1990). Currently, it is admitted that maritime transport contributes to marine litter in two ways: land-based, as shipbuilding and ship recycling activities along with industrial discharge, sewage, urban discharge or dumpsites contribute to the inputs of plastic litter and marine-based source, which include cargo, recreational and military navigation, fishing vessels, oil and gas platforms. Moreover, large quantities of plastics may enter the sea during storms, tidal flooding and shipping accidents.

However, the assessment of marine plastic pollution is relatively recent, and extensive areas of the ocean remain y*et al*most unexplored, including the Macaronesia biogeographical area. Recent studies showed that some areas of the Macaronesian archipelagos are increasingly blighted by marine debris, brought from elsewhere by currents to remote shorelines. Much of the debris identified could be linked to agricultural and fishing activities in the archipelagos and most of debris was floating plastics. Agriculture in both the Canary Islands and Madeira uses all available fertile land (i.e. farming to the edge of the cliff top) and plastic covering to both protect crops and 'speed up' cropping (Carswell *et al.,* 2011). Still, addressing the question of tracking ocean debris to maritime transport route in Macaronesia is somewhat prohibitive.

2. **Environmental impact spatial extent**: Broad. Plastics are transported by currents for variable distances until they are settled on the seafloor, from where they can eventually be re-suspended by wave action and tidal currents and re-transported. The spatial and temporal dynamics of plastics depend on numerous factors including broad seasonal and local hydrological factors, coastline geography, system-entry sources (including shipping routes) (Possatto *et al*., 2015).

Reported plastic concentrations in deep-sea sediments in the Atlantic Ocean, the Mediterranean Sea and Indian Ocean, refer up to 800,000 particles per cubic meter, indicating that seabed could be acting as a large reservoir (Woodall *et al*., 2104).

3. **Maritime activity (MA) pressure solution: YES.** Several legal frameworks and policy initiatives are joining efforts to address the prevention and management of marine debris. The EC Directive 2000/59/EC aimed to reduce the discharge of waste into the sea by ensuring the availability and use of port waste reception facilities. A proposal for a new directive is currently under discussion within the Commission, in order to better align operations at port and operations at sea regulating the shore-sea interface. The new proposal seeks to adapt its scope definitions to the international framework, in particular the MARPOL Convention and its thematic annexes I through VI. MARPOL is one of the most important global legal instruments. With 153 signatories, it currently regulates more than 98% of the world's shipping tonnage (98.52% on 15 July 2015) (IMO, 2015), aiming at the prevention and minimization accidental pollution and pollution from routine operations on board ships. Annex V of the MARPOL Convention addresses garbage and its management and disposal. Even though the Annex V was optional, it did receive a sufficient number of ratifications and has entered into force on 31 December 1988. Since then, a number of areas for its amendment have been recognized (IMO, 2011) and the revised Annex V came into force on 1st January 2013. Annex V provides the framework for the control of garbage generated by all ships and offshore platforms, both fixed and floating (IMO, 2011). Unlike discharge of some other types of ship-generated wastes such as paper, rags, glass, metal, crockery, which was permitted outside special areas at defined distances from the nearest land by the previous version of Annex V, and it is prohibited by the revised version, discharge of plastics has been prohibited by both versions.

In addition to plastics used or present on board of ships (packaging items, parts of ship construction, disposable eating utensils, bags, sheeting, floats, fishing nets, fishing lines, rope, sails and many other plastic items) revised Annex V also prohibits discharge of incinerator ashes from plastic products. Exemptions apply only in limited situations when discharge of garbage/fishing gear is necessary for the purpose of securing the safety of a ship and those on board or saving life at sea, or when accidental loss of fishing gear or garbage resulting from damage to a ship or its equipment occur, provided that all reasonable precautions were taken (IMO, 2012). For such discharges, entries into the Garbage Record Book (GRB), or the ship's official log-book for ships of less than 400 GT are required.

Regarding documents that must be carried onboard Annex V imposes the following requirements:

(a) Every ship of 100 GT and above (instead of 400 GT required by the superseded Annex V), and every ship which is certified to carry 15 or more persons, and fixed or floating platforms must carry a garbage management plan, (GMP) (based on IMO Guidelines MEPC.220(63) and in working language of the crew) containing procedures for minimizing, collecting, storing, processing and disposing of garbage, including the use of the equipment on board.

(b) Every ship of 400 GT and above, and every ship certified to carry 15 persons or more engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties to Annex V, and every fixed or floating platform must carry and maintain a GRB.

However, Annex V fails to impose recordkeeping requirements for the handling of garbage for ships under 400 GT. This means that most of the global fishing fleet is not required to record discharge operations (Chen & Liu, 2013). This gap in the control could be one of the reasons why fishing vessels often discharge plastic debris into sea (Chen & Liu, 2013; Jones, 1995; Topping *et al.*, 1997).

Port reception facilities are also one of the most important tools for addressing waste generated at sea from all sectors, and if appropriately designed can incentivize best practices (Newman *et al*. 2015). Well-designed port reception facilities will encourage shippers to dispose of their waste correctly, relying on clear waste definitions, communication between actors, timely administration and appropriate inspections (Øhlenschlæger *et al*. 2013). The IMO has also published a Comprehensive Manual on Port Reception Facilities (IMO 1999), giving guidance on waste management strategies, types of waste, collecting and treating waste, financing and cost recovery. Since 2006 the IMO has also integrated a port reception facility module, the Port Reception Facility Database (PRFD), into its Global Integrated Shipping Information System (GISIS) (IMO, 2015. Should be referred the Community Directive Port Reception Facilities which was implemented by the European Commission in 2018.

4. Impact mitigation measures values: **YES.**Other measures to reduce plastic pollution are very important. Environmental education is one of the tools to address the problem (GESAMP, 2015). Raising awareness of the detrimental consequences of operational or accidental pollution of the marine environment is needed to alter disposal practices. Therefore, the Seafarers Training, Certification, & Watchkeeping (STCW) Code requires that maritime officers gain knowledge on the prevention of pollution to the marine environment. In 2011, the IMO accepted the model course “Marine Environmental Awareness”, which is developed to give knowledge on the concept of sustainable shipping, complexity and diversity of the marine environment, impact of shipping on the environment, role of regulations procedures and technical installations to protect the environment, marine environmental awareness, personal responsibility and role of human element to prevent pollution, proactive measures (IMO 2015c).

Ship passengers have a significant role in protecting marine habitats and it is important to *raise* their awareness about *plastic pollution*. A challenge for policy makers is to communicate environmental information in a way that will affect their disposal practices.

Furthermore, it is important to engage? stakeholders of the maritime transports in seeking solutions, since marine litter can have impacts in the activity, from own waste and other sources, as marine litter can foul propulsion equipment, disrupting operations, requiring clean up, repair and rescue efforts, and potentially loss of life or injury.

