European Union Network for the Implementation and Enforcement of Environmental Law

Monitoring large marine vertebrates along fixed transects from ferries and cargo vessels: a state of the art.

Final Report

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Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the EU Member States, acceding and candidate countries of the European Union and EEA countries. The association is registered in Belgium and its legal seat is in Brussels, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network's objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns raising awareness, capacity building, and exchanging information and experiences on implementation, enforcement, and international enforcement collaboration, as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the last few years, IMPEL has developed into a considerable, widely known organisation and is mentioned in a number of EU legislative and policy documents, e.g. the 7th Environment Action Programme and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation.

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Executive Summary

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Target groups

European Commission (EC), United Nations Environment Programme- Mediterranean Action Programme -UNEP-MAP, International Union for the Conservation of Nature (IUCN), International Whaling Commission (IWC) , Convention on the Conservation of Migratory Species of Wild Animals (CMS/Bonn Convention) and its Agreement for Cetaceans in the Mediterranean, Black Sea, and Contiguous Atlantic Areas- ACCOBAMS, United Nations Convention on the Law of the Sea Convention (UNCLOS), The Convention of Biological Diversity (CBD), UNEP-RAC/SPA- Regional Activity Centre for Specially Protected Areas, Important Marine Mammal Areas (IMMAs).

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Disclaimer

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3) The project team is not liable for the information and facts given in the case studies.
4) This report is subject to the Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information.

This project report is intended as a reference document for competent authorities and practitioners. It does not prescribe what a competent authority should do. Instead, it aims to provide information to assist competent authorities in making better decisions about the ascertainment of environmental damage. In this way, it should contribute to improving protection of the environment and promoting compliance with the polluter pays principle.

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1. Introduction

1.1.Conservation needs

The marine ecosystem is a complex and dynamic environment, which is subject to a growing number of threats derived from the constant intensification/proliferation of human activities and their impacts (Evans *et al*, 2012; Hooker and Gerber, 2014). Indeed, intense marine traffic, overfishing, increased industrialization, and urbanization are affecting marine organisms both directly, causing entanglement, injuries and death by collision, chemical intoxication, disturbance by noise, or other forms of disturbance, and indirectly, through the general degradation of habitats and loss of functionality and biodiversity.

In this context, the conservation and management of marine biodiversity is a priority that represents a major challenge to science and policy. Monitoring is needed to understand the function of ecosystem components, the mechanisms of ecological processes, and to assess the effect of natural and anthropogenic pressures. In the marine environment, many studies focus on the ecology and conservation status of top predators, as they often play a crucial role for the conservation of the marine environment (Sergio *et al*, 2008).

Large marine vertebrates, such as cetaceans and marine turtles, are considered "keystone species'' in view of their relevant ecological role in the environment they inhabit, and “umbrella species”, whose conservation is expected to benefit a much wider range of naturally co-occurring species (Roberge & Angelstam, 2004, Roman *et al*, 2014). Indeed, cetaceans and marine turtles significantly influence their ecosystems and trophic webs in several ways (Bowen 1997). Given their high position in the food chain and their wide-range distribution, they store and transfer energy and regulate the ecosystem through a bottom-up mechanism influencing the lower levels of the trophic chain (*e.g.*, by controlling their prey, grazing seagrass, etc). They represent an important food source for other animals: cetacean calves may be the prey for orcas or sharks, as turtle hatchlings are prey for several marine organisms; moreover, once dead, their carcasses provide energy-rich habitats to benthic communities (Smith and Baco, 2003; Fujiwara *et al*, 2007). In addition to these regulation mechanisms, these species also contribute to enhance the horizontal and vertical circulation of nutrients through their seasonal migrations and superficial defecation: the so-called “whale pump” was indeed proven to increase primary productivity and play a role in climate regulation through carbon sequestration (Roman and McCarthy, 2010). Large marine vertebrates are also considered indicator species, as they are overly sensitive and responsive to ecosystem health and variations (Wells *et al*, 2004). Indeed, besides their ecological role in the marine ecosystems, the conservation of cetaceans is also relevant because, being long-lived animals with low fecundity and long gestation periods and proven to bioaccumulate toxic pollutants in their tissues, they are particularly susceptible to any change in the ecosystem, especially if human induced. Moreover, they are flagship charismatic species, being used to attract funding due to their high public profile (Eckert and Hemphill 2005; Sergio *et al*, 2008) and with a high potential value for touristic activities such as whale-watching (Roman *et al*, 2014) or turtle-based tourism, focused on the observation of sea turtles during egg deposition or hatching (*e.g.*, Wilson and Tisdell, 2001; Pegas and Stronza, 2010; Mendes *et al*, 2019). For all the above reasons, cetaceans and marine turtles are a strategic target for the preservation of biodiversity, as actions that protect these species tend to have positive conservation effects on other species. Indeed, by protecting their habitats, the habitats of less charismatic marine taxa, and the marine biodiversity in general, are also being protected (Williams, 2003). Consequently, species such as marine mammals, sharks, and sea turtles have been chosen as targets for dedicated assessment and monitoring programs, as the measures implemented directly for their protection tend to positively affect the conservation of marine ecosystems in general (Sergio *et al*, 2008; Hooker *et al*, 2011).

Compared to terrestrial vertebrates, there is a bigger dearth of information on marine mammals and marine turtles: they are elusive species that live a fully (or in the case of marine turtles- semi-) aquatic life, typically ranging over vast areas of ocean, and concentrating for shorter periods in smaller, localised regions (*e.g.*, during mating season). For most species and their populations, distribution and movement patterns are largely unknown, especially those occurring offshore where research is more costly and logistically difficult (De Boer, 2013). The lack of detailed knowledge is one of the main issues hampering the conservation of these species. According to the International Union for the Conservation of Nature (IUCN), information on several cetacean species is data deficient, meaning that there is not enough information to ascertain their status properly, and often "data deficient" is treated as "no concern", which may lead to delayed or no management actions (Parsons, 2016). Around 25% of all cetacean species are considered endangered, critically endangered, or vulnerable (IUCN, 2021), although the geographical scope needs to be taken into consideration. Of the seven known species of marine turtles, one is considered data deficient, whilst the others are considered either critically endangered, endangered, or vulnerable, with overall decreasing population trends for most species (IUCN, 2021).

Despite the recognised important ecological role of large marine vertebrate species and the increased number of studies over the last decades, a complete understanding of the species' ecology and interactions with human activities is lacking. Concern is rising regarding the status of large marine vertebrates worldwide, resulting in increasing interest in documenting the distributional ranges and phenology of both charismatic species and those that may be at particular risk from human activities in the marine environment (Leeney *et al*, 2012). Even though over the last decades an enormous effort has been dedicated to fill gaps in knowledge and assess cetacean and turtle abundance and distribution, due to recent obligatory regional legislation and policies, the current knowledge about many species'/population presence, richness, diversity, distribution, and habitat use still remains limited in several marine regions and sub-regions, especially those located in offshore areas, including sub-regions, such as the Mediterranean Sea and the North Atlantic. Furthermore, despite being the most abundant species in the basin, the current knowledge on the distribution, habitat use, connectivity, migratory routes, and behaviour of the loggerhead turtle (*Caretta caretta)* in the Mediterranean Sea are still hampered by important gaps (Casale *et al*, 2018).

Cetaceans and sea turtles are wide ranging, highly mobile migratory organisms that occupy distinct and often very distant habitats throughout seasons or their complex life cycle. To gather useful information on these species, large-scale surveys are required across basins, seasons, and preferably over sufficient time periods to allow detection of temporal trends and to model animal movements between seasons, years, and life stages (Evans and Hammond, 2004; Vella, 2014). Large-scale, long-term data are also needed to link information on species and anthropogenic pressures to guide the identification of effective management measures. Anthropogenic pressures are indeed increasingly affecting the offshore environment where most large marine vertebrates live (Abdulla and Linden, 2008; Halpern *et al*, 2008; OSPAR, 2008), highlighting the need to obtain more information and improve knowledge on species and threats at a basin scale, as to increase existing conservation mechanisms and strengthen their implementation.