In order to protect and restore marine biodiversity and ecosystems in the framework of sustainable fishing activities, the European Maritime and Fisheries Fund (EMFF) may support the collection of waste by fishermen from the sea such as the removal of lost fishing gear and marine litter (European Commission).

• Marking fishing gear to identify ownership.

• On board technology to locate (and avoid) lost gear.

• Provision of easy-to-use (no/low cost) collection facilities in ports.

• Incentive schemes for proper disposal of gear.

• Link to certification schemes

• Spatial zoning to make marine users aware of fishing gear.

• Produce fishing gear out of materials that are safer and more sustainable.

• Include plastic litter as a metric for the guidelines for safe seafood.

• Research into the redesign of plastic products.

• Research into and suitable use of non-plastic biodegradable components of gear to reduce duration of any ghost fishing.

Monitoring method available YES. Methodological standards in Europe are currently available for the assessment of litter on coastlines (OSPAR, HELCOM and Black sea regions). For litter at sea there are a number of methodologies in place such as the International Biological trawling surveys in the NE Atlantic and Mediterranean, diving or photographic transects for surveying litter on the seafloor, aerial surveys for large scale assessment of floating litter, ingested litter in seabird stomachs through the OSPAR Ecological Quality Objectives for the North Sea, and microparticle abundance through sea surface sampling, continuous plankton recorder and beach sampling.

A further challenge will be to link the indicators with pressures (e.g. point and diffuse sources of litter, coastal or packaging industries, tourism, shipping, fishing, aquaculture and offshore activities) and other factors such as rainfall, riverine input, currents, winds and geomorphological factors, which influence the distribution and abundance of litter. It will be possible to evaluate litter on beaches and at sea as well as microplastics using standard protocols on a European scale. Evaluating the impact of litter on marine organisms will be done at regional or sea-basin level, enabling transposition of protocols to local species. Highly polluted areas will be monitored locally. When possible, temporal scales should take into account seasonal variations. An initial evaluation is required by all member states on the current state of research in their region/subregion, in order to supply a scientific and technical basis for monitoring as well as to identify gaps in knowledge and priority areas for research. This will need to include the improvement of knowledge concerning impacts on marine life, degradation processes at sea, the study of litter-related microparticles, the study of chemicals associated with litter, the factors influencing the distribution and densities of litter at sea (human factors, hydrodynamics, geomorphology etc.), the standardization of methods and the determination of thresholds.

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2.1.4 D11. Energy, including underwater noise data

QD11 Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD11	The spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals.	D11C1	YES	BROAD	YES	YES	NO
	The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals.	D11C2	YES	BROAD	YES	YES	NO

D11C1: The spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals.

D11C2: The spatial distribution, temporal extent and levels of anthropogenic continuous low frequency sound do not exceed levels that adversely affect populations of marine animals

Underwater noise has become an emerging environmental issue in light of growing transport and industrial activities at sea (Frisk, 2012). Anthropogenic sounds may be of short duration (e.g. impulsive) or be long lasting (e.g. continuous); impulsive sounds may however be repeated at intervals (duty cycle) and such repetition may become “smeared” with distance and echoing and become indistinguishable from continuous noise. Higher frequency sounds transmit less well in the marine environment (fine spatial scale) whereas lower frequency sounds can travel far (broad spatial scale). There is however great variability in transmission of sound in the marine environment. Whether emitted deliberately (e.g. military sonar) or as a by-product of other actions (e.g. shipping), anthropogenic underwater sound can induce changes on marine species, ranging from exposures causing no adverse impacts, to behavioral disturbances, to loss of hearing, to mortality (Tasker *et al*., 2010). Potential effects depend on various factors, including overlap in space and time with the organism and sound source, duration, nature and frequency content of the sound, received level (sound level at the animal), and context of exposure (i.e., animals may be more sensitive to sound during critical times, like feeding, breeding/spawning/nesting, or nursing/rearing young). There have been numerous publications describing these potential impacts (see the MSFD Task Group 11 Report 2010 for references). Still, Short-term impulsive sounds from seismic surveys, impact pile-driving, or military sonar have the greatest potential to affect marine mammals and fish. These can lead to changes in their distribution, which in turn could affect life functions such as mating and migration, and thus species populations.

Macaronesia is recognized as a reference point to the cetacean’s migration routes, being a place of higher productivity, resting activities, as well, represents a place of feeding, reproductive and breeding of various mammals species (Cunha, 2013). Prolonged exposure to underwater noise can lead to physiological and behavioral stress, affecting in particular communication in whales and fish (European Environment Agency, 2014).

1. **Environmental impact: YES.** Under the scope of the MSFD, cetacean species have been considered relevant for several descriptors (D1, D4, D8, D9 and D11) of good environmental status (GES) (Santos & Pierce, 2015). In the Macaronesia is recognized the importance of offshore areas as important habitat for several species/groups of cetaceans (ICES, 2015).

Ships may negatively interfere with cetacean population, through shipping traffic, whale watching or sonar noising (Cunha, 2013; Williams, 2015), mainly by means of alteration of underwater sound environment (Worley & Walker, 1982; Zakaruskas *et al.*, 1990; Bachman *et al*., 1996; Heitmeyer *et al*., 2004; Harris *et al*., 2012, Cunha, 2013). The effect of noise pollution on the marine ecosystem can have a direct impact on behavioral changes and physiological conditions such as hearing loss and indirectly these damages can lead to mortality as a result of disorientation (Thomas *et al*., 1990; Clark, 1991; Romano *et al*., 2004; Fernández *et al*., 2005; Cox *et al*., 2006; Borsani *et al.*, 2007 Harris *et al*., 2012). Many marine mammals (such as baleen whales and some seals and sea lions), as well as other marine animals (e.g., many fishes), are particularly vulnerable to impacts from incidental shipping noise, because they produce and perceive low-frequency sounds (Tyack & Miller, 2002; Okeanos, 2008). Large vessels produce rather loud and mainly low frequencies (which spreads much more efficiently through the water). The main source of shipping noise is the result of propeller cavitation (collapsing of air spaces originated by the motion of the propellers) (Southall, 2005). The utmost energy input emitted by large commercial vessels is below 1KHz. Thus, animals that produce and receive sounds in this band are more vulnerable to these effects – mainly large whales (Zacharias & Greg, 2005; Weilgart, 2007). Consequently, the propagated noise from these vessels may interfere with the natural echolocation or biosonar systems of whales and dolphins, which they use to locate predators and preys. This can confuse them and interfere with their basic biological functions such as feeding and mating (Southall, 2007; Chekab *et al.*, 2013).

Another important problem is the effect of masking by vessel noise. The masking can result in disruption of breeding in animals that use sound during mating and reproduction, and disruption of foraging in animals that use sound to detect prey. In addition, noise can mask important acoustic environmental cues that animals use to navigate and/or sense their surroundings, including sounds that are used to detect predators (Erbe & Farmer, 2000; Morisaka *et al*., 2005; Nowacek *et al*., 2007; Okeanos, 2008).

Also, fish use sounds to communicate and to perceive information from the environment. More than 50 families of fish use sound, generally below 2-3 kHz, in a wide variety of behaviours including aggression, protection of territory, defence and reproduction (Abdulla & Liden, 2008). Although much less is known about the effects of anthropogenic sounds on fish than on terrestrial or marine mammals, there is a small but growing body of literature demonstrating that such sounds can mask fish communication (Wahlberg & Westerberg, 2005), generate stress that negatively affects the animals' welfare (Wysocki *et al*., 2006), induce fish to abandon noisy areas (Mitson & Knudsen, 2003), destroy the sensory cells in fish ears and, in the long term, cause temporary and possibly permanent loss of hearing (McCauley *et al.*, 2003; Popper, 2003; Smith *et al.*, 2004; Popper & *et al.*, 2005), and also damage eggs.

2. **Environmental impact spatial extent: BROAD.** Sound travels in water about five times faster than in air and absorption is less compared to air. Due to its relatively good transmission underwater, sound acts at considerable spatial scales. Transmission varies with frequency: low frequency signals typically travel further whereas higher frequencies attenuate more rapidly, therefore fewer individuals might be exposed. Persistence of sounds is also very variable – ships on passage generate continuous sound; explosions are very short-term and there is much temporal variance in between

these. Studies so far have shown that underwater noise can affect marine life at various distances from the source, from very close ranges to tens of kilometers (MSFD Task Group 11 Report, 2010). Moreover, as previously stated, when noise does cause effects, there may be temporary changes in behavior, such as startle responses or changes in swimming patterns, but there may also be long lasting effects such as long-lasting exclusion from important habitats, injury or, in extreme cases, death of the exposed animal. Long-term effects such as permanent hearing loss and auditory injury might happen only relatively close to the source, whereas short term effects such as disruption of behaviors might happen at longer ranges (MSFD Task Group 11 Report, 2010). Moreover, evaluation of the underwater energy and noise impact assessment is dependent on the assessment of the spatial scale of biological effects requires good information on the distribution and abundance of marine life.

3. Maritime activity pressure solution: YES. Reduction of shipping noise is a world-wide problem closely connected to the general problem of the impact of underwater noise on marine life (Richardson *et al*., 1995; Gisiner, 1998; NRC, 2000, 2003; Tyack, 2003; McCarthy, 2004; Merrill, 2004; Popper *et al*., 2004; Southall, 2005). This issue was discussed at the international symposium ‘Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology, in 2004. The final report (Southall, 2005) made several recommendations, including raising awareness within the shipping industry concerning marine noise issues, creating alliances across various stakeholder groups, and engaging the industry and other maritime industries in the development of creative and practical solutions to minimize vessel noise. In 2007 the NOAA organized the symposium ‘Potential Application of Vessel Quieting Technology on Large Commercial Vessels’ to further explore the problem, to examine the economic and practical issues in the extensive application of those noise reduction solutions already applied to military and research vessels (Mitson, 1995; NOAA, 2007).

To address the problem of increased ambient noise due to shipping, governments and stakeholders should promote the introduction of ship-quieting technologies (Abdullar & Liden, 2008). As the dominant cause of underwater noise on the noisiest vessels is excessive cavitation, reducing the extent of the cavitation on these vessels will reduce the underwater noise generated by them, and hence reduce the ambient level of the hydroacoustic noise in the ocean (Leaper *et al.*, 2014). Excessive cavitation is likely to be caused by either poor propeller design (not correctly matched to the vessel and its operating conditions) or a poor wake field into the propeller, generally generated by a poor design of the aft end of the ship (*idem, ibidem*).

There are some solutions to reduce the noise of the propellers, namely:

- Energy saving devices can lead to lower propeller loading, and hence reduced cavitation. As they can be retrofitted to an existing vessel they are considered to be potential solutions to the excessive cavitation experienced on the noisiest ships (Van Terwisga, 2013; Leaper *et al.,* 2014).
- Improving the wake into the propeller will reduce cavitation, and probably also increase efficiency (Al-Ali J., 2013). In this case, a vortex generator was fitted to a very large crude carrier to improve the wake field into the propeller which had been suffering from propeller cavitation. The vortex generator improved the wake into the propeller, eliminating the cavitation and reducing the fuel consumption by around 5% (Leaper *et al.*, 2014).
- By changing the shape of the hull form to improve the flow into the propeller, and hence to increase efficiency while reducing cavitation (Minchev *et al.*, 2013).

4. **Impact mitigation measures: YES.** Though not specific for the Macaronesia, some international measures have been adapted, namely to reduce the sound impact of propellers (Kappel propellers, that reduce cavitation and respective cavitation noise; confinement of the propeller's tip with a plane; implementation of Propeller Boss Cap Fins on the propeller hub that can contribute to reduce the radiated noise (Chekab *et al.*, 2013) and the bub cavitation (Renilson Marine Consulting Pty Ltd., 2009); Simplified Compensative Nozzle which will contribute to reduce the generated noise due to the propeller´s inflow oscillations (Chekab *et al.*, 2013; Renilson Marine Consulting Pty Ltd., 2009). Project SONIC (Suppression of Underwater Noise Induced by Cavitation – 2012-2015) also aimed at improving computational and measurement techniques to determine underwater radiated noise level and further applied these methods to potential noise mitigation measures to study the effect of these design and operational measures.

Other international projects, like AQUO-Achieve Quieter Oceans by shipping noise footprint reduction (2012-2015) have provided policy makers with practical guidelines to reduce shipping noise footprints. The practicality of these guidelines was ensured by involving shipyards and ship owners in an end-user committee with major stakeholders from the maritime industry. The solution portfolio aimed at the needs of several levels of maritime industry and were addressed with consideration of cost effectiveness (ensuring both fuel efficiency and noise mitigation reductions) and of fleet applicability (new builds or existing).

Also, ACCOBAMS Resolution 3.10 (ACCOBAMS, 2007), based on the document prepared by Pavan (2006), pressed all the parties to take noise into full consideration and to consider underwater noise levels a quality parameter in habitat assessments, zoning and managing marine areas of special interest.

5. **Monitoring method: YES.** A number of key projects addressing D11 have been developed in the last years (e.g. BIAS; AQUO; SONIC; MarVEN) in order to develop standardized monitoring programmers, that could be applied to the Macaronesia. AQUO project, in order to complement the marine engineering studies, conducted dedicated experiments on three species representing the 3 main orders potentially affected by noise: invertebrates, fishes and marine mammals. Outputs of the project included bioacoustics criteria that were implemented in the methodology to be able to quantify the effects on the fauna of a given scenario in a given area.

In 2014, DG Environment commissioned a study (Impacts of noise and use of propagation models to predict the recipient side of noise (ENV.D.2/FRA/2012/0025) to investigate the impacts of noise and use of propagation models to predict the recipient side of noise. The study had the following objectives: 1. To evaluate the current knowledge of the impacts of noise on marine biota at all levels (individuals, populations, and ecosystems) and methods to assess these impacts. 2. To develop modelling techniques to predict the recipient side of noise, i.e. as it is received by marine fauna.