Thus, beyond scientific objectives, the monitoring of large vertebrates, such as cetaceans and sea turtles, is required by a wide legislative framework, which is one of the main priorities in marine management plans to date. Monitoring the presence, distribution, and habitat use of large marine vertebrates is fundamental for their conservation; as previously mentioned, these species are good indicators for detecting environmental changes and assessing the general status of marine habitats, which is necessary information for designing effective conservation plans (Arcangeli *et al*, 2008). Successful management, of pelagic species and habitats, must consider differences in species distribution and relative abundance across geographical areas and different marine habitats, identify the conservation requirements and their variation over space and time, and assess and monitor populations' status, range, habitat, and the ecological impacts of increasing pressures on the marine ecosystem (Hastie *et al*, 2003; Halpern *et al*, 2008). Thus, the long-term monitoring of trends in species, habitats, and pressures through a range of monitoring techniques is highly required (Pullin *et al*, 2009; Berrow *et al*, 2012; Brereton *et al*, 2012).

1.2. The policy context

Since beginning of the '70th including different international organizations and a vast legislative framework attempts to promote the conservation of species and habitats, from international conventions targeting global conservation issues, to regional scale agreements with more specific objectives and national legislation, often reflecting the international or regional obligations at the national scale.

The historical evolution of international environmental law was usually distinguished in "traditional era", "modern era", and "postmodern era", delimited by two fundamental events in 1972 and 1992 (Weiss, 2011).

- In 1972, the United Nations Stockholm Conference on the Human Environment dealt with the need to address the potential conflict between economic development and environmental protection. As a result, countries established the first international intergovernmental organization with this focus, the United Nations Environment Programme (UNEP), and several important multilateral agreements associated, giving way to the so-called 'modern era' of environmental policy.

- In 1992 the United Nations Conference on Environment and Development in Rio de Janeiro (Earth Summit) laid the basis for significant leaps forward in developing and implementing international environmental policy, called the "postmodern era".

More generally, within the last decades, the protection of marine ecosystems has become a priority issue over regional and national jurisdiction and through area-based management measures (*i.e.*, marine spatial planning, also considered within the 2014/89/EU MSP directive). The ecosystemic approach guiding current legislation on marine conservation underlines the importance of considering the complex interactions between the natural and anthropic components of the marine environment to efficiently manage it. Because of the high mobility of large marine vertebrates, their protection can only effectively be achieved by means of international cooperation. Local or national approaches are not sufficient alone, due to the large-scale connectivity of the marine ecosystem, including long migratory pathways for species, such as sharks, sea turtles, and whales, as well as large-scale ocean current dynamics, so that wide approaches have been developed for a better understanding of this environment.

1.2.1. International measures for marine protection

International Council for the Exploration of the Sea - ICES

The International Council for the Exploration of the Sea (ICES) represents an intergovernmental marine science organization, created to meet societal needs for impartial evidence on the state and sustainable use of our seas and oceans. It was established in 1902 by an exchange of letters between participating countries and received full international status in 1964 through an agreed Convention. Its goal is to advance and share scientific understanding of marine ecosystems and the services they provide and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals. Through strategic partnerships, its work in the Atlantic Ocean also extends into the Arctic, Mediterranean Sea, Black Sea, and North Pacific Ocean (www.ices.dk).

International Union for the Conservation of Nature - IUCN

In 1948, the International Union for the Conservation of Nature (IUCN) was founded. It is a membership Union composed of both government and civil society organisations, with vast expertise that makes it the global authority on the status of the natural world and the measures needed to safeguard it. The Union aims to advance environmental law through the development of legal concepts and instruments and supports its application in national policy systems. Another key objective is to share the knowledge gathered by its unique global community of scientists through its conservation databases, such as the Red List of Threatened Species and the Database of Key Biodiversity Areas (KBAs).

International Whaling Commission - IWC

One of the first pieces of international environmental legislation was the International Convention for the Regulation of Whaling, established in 1946. The International Whaling Commission (IWC) was set up under the Convention with the purpose of providing the conservation of whale stocks through specific measures to regulate whaling, such as the Revised Management Procedure (RMP). Currently, the Commission also undertakes extensive studies and research on cetacean populations through Conservation Management Plans (CMPs) that provide a framework for countries within the range of vulnerable cetacean populations to work together towards their protection or through the establishment of sanctuaries that prohibit commercial whaling.

The Bonn Convention on the Conservation of Migratory Species of Wild Animals - CMS

The Convention on the Conservation of Migratory Species of Wild Animals (CMS), also known as the Bonn Convention, was signed in 1979 as an environmental treaty of the United Nations and entered into force in 1983. Its aim is to provide a global platform to conserve terrestrial, aquatic, and avian migratory species throughout their habitats and migration routes, and to encourage the development of multilateral agreements for species that cross national jurisdictional boundaries, emphasising the need for transboundary reporting. The CMS "*brings together the States through which migratory animals pass, the Range States, and* *lays the legal foundation for internationally coordinated conservation measures throughout a migratory range*" (www.cms.int). Most European cetacean and marine turtle species are highlighted as priority species under the CMS, being listed either under Appendix I (migratory species threatened with extinction) or Appendix II (migratory species that would significantly benefit from international co-operation). With respect to cetaceans in Europe, the CMS promoted regional agreements for their conservation, such as the "Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area" and the "Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas" (ACCOBANS and ASCOBAMS, see below). This latter agreement obliges parties to cooperate to achieve and maintain a favourable conservation status for small cetaceans in the agreement area.

The United Nations Convention on the Law of the Sea - UNCLOS

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) established rules governing all uses of the oceans and their resources, stating that countries are to protect and preserve the marine environment, including the areas beyond the limits of national jurisdiction (ABNJ), and set forth detailed measures to be taken in order to do so, as for example, the definition of the exclusive economic zone (EEZ) or ecological protection zone (EPZ).

The Convention of Biological Diversity - CBD

Signed by 150 government leaders at the 1992 Rio Earth Summit and entered into force in 1993, the Convention on Biological Diversity (CBD) has three main objectives: the conservation of biological diversity; the sustainable use of the components of biological diversity; the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. A major challenge had become the identification and assessment of risks to the environment and to human health, with the ecosystem approach at the heart of environmental policy, which resulted in a more robust and comprehensive approach. Many European governments have made ambitious commitments to sustainable development and wildlife conservation because of this agreement. To measure the progress toward the convention targets, biodiversity indicators have been and are being adopted. In the European seas, biodiversity indicators are required to assess the effectiveness of protected area designation, conservation, and marine resource management policy. Alongside conservation efforts, in 2008, the Conference of the Parties adopted the scientific criteria for identifying ecologically or biologically significant marine areas (EBSAs) in need of protection in open-ocean waters and deep-sea habitats (Decision IX/20). The CBD secretariat emphasized that the identification of EBSAs and the selection of conservation and management measures is a matter for States and competent intergovernmental organizations, in accordance with existing international law. The Strategic Plan for Biodiversity 2010-2020 set the 20 Aichi biodiversity targets, which established that by 2020, 10% of the global ocean should be protected. Despite ongoing efforts, biodiversity is however reported to be deteriorating worldwide, and the decline is projected to continue or worsen under business-as-usual scenarios (CBD/WG2020/3/3, 5 July 2021). The first draft of the post-2020 global biodiversity framework, builds on the Strategic Plan for Biodiversity 2011-2020 and "sets out an ambitious plan to implement broad-based action to bring about a transformation in society's relationship with biodiversity and to ensure that, by 2050, the shared vision of living in harmony with nature is fulfilled" (CBD/WG2020/3/3, 5 July 2021).

UN Rio Conference on Sustainable Development

At the 2012 UN Conference on Sustainable Development (Rio +20), States committed themselves to address the issue of the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (ABNJ), including the development of an international legally binding instrument under the UNCLOS (Resolution 72/249). ABNJ comprise the high seas and include complex ecosystems at vast distances from coasts, making resource management and biodiversity conservation difficult and challenging.

IUCN is supporting efforts to create an Implementing Agreement to UNCLOS, which would help close the existing ABNJ governance gap and ensure the conservation and sustainable use of biodiversity in these areas. In addition, within the IUCN process to constitute Marine Mammal Protected Areas, a specific task force was created to facilitate mechanisms to encourage collaboration and sharing information and experience for establishing and promoting effective spatial solutions for marine mammal conservation. Since 2016 the task force has been identifying Important Marine Mammal Areas (IMMAs), defined as "*discrete portions of habitat, important to marine mammal species that have the potential to be delineated and managed for conservation".* Based on eight standard criteria, this process will provide valuable input about marine mammals into existing national and international conservation tools with respect to marine protected areas, such as EBSAs and KBAs.

The 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) were adopted by world leaders in September 2015 at an historic UN Summit. Countries have the primary responsibility for follow-up and review of the progress made in implementing the Goals, and UNEP will play a key role in contributing to the implementation of those environment-related indicators in coordination with other actors. Goal 14 is to Conserve and sustainably use the oceans, seas, and marine resources.

1.2.2. The European legislative framework

Europe has some of the world's highest environmental standards, mostly developed after the Rio Summit, with many legislative initiatives that point to the protection and recovery of natural environments and populations by focusing on the sustainable use of marine resources and limiting the take and trade of species or habitat degradation. Most of these agreements require monitoring and assessment of the status of the species populations and habitats, which State Parties need to provide at regular intervals.

The Bern Convention on the Conservation of European Wildlife and Natural Habitats

Among the multinational conservation efforts of the "modern era", in 1979 the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) was the first international treaty to protect both species and habitats and to bring European countries together to decide how to act on nature conservation, along with the Birds Directive.

The Habitats Directive (92/43/EEC)

The Habitats Directive was signed in 1992 with the aim "to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements" and to compel Member States to take action to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora specified as being in need of strict protection. Conservation status is defined as "*the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations in the European territory of the Member State to which the Treaty applies".* This is considered favourable if the species stays as a viable component of its natural habitats and if its abundance and range are maintained, according to reference values; for this reason, the parameters to assess the conservation status of species are core elements of the directive (DG Environment 2017).

Annex II of the Directive lists the species for which the core areas of their habitat have to be identified as Sites of Community Importance (SCI) and designated as Special Areas of Conservation (SACs), to become an integral part of the Natura 2000 network the "largest coordinated network of protected areas in the world". Annex IV lists all species under strict protection, and Annex V ensures that species exploitation is compatible with their favourable conservation status. All cetacean and marine turtle species are listed under the Annex IV, which requires a strict protection regime across their entire range in European waters and EU member states reporting on their conservation status every six years. Bottlenose dolphins (*Tursiops truncatus*), harbour porpoises (*Phocoena phocoena*), loggerhead turtles (*Caretta caretta*), and green turtles (*Chelonia mydas*) are also listed under Annex II, which indicates that the core areas of their habitat have to be identified as SCIs and designated as SAC as part of the Natura 2000 network.

Specifically, Article 3 of the Directive states that a coherent ecological network of SACs should be set for key sites that are used regularly by the species and that 'must be clearly identifiable areas representing the physical and biological factors essential to the species life and reproduction'. SACs would enable species' habitats to be maintained or, where appropriate, restored at a Favourable Conservation Status (FCS), which must be assessed considering four parameters: natural range, population size, habitat (extent and condition), and future prospects. A species is in a FCS if: "population dynamics data indicate that the species is maintaining itself on a long-term basis as a viable component of its natural habitats, the natural range of the species is neither being reduced nor is likely to be reduced in the foreseeable future, and there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis." Article 3 also requires Member States to contribute to the creation of Natura 2000 sites proportional to the representation within their territory of Annex I habitats and Annex II species. Article 4 states that for aquatic species ranging over wide areas, such sites will be proposed where there is an identifiable area characterized by the physical and biological factors essential to their life and reproduction. Article 12 requires MS to establish a system of strict protection that includes prohibiting the deliberate capture or killing and disturbance of listed species and monitoring their incidental capture and killing. Under Article 17, MS are required to report the conservation status and trend of each species included in Annex II across their entire natural range, and the evaluation of the influence of conservation measures, pressures, and threats, through monitoring every six years, as specified in Article 11. Under this article, EU Member States have a legal obligation to undertake surveillance of all cetacean species and marine reptiles occurring in their waters to determine their conservation status and report every six years. Monitoring must lead to a clear picture of the species actual conservation status and its trends and should be coordinated to better detect changes in the distribution or abundance of those species that could reflect a failure to achieve FCS.

The Marine Strategy Framework Directive (2008/56/CE)

The Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) was adopted on 17 June 2008 with the aim to restore the European marine ecosystem. It capitalises on former conservation instruments such as the HD, but deals with their gaps with an ecosystem approach. Its goal is to achieve or maintain a Good Environmental Status (GES) of EU marine waters, so that *these provide ecologically diverse and dynamic oceans and seas, which are clean, healthy, and productive*. The Directive sets out eleven qualitative descriptors (Annex I) describing what the environment would look like when GES is achieved and several criteria and associated indicators for determining GES in relation to each descriptor (COM Decision 2017/848/EU). Member States may choose which descriptors to apply and which criteria and indicators to use and set targets according to the background conditions relevant to each area. The Directive establishes European Marine Regions, also according to the existing Regional Sea Conventions, and follows an adaptive management approach that foresees its update and review every six years after implementation (2012-2018 and 2018-2024 cycles).

The MSFD is considered the environmental pillar of the Integrated European Maritime Policy and requires the adoption of specific and standardized methods for monitoring and assessing the achievement of GES, to ensure consistency and comparability among assessments done by different European MS. The process link to those foreseen under the HD is Descriptor 1 (D1, *i.e.*, biological diversity), based on the primary criteria (C2) Population abundance; (C4) Distributional Range and pattern; (C5) Habitat for the species. The main aspects to monitor for the assessment of GES shall be consistent with the reference parameters of the HD. The evaluation of trends in abundance is considered a relevant indicator to set threshold values and to express the extent to which GES is being achieved. Both cetaceans and marine turtles have been identified as target species for the assessment of GES within this descriptor, as well as within other descriptors to which they are less directly related, such as D4 (food webs), D8 (contaminants), D10 (marine litter), and D11 (noise). According to this integrated approach, the assessment of species also requires 'an understanding of the distribution, extent, and condition of their habitats to make sure that there is a sufficiently large habitat to maintain its population, taking into consideration any threat of deterioration or loss of such habitats' (COM_DEC 2017/848/EU).

Marine Spatial Planning Directive (2014/89/EU)

This directive establishes a comprehensive framework for MS to manage human activities, their multiple uses and interests in the maritime environment, and to minimize environmental impacts while reducing conflicts among users through Maritime Spatial Planning (MSP). With the growing impact of human activities in areas beyond national jurisdiction, the European Commission adopted a legislation that "works across borders and sectors to ensure human activities at sea take place in an efficient, safe and sustainable way". This Directive followed an Impact Assessment in 2013 that documented the expansion of commercial activities at sea, such as fisheries, shipping, dredging, oil exploitation, tourism, mineral extraction, wind energy, and offshore marine aquaculture and identified several problems in managing the use of marine space. The target is to define the maritime spatial plans by 2021.