At the Macaronesia level, Mistic Seas Project Technical Report 1 (http://mistic-seas.madeira.gov.pt/en) referred that the effects of underwater noise in Macaronesia should not be overlooked and there is a need to develop robust indicators to monitor impacts. Priorities should be established in setting up the monitoring network, considering existing information about known critical habitats as well as habitat databases, where available. Monitored areas must be carefully chosen to correctly represent both low-noise habitats, for example those that are far from commercial shipping lanes or noisy coasts, and high-noise areas close to shipping lanes and port facilities (Abdulla and Liden, 2008). Systematic coverage of ambient noise levels in large areas will be costly (MSFD Task Group 11 Report 2010). Instead sampling in representative areas at appropriate spatial scales may be sufficient. It may be possible to set up a monitoring network by using existing infrastructure. Furthermore, focusing on bands where most shipping noise is concentrated (e.g. 63 and 125 Hz 1/3 octave bands) would be a cost effective approach.

The report “Management and monitoring of underwater noise in European Seas-Overview of main European-funded projects and other relevant initiatives” (TG-Noise,2017), presents a selection of key projects and initiatives and their relevant knowledge results for the implementation of Descriptor 11 – Underwater noise: impulsive sound and continuous sound (indicator 11.1.1 and 11.1.2, respectively). Their findings and outputs are made accessible, allowing to be replicated in Macaronesia.

Projects like ECOMARPORT (INTERREG V Spain-Portugal-MAC 2014-2020) are important since they aim at promoting marine and maritime R& D Innovation by creating an operational network of environmental and marine observation of water and air quality in ports.

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2.2 Descriptors that apply indirectly

2.2.1 D8. Concentrations of contaminants are at levels not giving rise to pollution effects

DC8 Concentrations of contaminants are at levels not giving rise to pollution effects							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD8	Concentrations of contaminants (ubiquitous persistent, bioaccumulative and toxic substances - Article 8a(1)(a) of Directive 2008/105/EC) do not exceed the established (WFD) threshold values in water, sediment or biota.	D8C1	YES	BROAD	YES	YES	NO
	The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminants including cumulative and synergetic effects.	D8C2 — Secondary	YES	BROAD	NO	NO	YES
	The spatial extent and duration of significant acute pollution events (Dicharging oil and noxious liquid substances - MARPOL 73/78Article 2(2) of Directive 2005/35/EC) are minimised.	D8C3	YES	BROAD	YES	YES	YES
	The adverse effects of significant acute pollution events on the health of species and on the condition of habitats (such as their species composition and relative abundance)	D8C4	YES	BROAD	YES	YES	YES

D8C1: Concentrations of contaminants (ubiquitous persistent, bioaccumulative and toxic substances – Article 8a(1) of Directive 2008/105/EC) do not exceed the established (WFD) threshold values in water, sediment or biota.

D8C2: The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminant including cumulative and synergetic effects.

D8C3: The spatial extent and duration of significant acute pollution events (Dicharging oil and noxious liquid substances – MARPOL 73/78 Article 2(2) of Diretive 2005/35/EC) are minimized.

D8.C4: The adverse effects of significant acute pollution events on the health of species and on the condition of habitats (such as their species composition and relative abundance).

The most documented adverse effects are those resulting from pollution, especially by petroleum hydrocarbons and other chemicals that originally constitute cargo but end up in the sea following collisions, groundings or other accidents (Abdulla & Liden, 2008). Carriage of chemicals is also a common threat from maritime transport mainly through accidents. TBT (Tributyltin) is considered the most toxic substance that is intentionally introduced into marine environments. The impact of TBT and its degradation products on gastropods is that it accumulates in tissues of these marine organisms and move up the food chain (Med Marine Integrated Projects Med – IAMER).

Oil spills from ships are also considered another source of pollution of marine ecosystems. However, many efforts have been made in recent years to minimize or mitigate the impacts of these types of pollution.

1. Environmental impact: YES. Crude oil is composed of thousands of complex gaseous, liquid and solid organic compounds, of which hydrocarbons are the most abundant (Kennish, 1992). One of the them is the polycyclic hydrocarbons (Ernst *et al.,* 2006). This compound can be dissolved in water and become incorporated into the water-soluble fraction (Zieman *et al*., 1984).
TBT is considered the most toxic substance that is intentionally introduced into marine environments. Marine invertebrates are very sensitive to TBT, and its effects include morphological changes, growth inhibition, suppressed immunity, reduced reproductive potential and changes in population structure while another known effect is the development of male sexual characters in female prosobranch gastropods (idem). Very high concentrations of TBT were found in top predators including the bottlenose dolphin, bluefin tuna and blue shark collected off Italy (ICES, 2003). Continued bioaccumulation of these chemical pollutants continues to manifest itself at different levels of biological complexity, from molecules to communities (IUPAC, 1993; Abdulla & Liden, 2008). The bioaccumulation in marine flora may result from food-chain biomagnification processes or from concentration of pollutants by filter feeders (Abdulla & Liden, 2008).

Oil spills or illegal discharges can provoke damage in the species. The oily residue discharges or oil spill from ships represent a significant threat to marine and coastal ecosystems (Med Marine Integrated Projects Med – IAMER; Instituto Español de Oceanografia, 2012). Some studies have demonstrated increased mortality of fish as a result of oil spills (Fordie *et al.,* 2014; Hjermann *et al*., 2007; IPIECA, 1997). Nevertheless, fish stocks may be especially vulnerable to oil spills close to the spawning grounds or egg and larval drift areas (Hjermann *et al*., 2007; Rooker *et al*., 2013). Fish eggs and larvae are typically vulnerable to toxic oil compounds due to their small size, poorly developed membranes and detoxification systems as well as their position in the water column (Langangen *et al.*, 2017). Invertebrates include shellfish (both molluscs and crustaceans), worms of various kinds, sea urchins and corals. All these groups may suffer heavy casualties if coated with fresh crude oil (IPIECA, 2002). Regarding wildlife, oil spills can cause real catastrophes to sedentary and/or migrating species of an affected environment (Instituto Español de Oceanografía, 2012). Birds using the water-air interface are at risk. Badly oiled birds usually die (IPIECA, 2002).
Some studies show that at least three years, and sometimes even up to fifteen years are needed for intertidal animal communities to recover to their original level after being exposed to oil spills (Hawkins *et al*., 2002; Abdula & Liden,2008). However, there are some species that are not influenced by oil spills. The oil-induced disturbance has no influence on copepods, which increased slightly after the oil spill, probably because they were dominated by epibenthic forms which were able to escape from the toxic effects of hydrocarbon pollution (Abdula & Liden, 2008). In the case of Macaronesia, it was registered in Autonomous Region of Madeira a serious accident with the oil tanker

Aragon. The black tide was one of the biggest ecological disasters for Portugal, affecting coastal fishing activity, which suffered some damage as the oil damaged local ecosystems, including algae, mollusks and small crustaceans living in the rock were hit by crude pockets. Once they constitute the food base of the local marine fauna, with the consequent destruction of the food supply resulting therefrom, the fish were forced to migrate to other uncontaminated areas (Nunes, 2003).