EU Biodiversity Strategy

The recent EU Biodiversity Strategy for 2030, adopted in May 2020, is a comprehensive, ambitious, and long-term plan to strengthen the protection of natural habitats and reverse the degradation of ecosystems. Its main objective is to establish a larger EU-wide network of protected areas on land and at sea, and strictly protected areas for habitats and fish stocks recovery.

According to this legislative framework, the delimitation of Marine Protected Areas (MPAs) based on species richness, distribution and habitat requirements is a key measure for mitigation. Within the European waters, several areas were designated as SCIs in the Natura 2000 network, although few of them have a management plan defined or, at least, reported (http://natura2000.eea.europa.eu). As highly mobile marine species, cetaceans and marine turtles challenge all attempts to develop conservation measures, particularly if the information on species abundance and distribution is fragmented. Thus, MPAs should be developed in a precautionary manner that ensures they are sufficiently large, flexible, and adaptive to new information to provide buffers against uncertainty and that spatially and temporarily critical habitats have been protected (Clark *et al*, 2010). A sound knowledge of the occurrence and distribution of cetaceans is needed to efficiently define critical habitats for the species and designate MPAs, especially in the high seas, where several features, such as seamounts, thermal fronts, upwellings, and eddies, are favourable for their habitats (Hoyt, 2011). The acquisition of population and ecology data and a better understanding of the habitat use by different species are essential to prioritize areas where protection measures are most critical and assess both the need for conservation management actions and the effectiveness of such actions (Arcangeli *et al*, 2017).

1.2.3. Regional Sea Conventions and Multilateral Environment Agreements

As mentioned above, the European Seas are under strict regulation. The entire Mediterranean region, also beyond country boundaries, is subject to the legislative framework of EU laws and international agreements (*e.g.*, the Bern Convention, ACCOBAMS): the Black Sea is considered under ACCOBAMS, the Baltic sea area is protected under the HELCOM convention, and the Eastern North Atlantic is covered by several international organizations and agreements, including the ICES, the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), ASCOBANS, and ACCOBAMS (Correia *et al*, 2019b). Such international agreements are essential for ensuring the conservation of large marine vertebrates in international waters, obtaining baseline data, assessing population status, and designing and implementing management measures. Besides the large-scale legislation, several regional agreements and local regulations were also developed to act as legal conservation tools for the marine environment and deal with specific issues.

Regional Sea Conventions

Regional Sea Conventions (RSC) provide international regional approaches to preserve the marine environment and promote international collaboration beyond the EU borders, across marine waters shared among EU and non-EU countries. A close collaboration is needed for the designation of management and conservation plans for the threatened marine fauna, and to this aim some of these conventions foresee the use of fixed line platforms to monitor these species.

Barcelona Convention

The Barcelona Convention was first signed in 1975 as “the Convention for Protection of the Mediterranean Sea against Pollution” and is the first Regional Sea programme adopted under the UNEP. In 1995, it was modified to the “Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean”, through the adoption of the Action Plan for the protection of the marine environment and the sustainable development of the coastal areas of the Mediterranean (Mediterranean Action Plan, UNEP/MAP), which now constitutes the principal legally binding multilateral environmental agreement in the Mediterranean. The convention included the protection of marine endangered species (Genoa Declaration, 1985) and various action plans for endangered Mediterranean species among its priority targets (Notarbartolo di Sciara and Mifsud, 2002; UNEP/MAP, 2017a).

The UNEP/MAP is the implementation instrument of the Barcelona Convention and represents the comprehensive institutional, legal, and implementation framework that the Contracting Parties have adopted to fulfil the vision of a healthy Mediterranean Sea and coast that underpins the sustainable development in the region. Among the several initiatives of this RSC, it established a List of Specially Protected Areas of Mediterranean Importance (SPAMI List) through the Specially Protected Areas and Biological Diversity SPA/BD Protocol in order to promote cooperation in the management and conservation of natural areas, as well as in the protection of threatened species and their habitats in the Mediterranean. Under the Protocol, adopted in 1995, Parties are called to protect areas of particular natural or cultural value through the establishment of Specially Protected Areas (SPAs) or Specially Protected Areas of Mediterranean

Importance (SPAMIs) and to protect the threatened or endangered species of flora and fauna listed in the Protocol's Annexes. The conservation of marine turtles and cetaceans has been a priority for UNEP/MAP for a long time, through the adoption of the Action Plan for the Conservation of Mediterranean Marine Turtle in 1989 and the Action Plan for the conservation of cetaceans in the Mediterranean Sea in 1991 (https://www.unep.org/unepmap/). With regards to the SPA & BD Protocol, the Regional Centre for Specially Protected Areas or RAC/SPA, has issued a series of action plans targeted at the implementation of the SPA and Biodiversity Protocol including the 'Action Plan for the Conservation of Mediterranean Marine Turtles' and one on cetaceans. Although these action plans are not legally binding, they set priorities and activities to be undertaken by the contracting parties. These action plans call for a coordination of efforts between states of the region to ensure the conservation and sustainable management of the concerned species in their area of distribution within the Mediterranean. Apart from these Action plans, the centre also issued guidelines and other relevant information to the parties including 'Guidelines to Design Legislation and Regulation Relative to the Conservation and Management of Marine Turtle Populations and their Habitats, 2003, and the 'Guidelines to Improve the Involvement of Marine Rescue Centres for Marine Turtles, 2004.

In 2016, Contracting Parties agreed on adopting the Mediterranean Strategy for Sustainable Development (MSSD) and the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP), which outline the principles for an integrated monitoring of biodiversity, non-indigenous species, pollution and marine litter, the coast, and hydrography. The IMAP implementation is structured on 11 Ecological Objectives and 27 Common Indicators (Decision IG. 22/7), of which Common Indicator 3, under the Ecological Objective 1 (*Biological diversity is maintained or enhanced*), specifically refers to marine mammal, seabird, and marine reptile distributional ranges.

OSPAR

The Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic is a "mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic." (www.ospar.org). It works under the umbrella of customary international law as codified by the 1982 United Nations Convention on the Law of the Seas (UNCLOS) and is guided by the ecosystem approach to an integrated management of human activities in the marine environment. It was defined in 1992 with the objective of protecting the maritime area against the adverse effects of human activities, safeguarding health, conserving marine ecosystems, and restoring areas that have been adversely affected. States covered by the Convention are required to undertake assessments of the quality status of the marine environment at six-years intervals (Quality Status Report, QSR). These assessments should also evaluate the effectiveness of measures taken or planned for the protection of the marine environment and identify priorities for action (Article 6 and Annex IV). To monitor environmental quality, the Commission adopted a Joint Assessment and Monitoring Programme (JAMP, OSPAR, 2014), based on the most recent information available from national and international sources, which sometimes are lacking or sparse. The Coordinated Environmental Monitoring Programme (CEMP) aims to deliver comparable data from across the OSPAR Maritime Area, which can be used in the assessments and for the coordinated implementation of other directives among States. OSPAR has been working with other RSCs and the European Commission to develop assessment tools, such as indicators of the state of the marine environment, and aims to protect the marine environment, among other tools, through the establishment of MPAs for threatened and declining species, particularly in the high seas.

HELCOM

The Convention on the Protection of the Marine Environment in the Baltic Sea Area was also adopted in 1992 (Helsinki Convention, HELCOM), taking measures to reduce all sources of pollution in the area.

Bucharest Convention

The Convention for the Protection of the Black Sea (Bucharest Convention) was also signed in 1992, posing the basic legal framework for regional cooperation to protect the coastal and marine environment in the Black Sea. It is implemented by the Black Sea Commission, and it is currently considering the EU accession to the Convention, which would be beneficial for a better application of European and regional directives.