2. Environmental impact spatial extent: Broad. Most of polycyclic hydrocarbons concentration is in the shipping lanes and it was registered higher concentrations in offshore areas, which were most probably due to direct discharges from ships (Abdulla & Liden, 2008).

The TBT affects non-target biota, especially in areas with high vessel density and restricted water circulations. Highest concentrations of TBT are found in sediments from harbours, marinas and shipping channels because TBT is broken down only very slowly in sediments with low oxygen content. Its use in large vessels is currently the major source of input to the sea (Med Marine Integrated Projects Med – IAMER).

Illegal discharges of oil from ships are often limited in size and scattered in specific areas but their sum is greater than that of oil spills and they may create a chronic impact of oil in specific regions (Med Marine Integrated Projects Med – IAMER). The presence of a refinery in Tenerife and refueling or bunkering in the Santa Cruz port have caused some episode of oil spills to the sea (Instituto Español de Oceanografía, 2012). The Spanish oil tanker *Aragon* provoked a spillage of 25-30 thousand tons of crude oil about 100 miles northeast of Madeira Island.

3. Maritime activity pressure solution: YES. Relatively to the oil spills or discharges, to minimize the effects of accidents and leaks, there are several initiatives of the European Union, e.g.: Regulation (EC) No 1406/2002 of the European Parliament and of the Council of 27 June 2002 establishing a European Maritime Safety Agency and Directive 2009/123/EC of 21 October 2009 amending Directive 2005/35/EC on ship-source pollution and on the introduction of penalties for infringements.

It was created by European Commission the European Maritime Safety Agency (EMSA). The agency provides technical assistance and support to the European Commission and Member States in the development and implementation of EU legislation on maritime safety, pollution by ships and maritime security (EMSA). It has also been given operational tasks in the field of oil pollution response, vessel monitoring and in long range identification and tracking of vessels.

Some projects have been developed to reduce or prevent the impact of the oil spills. The European project “Reducing the Impact of Oil Spills – RIOS” had as objective develop an Action Plan focusing on negative impacts of oil spills on marine wildlife, such as marine and coastal birds, marine mammals and sea turtles, and how these effects can be minimised, e.g. through investments into research and development.

The *International Convention for the Prevention of Pollution from Ships* (MARPOL), signed in 1973, is one of the most important international marine environmental conventions. It aims at protecting the marine environment through the minimisation or complete elimination of pollution by oil and other harmful substances. It is constantly updated in order to tackle new aspects of environmental pollution, which is performed by amendments and annexes to the convention (Grote *et al.*, 2016).

4. Impact mitigation measures: Yes. Due to such harmful effects, many countries have prohibited or restricted the use of TBT (EMSA, n.d.). Legislation to ban TBT in ships' anti-fouling paints was agreed by the adoption of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships at International Maritime Organisation (AFS) in 2001 (International Maritime Organization, 2001; EMSA, n.d.). Under this convention, the last date for the application of organotin paints on ships was January 1st, 2003. The total phase-out of organotin antifouling coatings should have been completed by January 1st, 2008 (EMSA, n.d.). The AFS convention entered into force on September 17th, 2008. To support the implementation, IMO has adopted several sets of guidelines, namely the "Guidelines for Survey and Certification of Anti-fouling Systems on Ships" (Resolution MEPC.102(48)), the "Guidelines for Inspection of Anti-fouling Systems on Ships" (Resolution MEPC.105(49)) and the "Guidelines for brief sampling of anti-fouling systems on ships" (Resolution MEPC.104(49). Most recently, IMO has adopted the "Guidance on best management practices for removal of anti-fouling coatings from ships, including TBT hull paints" (Circular AFS.3/Circ.3 of 22 July 2009) developed by the London Convention on Dumping 1972 and its 1996 Protocol. This Guidance is limited to the subject of removal of harmful anti-fouling systems as the subject of (in-water) hull cleaning has been dealt with in separate guidelines (EMSA, n.d.).

The AFS Convention has been transposed into EU legislation through Regulation (EC) No 782/2003 on the prohibition of organotin compounds on ships. According to the Regulation, organotin compounds which act as biocides in anti-fouling systems are no longer allowed to be applied on ships flying the flag of a Member State as from 1 July 2003. As from 1 January 2008, EU ships and other ships visiting EU ports were obliged either not to bear anti-fouling systems containing such compounds, or to bear a coating that forms a barrier to such compounds leaching from underlying non-compliant antifouling system. The Regulation is further supplemented, firstly, by Council Directive 76/769/EEC as amended, which prohibits the marketing and use of organotin compounds within the EU and, secondly, by Commission Regulation (EC) 536/2008 comprising measures enabling ships flying the flag of a third State to demonstrate their compliance and procedures for control.

5. Monitoring method: YES. With the adoption of Directive 2005/35 / EC on pollution from ships, spill detection, including illegal dumping at sea, is included in EMSA activities as part of its response capacity. EMSA has established a network of stand-by oil spill response vessels through contracts with commercial vessel operators. Following a request for assistance, the maximum time for the oil spill response vessel to be ready to sail is 24 hours. Regardless of their area of commercial operations, all vessels in the EMSA´s network can be mobilised for response to an oil spill, anywhere in European waters and shared sea basins. EMSA´s currently maintains 17 fully equipped stand-by oil spill response vessels around Europe, one of them in Canary Islands.

Another service of EMSA is the *CleanSeaNet*. The service includes identification of potential polluters, by combining the image captured by the satellite with the vessel's traffic information. After receiving the enriched information, the national authority shall decide on the appropriate operational response, e.g. to send air equipment to probe the area and check the spill or request an inspection of the ship at the next port of call (European Commission, 2018). According to European Commission[5], regarding the impact of the *CleanSeaNet* service in terms of deterrent effect, the overall trend over most of the past decade, has been a year-on-year reduction in the number of possible spills detected per million km^2 monitored. The marked decrease per year in the period

[5] European Commission (2018) - Mid-term evaluation of Regulation (EU) No 911/2014 on multiannual funding for the action of the European Maritime Safety Agency in the field of response to marine pollution caused by ships and oil and gas installations.

2008-2010 coincided with the economic downturn, as well as an increase in awareness of maritime pollution related issues and an improvement in the provision of port reception facilities across the continent while the decrease in the period 2010-2015 is more gradual. In 2016, the trend reversed, with an increase in the number of possible spills detected. There are a number of possible reasons why the trend may have reversed in 2016: the introduction of the Sentinel-1 satellites, which resulted in improved detection capabilities, the optimisation of *CleanSeaNet* planning, and, to a lesser extent, an increase in shipping volume which could have caused the increase in detections (European Commission, 2018).

In the Madeira Archipelago, in the area affected by the oil spill provoked by Aragon (Porto Santo Island), a monitoring scheme has been implemented to evaluate the evolution of species and *habitats* (Araújo *et al*., 2005).

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2.2.2 D5. Eutrophication

QD5 Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD5	Nutrient concentrations (Dissolved Inorganic Nitrogen (DIN), Total Nitrogen (TN), Dissolved Inorganic Phosphorus (DIP), Total Phosphorus (TP)) are not at levels that indicate adverse eutrophication effects.	D5C1	YES	NARROW	YES	YES	YES
	Chlorophyll a concentrations are not at levels that indicate adverse effects of nutrient enrichment.	D5C2	Yes	NARROW	YES	YES	YES
	The number, spatial extent and duration of harmful algal bloom (e.g. cyanobacteria) events are not at levels that indicate adverse effects of nutrient enrichment.	D5C3 — Secondary	Yes	NARROW	YES	YES	YES
	The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment.	D5C4 — Secondary	Yes	NARROW	YES	YES	YES
	The concentration of dissolved oxygen is not reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats (including on associated biota and mobile species) or other eutrophication effects.	D5C5	YES	NARROW	YES	YES	YES
	The abundance of opportunistic macroalgae is not at levels that indicate adverse effects of nutrient enrichment.	D5C6 — Secondary	NO				
	The species composition and relative abundance or depth distribution of macrophyte communities achieve values that indicate there is no adverse effect due to nutrient enrichment including via a decrease in water transparency	D5C7 — Secondary	NO				
	The species composition and relative abundance of macrofaunal communities, achieve values that indicate that there is no adverse effect due to nutrient and organic enrichment	D5C8 — Secondary	Yes	NARROW	YES	YES	YES

D5C1: Nutrient concentrations (Dissolved Inorganic Nitrogen (DIN), Total Nitrogen (TN), Dissolved Inorganic Phosphorus (DIP), Total Phosphorus (TP)) are not at levels that indicate adverse eutrophication effects.

D5C2: Chlorophyll a concentrations are not at levels that indicate adverse effects of nutrient enrichment.

D5C3: The number, spatial extent and duration of harmful algal bloom (e.g. cyanobacteria) events are not at levels that indicate adverse effects of nutrient enrichment;

D5C4: The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment.;

D5C5: The concentration of dissolved oxygen is not reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats (including on associated biota and mobile species) or other eutrophication effects.;

D5C8: The species composition and relative abundance of macrofaunal communities, achieve values that indicate that there is no adverse effect due to nutrient and organic enrichment.

1. **Environmental impact: YES.** Marine eutrophication is defined in the OSPAR Eutrophication Strategy as "the enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients as described in the Common Procedure" (OSPAR Commission, 2009). Eutrophication is still a problem in 7% of the North-East Atlantic, mainly affecting coastal areas (OSPAR Commission, 2017) and seasonal oxygen deficiency has been reported for some stratified coastal or offshore areas with long residence time of enclosed bottom waters. Though there is no clear evidence that Mediterranean archipelagos would suffer eutrophication impacts due to maritime transports, this is not a definitive statement since relatively few nutrient data are available and this is why the authors believe that D5 should be monitored in this biogeographical area.

Shipping contributes significantly to the eutrophication through nitrogen air emissions, sewage and waste pollution, and, as a result, the maritime transport system needs to be optimised to meet the demands of a sustainable development (Boteler *et al.*, 2015; HELCOM, 2015; OSPAR Commission, 2017). Nitrogen oxides, sulphur oxides and greenhouse gases are the key air emissions from port operations and vessel traffic. Nitrogen oxides cause eutrophication, whilst sulphur oxides acidify waterways (Boteler *et al.,* 2015; Huhta *et al*., 2007). The eutrophication caused by nitrogen reduces visibility, leads to changes in the interactions between species and causes benthic oxygen depletion (Ministry of Transport and Communications, Transport Policy Department, 2012). According to HELCOM, one vessel during 8 hours at a port emits an amount of NOx equivalent to that of 10,000 cars driving 1,000 km each. Ferries and ro-ro vessels make the most significant contributions to emissions, followed by tankers, cargo ships and container ships (Klopott, n.d.).

Also, sewage is generated on-board all ships, sometimes in large quantities, especially in the case of large passenger vessels. For example, a medium-sized passenger ship generates 50 tonnes of blackwater daily (Klopott, n.d.). Discharges of such waste into port waters may include organic, biological, chemical and toxic pollutants. Even though the total nutrient load from ship sewage is much lower than from land-based sources, it still constitutes a significant amount (Klopott, n.d.; OSPAR Commission, 2009; HELCOM, 2010; EMEP, 2016). Depending on the hydrodynamics of the ports and marinas, nutrient enrichment may cause an increase in the growth of algae and higher forms of plant life (OSPAR Commission, 2017). This in turn may lead to a range of undesirable disturbances in the marine ecosystem, such as the oxygen depletion in bottom waters causing the death of fish and other species and significant shifts in the composition of the flora and fauna affecting habitats and biodiversity (OSPAR Commision, 2017).

2. **Environmental impact spatial extent: Narrow.** Eutrophication from maritime transport is recorded mainly in port areas and in shipping routes.

3. **Maritime activity pressure solution: YES.** Prevention or reduction of eutrophication status is largely dependent on reducing anthropogenic inputs of nitrogen and phosphorus into problem areas. (OSPAR Commission, 2017).

The Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL) was revised by IMO in 2008. The goal of the revised Annex is to reduce nitrogen oxide (NOx) and sulphur oxide (SOx) emissions from ships. Among other things, the new regulations enable the establishment of NOx Emission Control Areas. In these special areas, the engines of new ships should emit 80 *pe*r cent less nitrogen oxides as from 2016 than they do at present. Shipping accounts for about 6 *per* cent of the total nitrogen load in the Baltic Sea, but owing to the ever-brisker marine traffic, this percentage will increase in the future (Prime Minister's Office, 2009).

It was developed various European legislations to reduce nutrient discharges and emissions, including for example the Nitrates Directive (91/676/EEC), Urban Waste Water Treatment Directive (91/271/EEC), the Water Framework Directive (2000/60/EEC) and the Marine Strategy Framework Directive (2008/56/EC).

4. **Impact mitigation measures: YES.** The aim of the OSPAR Eutrophication Strategy is to make every effort to combat eutrophication in the OSPAR Maritime Area in order to achieve and maintain, by 2020, a healthy marine environment where eutrophication does not occur (OSPAR Commission,2017). Although Madeira and the Canary Islands do not belong to OSPAR, it will be interesting if they use the same methodologies.