ASCOBANS

The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish, and North Seas was concluded under the auspices of the Convention on Migratory Species (CMS) known also as the Bonn Convention (CMS) in 1992 and entered into force in 1994. It aims to promote close cooperation between countries to achieve and maintain a favourable conservation status for small cetaceans throughout the Agreement Area, with a general conservation objective "*to allow populations to recover to and/or maintain 80% of carrying capacity in the long term*". To respond to the urgent need for more accurate data on the distribution and abundance of cetaceans, ASCOBANS recommends adequate surveillance schemes using sighting surveys (vessel & plane), as well as acoustic ones.

ACCOBAMS

The Agreement for the Conservation of Cetaceans in the Black Sea, Mediterranean Sea, and Atlantic contiguous waters was created in 1996 after consultations between the secretariats of four Conventions (Bern, Bonn, Barcelona, and Bucharest) in response to the increased awareness of the numerous and synergistic threats to which cetaceans in the Mediterranean Sea are exposed. Its overall objective is *"to improve the conservation status of cetaceans and of their habitats in the area of competence of the Agreement by 2030"*.

The Agreement recommends the implementation of effective protection measures for cetacean species throughout its region. Several countries cooperate to conduct such monitoring accordingly (https://accobams.org/), when also considering the implementation of surveys from the so-called "platforms of opportunity".

RAMOGE

RAMOGE is an agreement among France, Italy, and Monaco on the protection of Mediterranean coastal waters, within the framework of the Barcelona Convention and the Action Plan for the Mediterranean Sea. It aims to implement actions to promote integrated coastal management and preserve the marine environment. It considers issues, such as pollution from land-based sources (including marine macrolitter and general waste) and promotes studies on important key marine species that would provide the data necessary to make recommendations to protect biodiversity.

The Pelagos Sanctuary agreement

The Pelagos Sanctuary is a Mediterranean marine SPAMI subject to an agreement between Italy, France, and the Principality of Monaco (1999) made to ensure the conservation of marine mammal populations in the area. To assure that they remain in a favourable condition, the agreement promotes their monitoring efforts and strengthens the scope of existing legislation with regard to certain sea-based activities and the reduction of pollution.

Other conservation initiatives

The General Fisheries Commission for the Mediterranean (GFCM) of FAO (Food and Agriculture Organization of the United Nations) adopted recommendations aimed at minimizing the adverse effects of fisheries operations on marine turtles & cetaceans. These recommendations call for Contracting Parties to ensure the implementation of fisheries management measures to mitigate or eliminate the risk of incidental taking of sea turtles and cetaceans in fishing operations and/or the mortality associated with those incidental takings. These recommendations also call for monitoring and recording data in relation to incidental taking, as well as for advice and guidance from the Scientific Advisory Committee with respect to mitigation measures. The GFCM Recommendations specify that purse seine vessels should avoid encircling sea turtles and release encircled or incidentally entangled sea turtles, including on Fish Aggregating Devices. According to the GFCM recommendation, pelagic longline vessels should carry on board safe handling, disentanglement, and release equipment, capable of releasing sea turtles unharmed and in a manner that maximises the probability of their survival.

Council Regulation (EC) No 1967 of 2006, concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, calls for a sustainable exploitation of fishery resources in the Mediterranean Sea. Article 3 of this regulation refers to the Habitats Directive (92/43/EEC) and prohibits deliberate catching, retention on board, transhipment or landing of protected species listed in Annex IV of the Habitats Directive (which includes cetaceans and marine reptiles). *However, fishermen may be authorised* *to land such turtles subject to the provision that the retention on board, transhipment or landing of incidentally caught specimens is necessary to secure assistance for the recovery of the individual animals, and provided that the competent national authorities concerned have been duly informed in advance.*

1.3. Requirements from the main policies

Although the specific objectives and measures may be different, the European body of laws dealing with species conservation is delimited and shows interactions and synergies with scopes and monitoring plans defined under one legislative process being supportive for the others. For example, the parameters indicated by the HD are of reference for the OSPAR assessment, and the QSR under OSPAR gave an important regional contribution to the initial assessment required by the MSFD. Additionally, the methods developed for the assessment of large marine vertebrates by the HD should be considered for the process of harmonisation of methods within the MSFD. Indeed, reporting under the HD and MSFD were streamlined so that MS can report on the required features using the same formats and timescales (Palialexis *et al*, 2019). Table 6 summarizes the main equivalences between legislative requirements, with respect to the criteria for assessing species status, and particularly large marine vertebrates. This comparison underlines the consistency of the most recent requirements with some of the criteria already in place.

Table 6. Comparison among the objectives and parameters/criteria used for the Biodiversity assessment (and specifically for large marine vertebrates) within the main European policies.

Policy	HD	MSFD Descriptor 1	OSPAR JAMP 2014–21	Barcelona Convention Ecological Objective 1	CMS	IUCN Red List
OBJECTIVE	Conservation status for the species will be taken as 'favourable' considering these parameters:	Biological diversity is maintained. The quality and the occurrence of habitats and the distribution and abundance of species are in line with predominant physiographic, geographical, and climatological conditions.	Assess the status of threatened and/or declining species and habitats and whether the range of measures taken is adequate to protect and conserve species.	Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic, and climatic conditions.	Ensure protection of endangered migratory species across their full range.	Assess the conservation status of species.
PARAMETERS/C	**Population** Population dynamic data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats.	C2 Population abundance Primary for species covered by Annexes of HD	Population abundance	Common Indicator 4 Population abundance	Population distribution and abundance	Population size
		C3 Demographic characteristics of the population (Primarily only for commercially exploited fish and shellfish)	Population conditions (demography)	Common Indicator 5 Population demographic characteristics	Population dynamic and viability	

R I T E R I A	**Range** The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future.	C4 Distributional Range and pattern Primary for species covered by Annexes of HD	Geographical range and distribution	Common Indicator 3 Species distributional range	Species range, population distribution	Range
	Habitat of species There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.	C5 Habitat for the species Primary for species covered by Annexes of HD				Habitat quality included in the range

Population refers to the *total population in the biogeographical or marine region* of interest. The estimate of population size or abundance has to be related to management units (*e.g.*, IWC), particularly for wide ranging marine species; for this reason, many assessments are based on statistically robust estimates obtained from regional Agreements or Conventions (ACCOBAMS, ASCOBANS, OSPAR, HELCOM, Barcelona), or from coordinated surveys carried out by MS sharing the same populations (*e.g.*, SCANS, NASS).

Sea turtle assessments require a more comprehensive database, considering not only nesting females, but also turtles of different size/age classes in all the areas and habitats used by the species. The estimate of population abundance will therefore include observations at sea complemented by modelling and/or extrapolation (Palialexis *et al*, 2019).

The reporting unit for HD is "individuals", which may be expressed as intervals, best available single values, or number of occupied 1x1 km grids (population distribution). The expected assessment outputs include trend analysis and density maps, with a similar approach to other regulations (DG Environment, 2017). More detailed demographic characteristics are required by OSPAR, IMAP, MSFD, but mainly for exploited species.

Range is defined as "*the outer limits of the overall area in which a species is found at present and it can be considered as an envelope within which areas actually occupied occur*" (DG Environment, 2017).

For HD and IMAP reporting, species spatial distribution is required in the form of a presence/absence map in a 10x10 km grid, indicating the space regularly used by the population(s). The distribution area is obtained from the sum of the area of the cells where the species is present.

Some highly mobile or migratory species can occupy large territories during their life cycle (*sensu* CMS), so reporting should be presented at biogeographical level (*e.g.*, 50x50 km grids, UNEP/MAP 2017b); in these cases, the gridded distribution will approximate the range when the distribution is derived from the large-scale surveys, modelling, and/or extrapolation (DG Environment 2017). Presence/absence data combined with environmental indices would allow predicting the probability of occurrence in areas where no data are available.