5. **Monitoring method: YES.** For each chemical for priority action, OSPAR has developed a monitoring strategy that sets out the best way to collect data and information on sources, pathways, concentrations and effects, in order to track progress towards OSPAR's objectives for hazardous substances in periodic assessments. This includes long-term data collection under the OSPAR monitoring programmes for:

- atmospheric inputs (Comprehensive Atmospheric Monitoring Programme - CAMP)
- riverine inputs and direct discharges (Comprehensive Study on Riverine Inputs and Directive Discharges - RID)
- concentrations and effects in the marine environment (Coordinated Environmental Monitoring programme - CEMP)

Mobile air quality monitoring stations have been set up as they do at the Port of Helsinki. The measurements are mainly used to monitor emissions from ships, vehicles and industrial machinery; power generation; and cross-border pollution (Port of Helsinki). This is a methodology could be interesting to be applied in the most busiest ports of Macaronesia.

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Lars M. Svendsen1 (Project Manager), Jerzy Bartnicki2, Susanne Boutrup1, Bo Gustafsson3, Waldemar Jarosinski4, Seppo Knuuttila5, Pekka Kotilainen5, Søren E. Larsen1, Minna Pyhälä6, Tuija Ruoho-Airola7, Lars Sonesten8, Håkan Staaf (2015) - Baltic Sea Environment Proceedings No. 145 - Updated Fifth Baltic Sea Pollution Load Compilation (PLC-5.5), Helsinki, Finland.

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2.2.3 D6. Sea – floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguard and benthic ecosystems, in particular, are not adversely affected

QD6 Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD6	Spatial extent and distribution of physical loss (permanent change) of the natural seabed	D6C1	YES	NARROW	YES	NO	NO
	Spatial extent and distribution of physical disturbance (including intertidal areas) pressures on the seabed.	D6C2	YES	NARROW	YES	NO	NO
	Spatial extent of each habitat type which is adversely affected, through change in its biotic and abiotic structure and its functions (e.g. through changes in species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), by physical disturbance.	D6C3	YES	NARROW	YES	NO	NO

D6C1: Spatial extent and distribution of physical loss (permanent change) of the natural seabed

D6C2: Spatial extent and distribution of physical disturbance (including intertidal areas) pressures on the seabed.

D6C3: Spatial extent of each habitat type which is adversely affected, through change in its biotic and abiotic structure and its functions (e.g. through changes in species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), by physical disturbance

5.5. D1 & D6 Benthic habitats (relating to Descriptors 1 and 6)

QD1& QD6 Benthic habitats (relating to Descriptors 1 and 6)								
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD1&QD6	The extent of loss of the habitat type, resulting from anthropogenic pressures, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.	D6C4	NO	-	NO	NO	NO
	The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.	D6C5	YES	Narrow	YES	NO	NO

D1 & D6: The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.

"Sea Floor" includes both the physical structure and biotic composition of the benthic community. "Integrity" includes the characteristic functioning of natural ecosystem processes and spatial connectedness. Scale for assessing GES of the sea floor is particularly challenging for four reasons. First, benthic ecosystem features are patchy on many scales. Second, a wide range of human activities cause pressures on the sea floor, and they usually operate at patchy spatial scales. Third, although initial impacts of human activities are often local and patchy their direct and indirect ecological consequences may be transported widely by physical and biotic processes. Fourth, all monitoring of the seafloor is also patchy and often local. In all evaluations of impacts the scale of the impact relative to the availability of the ecosystem properties being impacted is an important consideration (Rice *et al.*, 2010).
To fully comprehend the effects of anthropogenic activities on D6, it is necessary to understand that there is a high degree of overlap between D6 and the habitat diversity criteria of D1 (1.4, 1.5 and 1.6). Criterion 6.1.2 (Extension of the seabed significantly affected by human activities in the different types of substrates) is also related to criteria 1.5.1, 1.6 and 6. 2. Moreover, ANNEX III of the MSFD provides an indicative list of the

pressures and impacts on the marine environment. Amongst the impacts are physical loss - associated to smothering and sealing pressures- and physical damage- associated to pressures on the environment due to siltation and abrasion.
Maritime Transport, including port operations may produce both types of impacts, which in turn are directly related to D6.

1. **Environmental impact: YES.** Maritime transports can affect all three criteria of the descriptor, directly or indirectly and in more narrow or broader range.

Firstly, it is important to context the definition of physical loss and disturbance. The physical loss is defined in the revised COM DEC (2017) as 'a permanent change to the seabed which has lasted or is expected to last for a period of two reporting cycles (12 years) or more'.
In that sense, physical loss is indirectly related with maritime transports due to construction of associated infrastructures, such as fishing harbors; industrial and ferry ports (harbors, bunkering points at sea; oil terminals), bridges and causeways; tunnels; transport shipping; ship/boat-building facilities.
The physical disturbance is defined as 'a change to the seabed which can be restored if the activity causing the disturbance pressure ceases'. Pressures included in Criteria 2 are directly associated with passage of ships/boats (passenger shipping; shipping density); Mooring, anchoring, beaching, launching may contribute to not achieving GES within C2 and C3, since physical disturbance of seafloor can interfere with the condition of benthic communities (D1&D6), changing the presence of particularly sensitive species, species diversity or richness, etc. Though Macaronesia islands have very steep depths near coast, it is still possible that cruise ships, cargo vessels and fishery boats can have an impact in the physical structure of the seabed near coast. Ship anchoring and shading, when vessels sit for extended periods of time in one place, may also have adverse effects 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. 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 (Abdulla & Linden, 2008).
The type and magnitude of alterations to habitat resulting from anchoring depends not only of the physical characteristics of area (namely depth and topography) but also on the dimensions and type of the anchor used and on chain size and length, which in turn depend on the size of vessel (Milazzo *et al.*, 2004; Montefalcone *et al.*, 2006). Crabbing, which refers to sideways movement on the anchor and chain to sideways movement of the anchor and chain or rope due to movement of the vessel in response to currents and wind, exacerbates the effect since a larger area of the benthic habitats is affected (Abdulla & Liden, 2008).

Moreover, maritime transports may be subject to accidents where there may be loss of cargo. Even though so far no reported accident has been described in Macaronesia (except for oil spill), examples of loss of cargo with effects on the seafloor integrity have been reported worldwide. In 1996 the vessel Fenes ran aground within the Lavezzi Islands' Nature Park, South of Corsica, France. The seagrass bed, including the protected species Posidonia and sessile animals, were covered by a thick layer of wheat, ranging from dozens of centimetres to several metres (Grote *et al*., 2016). Although only about 3000 tonnes of wheat were released, eight hectares of Posidonia has been affected (*idem, ibidem*). A complete destruction of the grass beds has been reported on an area of 2,500 m^2 covered by Posidonia (*idem, ibidem*). The seabed may also be affected when a cargo ship is shipwrecked. In 2000, the carrier *Eurobulker IV*, carrying 17,000 tonnes of coal, sank at the southern coast of Sardinia in the Mediterranean Sea.

Mechanical phenomena like smothering of vegetation related to the coal were noted. Chemical analysis of the sea water showed no significant results as the wreck lay in a zone of heavy industrial metal contamination. Specific studies on accidental coal immersion (Cabon *et al.,* 2007; Lucas & Planner, 2012) showed that most effects were physical, and no significant release of noxious inorganic compounds could be measured.

2. **Environmental impact spatial extent: Narrow.** In the area where the impact occurs.

3. **Maritime activity pressure solution: YES** (partially) Maritime safety, which aims not only to the protection of passengers and seafarers, but also the preservation of the coastal regions - is a key objective of European sea transportation. The overall scope of maritime transport leads the International Maritime Organization (IMO) to establish uniform international safety standards. The main international agreements relating to shipwrecks and loss of cargo are the International Convention for the Prevention of Ship Pollution, the International Convention for the Safety of Human Life at Sea and the International Convention on Standards of Training, Certification and Seafarers' Room Service.

4. **Impact mitigation measures: No.** 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 maritime transports in seafloor integrity, particularly in Macaronesia.

5. **Monitoring method: NO.** Presently, there is clearly a lack of data on direct physical effects of vessels on Macaronesia benthic habitats and species. As Abdulla & Linden (2008) referred for other areas of the world, there is an urgent need to acquire data that to understand the magnitude and extent of adverse impacts resulting from direct physical effects and develop the necessary technical and procedural strategies and management guidelines for shipping activities to eliminate, or at least minimize, adverse impacts.

In order to do that, it is important to map in Macaronesia the distribution of substrates/habitats, especially those that are considered sensitive to human impacts. Because of the patchiness of seafloor attributes, pressures and impacts on many scales, the optimal suites of Indicators and their reference levels will differ at a local scale. The scale aspect is essential here as distribution of human activities and substrate types is generally very patchy but occupying relevant areas in the Macaronesia. Monitoring should consider all substrate types in a given area but the monitoring effort per type should be proportional to a sensitivity or risk criteria rather than to the surface of each substrate type. For instance, biogenic substrates have smaller spatial extent compared to most other substratum types, and, considering their vulnerability to physical impacts, may require more intensive monitoring and at higher spatial resolution compared to other substrate types.

Projects like ECOMARPORT (INTERREG V A Spain-Portugal-MAC 2014-2020) are important since they aim at promoting marine and maritime R& D Innovation by creating an operational network of environmental and marine observation of water and air quality in ports.

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2.3 Non applying descriptors

2.3.1 QD3.The population of commercial fish species

QD3 Populations of all commercially-exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD3	The *Fishing mortality* rate of populations of commercially-exploited species	D3C1	NO				
	The Spawning Stock Biomass of populations of commercially-exploited species are above biomass levels capable of producing maximum sustainable yield.	D3C2	NO				
	The age and size distribution of individuals in the populations of commercially-exploited species is indicative of a healthy population. This shall include a high proportion of old/large individuals and limited adverse effects of exploitation on genetic diversity.	D3C3	NO				

The descriptor D3 does not apply to maritime transports, as this activity does not contribute directly to an increased fish mortality (3.1.1) nor to the secondary indicators, namely to the ratio between catch and biomass index or the reproductive capacity of the stock.

2.3.2 D7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems

DC7 Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems							
QD	Criteria (element)	CODE Criteria	Env. Impact	Env. impact spatial extent	MA pressure solutions	Impact mitigation measures	Monitoring method
QD7	Hydrographical changes to the seabed and water column (including intertidal areas).Spatial extent and distribution of permanent alteration of hydrographical conditions (e.g. changes in wave action, currents, salinity, temperature) to the seabed and water column, associated in particular with physical loss (7) of the natural seabed.	D7C1 — Secondary	NO				
	Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) due to permanent alteration of hydrographical conditions.	D7C2 — Secondary	NO				

Regular activity of Maritime Transports does not contribute to permanent hydrographical changes of the seabed and water column, regarding physical and biological (secondary) loss. Though construction of ports and marinas are an indirect consequence of maritime transports that may change permanently hydrographic conditions, these were not included in this report.

2.3.3 D1. Pelagic habitats (relating to Descriptor 1)

QD1 Pelagic habitats (relating to Descriptor 1)							
QD	Criteria (element)	CODE Criteria	Env. Impact	Env. impact spatial extent	MA pressure solutions	Impact mitigation measures	Monitoring method
QD1	The condition of the habitat type, including its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), is not adversely affected due to anthropogenic pressures.	D1C6	NO				

Though a consistent increase of harbors and marina facilities has occurred along the Macaronesia archipelagos, namely in the Canarian coast, little is known of the impacts of these coastal structures on marine biodiversity. Besides, impacts of land logistic facilities and transport infrastructure associated with harbors would add additional impacts and pollution sources at different levels upon mesolittoral and sublittoral habitats. Still, for the present report, D1 was not analyzed as there is not direct link between the regular activity and changes the condition of the habitat type including its biotic and abiotic structure and its functions. A separate report could be performed in terms of coastal pressure, considering harbors, ports and marinas, or other pressures associated to constructions related with desalinization units, hotels, etc.

2.3.4 D1 & D4 Ecosystems, including food webs (relating to Descriptors 1 and 4)

QD1&QD4 Ecosystems, including food webs (relating to Descriptors 1 and 4)							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD1&QD4	The diversity (species composition and their relative abundance) of the trophic guild is not adversely affected due to anthropogenic pressures.	D4C1	NO				
	The balance of total abundance between the trophic guilds is not adversely affected due to anthropogenic pressures.	D4C2	NO				
	The size distribution of individuals across the trophic guild is not adversely affected due to anthropogenic pressures.	D4C3 — Secondary	NO				
	Productivity of the trophic guild is not adversely affected due to anthropogenic pressures.	D4C4 — Secondary	NO				

Descriptors D1 & D4 do not apply to maritime transports, as this activity does not contribute directly to modification of the food webs.

2.3.5 D9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards

QD9 Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards							
QD	**Criteria (element)**	**CODE Criteria**	**Env. Impact**	**Env. impact spatial extent**	**MA pressure solutions**	**Impact mitigation measures**	**Monitoring method**
QD9	The level of contaminants in edible tissues (muscle, liver, roe, flesh or other soft parts, as appropriate) of seafood (including fish, crustaceans, molluscs, echinoderms, seaweed and other marine plants) caught or harvested in the wild (excluding fin-fish from mariculture) does not exceed Regulation (EC) No 1881/2006	D9C1	NO				

The Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs which sets the maximum levels of Polycyclic aromatic hydrocarbons (PAH). Maritime transport is responsible for the release of PAH through navigation and the type of paint used on ships' hulls. PAHs have been recorded in marine species, as is the case of commercial fish. Still, the direct contribution of the regular activity of maritime transports to the levels of contaminants in commercial fish is difficult to be assessed. Therefore, this descriptor was not contemplated in the analysis. Exception should be considered in oil spills or cargo accidents, that could have direct contribution in the levels of contaminants in the surrounding populations of fish, crustaceans, molluscs, etc.