For species that display wide range movements, as in ABNJ, the distributional range could be used to monitor abundance, as the significance of variation of trends in the number of occupied cells or in the occupied area may be statistically assessed (Palialexis *et al*, 2019).

According to the IUCN criteria, Area and Extent of Occupancy have to be mapped in a 2x2 km grid, for a fine scale evaluation of the spatial spread of risk that a species can deal with. Estimating the quantity of occupied habitat for taxa with markedly different body sizes, mobility and home ranges requires different spatial scales of measurement (IUCN, 2019). When calculating the area of occupancy, scale dependent biases occur, so the species condition must be critically assessed, both biologically and statistically.

Habitat of species is *an environment defined by specific abiotic or biotic factors, in which the species lives at any stage of its biological cycle* (DG Environment, 2017). The evaluation of this parameter is only included in the HD and MSFD, while the IUCN criteria recognize the suitable habitat in the evaluation of the species range and risk exposure (IUCN, 2019). For highly mobile species, the habitat will often equal the range, so it might be difficult to precisely identify the area used. In this case, habitat could be assessed through predictions, modelling, and/or extrapolation from a limited amount of data, and the assessment should mainly focus on the 'habitat quality' (Palialexis *et al*, 2019).

According to the IUCN, the minimum period recommended to assess changes in abundance and range is 10 years (IUCN, 2019). Within the HD, a "trend" is defined as a (measure of a) directional change of a parameter over time and is a decisive information for conservation status assessment, while "*Future prospects*" should be interpreted as the future condition of the species parameters within the next 12 years (2 reporting cycles) for detecting short-term trends, or the next 24 years for long-term trends (DG Environment, 2017).

A comparison on the indications on spatial and temporal resolution required by the different EU policies is reported in Table 7.

Table 7. Spatial and temporal requirements foreseen by the different environmental policies.

Policy	HD	MSFD	OSPAR	Barcelona Convention	CMS	IUCN
Spatial resolution	National 10x10 km grid (50x50 km for biogeographical scale)	MarineUnit (Subregion-Area)	Regions	10x10 km grid (50x50 km for biogeographical scale)	migratory range	2x2 km grid
Temporal resolution	6 years (12 y short-term 24 y long-term)	6 years	6 years	3-6 years	seasonal for migration	10 years / 3 generations

1.4. Scope of the document

The success of carrying out proper conservation science depends on the ability of policy and science to effectively interact to identify the questions of greatest concern. The dialogue between science and policy promises major improvements in the impact of conservation science on the development of strategies in Europe (Pullin *et al*, 2009). However, the growing body of environmental law and an increasing number of states to monitor, with different legal and administrative capacities, lead to a high level of non-compliance with directives in the EU (Börzel and Buzogány, 2019). Reptile, mammal, and bird monitoring is limited in most Regional Seas (Patricio *et al*, 2016), although it is required by the Habitats and Birds Directives. However, the EU has increased its efforts to build Member States capacities for achieving compliance by funding programs and trans-governmental networks, fostering a common understanding of what compliance entails and facilitating mutual learning, and carrying out extensive collaborations with RSC so that compliance is also achieved within regions with the assistance and 'compliance' of non-EU states.

The EU Network for the Implementation and Enforcement of Environmental Law (IMPEL) was established in 1992 as an informal network of European regulators and authorities concerned with the implementation and enforcement of environmental law (Börzel and Buzogány, 2019). In 2020, IMPEL funded the Project "Fixed Line Transect Europe", involving the European networks that undertake marine megafauna surveys using large vessels, such as ferries or cargos, as platforms of systematic observations. The objective of this project is to strengthen the collaboration among these bodies with the aim of setting up and standardizing protocols for data collection and defining the appropriate analyses to efficiently respond to the legislative drivers and supporting decision making across Europe.

Ferries and large commercial vessels provide valuable platforms to carry out sustainable, long-term monitoring programs that allow coverage at large geographic scales, including high seas, throughout several seasons and years, where and when data are generally scarce. Data collection from fixed line platforms could be done through relatively simple protocols, and their application is leading to growing collaborations across the European seas; however, there are still some aspects of this methodology that could be improved, including: assessing the consistency of data collection; improving the methods for data storing through, *e.g.*, the development of mobile applications; standardizing and improving the data validation and data analysis process; improving the communication between the network, the scientific community, the policy makers, and the wider community to sustain the application of this method for conservation and fundraising.

This document is intended to provide an overview of the state-of-the-art monitoring of large marine vertebrates from fixed line platforms, with a special focus on commercial ferries and cargoes, considering the relative framework of international and regional agreements and conventions, and the main monitoring programs developed within research institutions, NGOs, and national initiatives (Chapter 2).

Based on a detailed review of the available scientific literature, and protocols applied by the ongoing monitoring initiatives across Europe, the main characteristics of monitoring protocols will be described, including their temporal and spatial scale of application, the main aspects related with the monitoring platforms, observation parameters, and data collection practicalities, such as data collection formats and mobile applications (Chapter 3 and 4). The methods used for data analysis will also be listed, in order to describe the scientific questions that can be addressed with respect to the EU environmental legislation in detail (Chapter 5).

The thorough analysis of the available methodologies for monitoring and data analysis will lead to the identification of potential gaps or inconsistencies that might need to be filled or investigated, and the development of a series of recommendations to improve the standardization and coherence of the methods for monitoring large marine vertebrates from fixed line platforms (Chapter 6).

2. Monitoring cetaceans and marine turtles from fixed line platforms: past and ongoing initiatives

2.1. Review of the scientific literature

Despite scientific research on threatened marine vertebrates, such as cetaceans and marine turtles, steadily increasing during the past decades, the scientific production derived from fixed line monitoring transects has been relatively scarce until a series of studies were published in the first decade of 2000 (*e.g.*, Evans and Hammond, 2004; Kiszka *et al*, 2007; MacLeod *et al*, 2009) supporting the scientific relevance of data collected through this method.

To prepare this document and provide a detailed overview of the state-of-the-art fixed line monitoring from ferries and cargoes, a thorough review of the protocols applied and analyses performed from all the scientific production derived by the monitoring networks that are currently active in Europe and involved in the IMPEL initiative Fixed Line Transect Europe (*i.e.*, FLT MED NET, CETUS, ORCA) was considered. Furthermore, to complement the analysis with other available information from similar experiences across the world, a literature search in Google Scholar was performed using the keywords “Ferry monitoring”, “Cargo monitoring”, “marine mammal/cetacean monitoring”, “platforms of opportunity and marine vertebrates”. The collection of bibliographic information resulted in the consultation of almost 60 international and national research papers, over 30 conference abstracts and proceedings, 10 technical reports, four PhD theses, and four MSc theses. The largest proportion of the recent scientific production derived from the FLT MED NET and CETUS projects, with a smaller proportion of less recent studies derived from the earlier surveys performed by ARC and IWDG in the North Atlantic (see Annex I). This information was used to compile the sections of this report relative to European projects and networks, the third chapter, concerning the details of monitoring protocols, and the fourth, relative to data analyses. A few examples of experiences derived from the use of platforms other than ferries and cargo vessels, or outside European Seas, are also briefly described. When relevant, information included in these publications was also considered in the third chapter, regarding the relative aspects of the protocol for data collection.

2.2. Dedicated large-scale surveys

The maintenance of long-term surveillance schemes to monitor the changing status of marine fauna populations is needed to obtain data for temporal analyses, provide information on trends in species distribution and abundance, and evaluate the conservation status of their populations. The use of the same methodology, protocol, and similar survey conditions within the same marine regions allows the comparison of data regarding the presence and distribution of the species in the study area. However, studies on pelagic species are always constrained by trade-offs imposed by the difficulties of accessing these animals, which limit a complete scientific understanding and often generate scattered information.

According to Patricio *et al* (2016), marine biodiversity monitoring has increased over the last 100 years, especially over the last three decades, with differences between regional seas. While the Baltic Sea and North-East Atlantic were monitored since the 1970s, few monitoring activities took place in the Mediterranean Sea prior to the 1990s and most Black Sea monitoring programs were only initiated in the 2000s.

In 1986, the IWC temporarily banned commercial whaling due to the lack of data on abundance and status of most whale populations. Such a moratorium should have been reconsidered after a “Comprehensive Assessment” of whale stocks, which led to the *North Atlantic Sightings Survey* (*NASS*), a large and wide-ranging whale research programme, involving several countries of the North Atlantic, and coordinated by the North Atlantic Marine Mammal Commission. The main purpose of these surveys, repeated in 1987, 1989, 1995, 2001, 2007, and 2015, was to obtain the information needed to assess the conservation status of cetaceans from Norway to North America, and to produce effective management of the species in response to direct human impacts such as whaling, fisheries interactions and ship strikes (Sigurjónsson and Víkingsson, 1997; Víkingsson *et al*, 2009; Pike *et al*, 2019). In addition to these aerial and ship-based surveys, a synoptic investigation took place in 2007 along the US coasts, the *Southern New England to Scotian Shelf Abundance survey* (*SNESSA*, National Marine Fisheries Service of US), which monitored the largest area ever covered by a coordinated survey.

In the mid-1990s, extended surveys were carried out to obtain the first comprehensive estimate of abundance of harbour porpoise in the North Sea and adjacent waters and evaluate the impact of bycatch on the population. A series of wide surveys called Small Cetaceans in the European Atlantic and North Sea (*SCANS*) covered the North Sea and adjacent waters, and were conducted in 1996, 2004, and 2007 (Hammond *et al*, 2002, 2013, 2017), along with the survey *Cetacean Offshore Distribution and Abundance in the European Atlantic* carried out in offshore waters in 2007 (*CODA*, 2009). Results obtained from this survey successfully contributed to the assessment of the Favourable Conservation Status of small cetaceans, in response to the requirements of EU policies.

In the Mediterranean Sea, the Conservation Biology Research Group at the University of Malta (CBRG) together with BICREF NGO, have sustained long-term commitment to research, monitoring, and local awareness with the aim of cetacean conservation around the Maltese Islands. A year-round monitoring of cetacean species has been carried out since 1997 using both aerial and marine surveys, but also through collaborative work with sea-users in the areas of research interest (Mifsud *et al*, 2017; Vella, 1998; Vella and Vella, 2015). This long-term study allowed investigating various aspects of cetacean species, as well as spatio-temporal associations of marine turtles (Vella, 2005, 2010, 2011, 2014), highlighting conservation priorities and proposing further research efforts (Vella, 2010, 2013).

2.3. Using large vessels travelling along fixed transects as monitoring platforms

Although large marine vertebrates, such as cetaceans and marine turtles, are under strict international, regional, and national protection, and conservation and legal requirements urge monitoring their status, the availability of information and funding for this scope are still limited. Most cetacean and marine turtle research is performed at a small spatial scale and only during summer months, when survey effort is less challenged by weather conditions or logistical constraints. For this reason, the available information on distribution and abundance in offshore regions and during winter months is limited. However, as the distribution of these species is often scale-dependent and may be affected by different multi-scale factors (*e.g.,* currents and large water masses at large-scale, local oceanographic features at small-scale), their populations need to be investigated throughout their range.

Long-term monitoring of cetacean and marine turtle populations is a priority within international conventions and agreements and assessing their trends in relative abundance and distribution is needed to support their conservation. The effective conservation of species that have a complex life cycle and use a variety of ontogenetic habitats requires knowledge of their spatio-temporal distribution throughout their life history (Mannocci *et al*, 2017). Like many of the threatened marine megafauna, cetaceans and marine turtles are migratory species that use specific sea regions only at certain times of the year or stages of their lives. These factors challenge the study of their distribution and abundance. Moreover, the use of different protocols and the scarce systematic regional coordination hamper the consistent collection of large-scale, long-term data. This is also a consequence of the high costs involved in carrying out large-scale and long-term systematic surveys, especially in open sea areas, which limits the capacity to secure continuous funding for such monitoring programmes (Evans and Hammond 2004; Arcangeli *et al*, 2019a).

Ideally, information necessary for cetacean and marine turtle conservation and management would be obtained from well-designed, well-executed, and well-analysed studies; monitoring programmes would need to cover a large enough area to ensure that a significant portion of a population is observed and be repeated at meaningful intervals during enough time to reveal intra- and inter-annual variations and detect population trends. The methodologies to study these species may vary depending on the species concerned and the availability of resources; but often require expensive research platforms such as sea-going vessels, fixed-wing aircraft, or helicopters. Equally relevant issues are the availability of such platforms and of experienced and trained personnel, permission to survey the areas, and the ability to collect data without violating important assumptions (Hammond, 2010). Aerial surveys are an effective method to perform large scale surveys that can be repeated over time, and they have been effectively used to monitor marine turtles and cetaceans in the Mediterranean Sea (*e.g.*, Lauriano *et al*, 2011; Panigada *et al*, 2017b; Laran *et al*, 2017). Satellite tracking has also become increasingly used to identify important marine areas and migratory corridors (*e.g.*, Panigada *et al*, 2017a), however this allows only the tracking of single individuals, and thus does not represent the whole population due to sampling biases and technological limitations (Arcangeli *et al*, 2019b). Unfortunately, budgets to perform these kinds of studies are often very tight, resulting in sporadic monitoring campaigns (Williams, 2003).

The problem of the logistical complexity and limited financial resources for monitoring may be overcome through the so-called "platforms of opportunity". According to Williams (2003) and De Boer (2013), this term has been often misused to describe opportunistic sightings, which are reported during non-dedicated monitoring activities, rather than platforms. Indeed, although the platforms used may be opportunistic, they can host research that is dedicated and effort-related. A "platform of opportunity" can be a whale-watching boat, an oceanographic or fisheries research vessel, a seismic survey vessel, a touristic cruiser, a ferry, or a cargo ship, which all typically cross an area of sea for other purposes (De Boer, 2013). Multidisciplinary cruises and synoptic surveys on research vessels are good examples of this approach as they may allow the simultaneous collection of environmental data useful for the interpretation of the data collected "opportunistically" (Wall *et al*, 2006). Although they may be highly beneficial in terms of costs and logistical aspects of research, the main limitation of these platforms is that their routes are neither determined by a research design targeted to the species of interest, nor, in some cases, random. If, for example, the scope of the platform is whale watching or environmental tourism, there may be a bias towards areas where the probability of spotting marine fauna is higher (Table 1). Conversely, the distribution of the effort performed on commercial vessels travelling along fixed shipping routes, which are merely determined by a commercial design, may be assumed to be independent of the target species (De Boer, 2013). Moreover, monitored routes can be chosen among the network of operating commercial routes in order to cover different sea regions and ecological conditions. Ferries, cargoes, and other "fixed line" platforms provide the opportunity to undertake repetitive surveys along fixed transects that cross large marine areas and are conducted regularly throughout seasons and years. Being by far the cheapest way to collect long-term information on cetacean distribution, relative abundance, and behaviour (Evans and Hammond, 2004; Wall *et al*, 2006; Kiszka *et al*, 2007), these methods have been in place in the Atlantic Ocean since 1994 for the large scale monitoring and assessment of trends of cetacean populations (MacLeod *et al*, 2007), and have been experimented in the Mediterranean since the 1980s (Marini *et al*, 1996; Cotté *et al*, 2009). In the last couple of decades, they have been increasingly used to synoptically monitor marine macro fauna and its potential threats (Santoro *et al*, 2015), and are currently used for dedicated cetacean research in the North-East Atlantic (*e.g.*, Correia *et al*, 2020), North Sea (*e.g.*, Kiszka *et al*, 2007), and in the northern Mediterranean Sea (*e.g.*, Arcangeli *et al*, 2013; Aïssi *et al*, 2015; Tepsich *et al*, 2020). Using fixed line platforms of observation allows systematic research in offshore habitats to be carried out and enables long-term monitoring in specific areas of interest to investigate potential trends in patterns of occurrence and to collect temporal fine-scale information on seasonal and inter-annual changes (MacLeod *et al*, 2008). In addition to using them for measuring distribution and abundance, line-transect data are also increasingly used for habitat modelling purposes, through the collection of information on habitat preference and distribution of other marine wildlife, such as turtles, seabirds, and pinnipeds, and to provide information necessary to improve to stratified design of future dedicated line-transect surveys (Williams *et al*, 2006).

Table 1. Main benefits and limitations of "opportunistic platforms" that can be used to carry out dedicated research on cetaceans and threatened marine fauna (adapted from De Boer, 2013).

"Opportunistic" platform	Pros	Cons
Island/Oil rig - fixed platforms	Long temporal scale Limited responsive movements of animals Fine scale detection of trends, habitat-use, census of local populations	Poor spatial coverage Difficult to travel to/from Housing/accommodation needed Cannot divert track to confirm ID
Wildlife operators	Long temporal scale Fine-scale detection of trends Can divert track to confirm ID Beneficial to operator Mark-recapture estimates, distribution,	Coverage limited by season (touristic), time schedules, local legislation Effort influenced by knowledge and alerts received by others

	and habitat use	Sometimes small/unstable Irregular Speed Responsive animal movements
Seismic vessels	Long temporal scale Under-recorded areas Large, stable platforms Oceanographic data may be available Commercial sponsorship Onboard accommodation Fine-scale detection of trends; estimates of index of abundance	Poor spatial coverage Cannot divert track to confirm ID Slow speed may influence findings Influenced by vessel activities
Oceanographic/ fishery monitoring vessels	Possibility for long temporal scale Coverage of interesting ecological areas Oceanographic data available Onboard accommodation May divert track to confirm ID Large, stable platforms Relative abundance estimates available	Spatial coverage depending on the monitoring target Weather dependent Influenced by vessel activities Irregular speed Responsive animal movements, fast speed
Cruise vessels	Long temporal scale Fine scale detection of trends Possible onboard accommodation May divert track to confirm ID Commercial Sponsorship Estimates of index of abundance	Poor spatial coverage Fast speed may affect findings Seasonality Effort influenced by knowledge and alerts received by others
Ferries and cargoes	Long Temporal scale Repeated measures across years/seasons Trans-boundary spatial coverage Fine scale detection of trends Large, stable platforms, wide angle view Commercial sponsorship Onboard accommodation Estimates of index of abundance	Spatial coverage limited to fixed areas Fast speed may affect findings Cannot divert track to confirm ID Seasonal (only in some cases)

Some limitations have been pointed out to bias data collected through fixed line platforms as compared to data obtained from dedicated surveys. Indeed, the non-standardized sampling effort and the unequal area coverage (transects are dependent on the company schedules and conditions and may cross some areas at night) (Correia, 2013) could lead to biased results (Wall *et al*, 2006; Viddi *et al*, 2010); these platforms do not allow animals to be approached to collect data, such as photo-ID, behaviour, biopsies, etc; the coverage of the study area is limited as these transects only sample one fixed area (although it may be extensive in linear terms) (Kiszka *et al*, 2007; Viddi *et al*, 2010); the visual capacity of inexperienced observers may lead to unreliable species identification (Moura *et al*, 2012), especially when volunteers with no previous experience are involved. Finally, as it happens also for dedicated platforms, assuring the strict application of the protocol and adequate training of the observers can be labour intensive, and there might be a perception bias related to swell-height, wind force and visibility conditions affecting cetaceans' detection and identification (Correia, 2013). Researchers using free platforms must be prepared to be flexible, because the financial and logistical benefits come with a loss in terms of control over study design (Williams *et al*, 2006), and they must be willing to build strong and effective international collaborations among scientific and commercial partners.

On the other hand, the advantages of using fixed line monitoring platforms are numerous. In general, most of the above limitations can be overcome if multiple routes are systematically monitored on a regular basis with a standardised protocol by expert observers. Large commercial vessels are stable platforms and provide an elevated observation height with a wide field of view above the sea surface, enabling sightings to be recorded in more extreme weather conditions than smaller, dedicated research vessels (Flynn *et al*, 2019). Multidisciplinary data from these platforms can be collected through simple standardised protocols, and the cost-effectiveness and logistic aspects facilitate collaborations among different organizations. Moreover, as some of the environmental parameters (*e.g.*, physiographic variables such as depth, distance to the coast, slope) remain constant along fixed transects during replicates, the potential correlations between changes in abundance and distribution, environmental variables, such as the temperature of chlorophyll concentration, and potential anthropogenic factors are less biased (Arcangeli, 2010; Arcangeli *et al*, 2014c). Monitoring cetaceans along the main shipping routes of large cargoes and ferries can enhance the understanding of ship strikes/near miss events to mitigate the risk of collisions and accidental strikes (Arcangeli *et al*, 2014b, 2016a, David *et al*, *in press*). This approach can provide essential data for the conservation management of a wide range of marine fauna in countries bordering vast sea areas where the abundance of species is unknown, and where lack of funding makes dedicated surveys unlikely to occur (Viddi *et al*, 2010). They are valuable in bridging the gap in time-windows between large-scale systematic surveys and can also be the only source of information relative to cetaceans in under-recorded or uncovered areas, where the data obtained can be used to set baseline values and identify potential areas of interest (*i.e.*, for species richness, presence of threatened or "data deficient" species, etc), where additional dedicated surveys can be implemented (Wall *et al*, 2006; De Boer, 2013; Correia *et al*, 2020). Indeed, they allow sustainable, long-term monitoring programs that are consistent over space and time, repeatable across years and seasons, and can cover large geographic scales, including high seas areas. To a lesser extent, fixed line platforms may also be used to train observers on protocols, and scientists to use equipment before conducting dedicated surveys (Williams *et al*, 2006). Moreover, according to Brereton *et al* (2001), commercial ships that carry large numbers of passengers and are managed by international companies, might be potentially receptive to providing sponsorship; and offer potential for raising the awareness about the ecology and conservation of endangered species.

The “fixed line transect” method has been used by the Joint Nature Conservation Committee (JNCC) for the regular conservation assessments of cetaceans in the UK (Brereton *et al*, 2000) and was recommended by ACCOBAMS and the French Biodiversity Agency to be included in the Members States monitoring programmes for the second cycle MSFD 2020-2026 (ACCOBAMS & AFB recommendation, 2019).

In recent years, researchers have been working on protocols to improve the collection of long-term standardized data (Correia, 2020). Data collected by dedicated researchers following a standard monitoring protocol that defines in detail the experience needed by the observers, the effort parameters, the instruments used for measurement, and the formalities of data collection, are more reliable and allow a greater number of analyses, such as the assessment of relative abundances and the use of ecological niche modelling techniques that require presence/(pseudo)absence data (Kiszka *et al*, 2007; Moura *et al*, 2012; Correia *et al*, 2015, 2019b). The ongoing training of observers for new routes and new organizations involved in monitoring, combined with the constant validation of data and a periodic exchange of experiences among partners maintains the coherence and high quality of such data.

2.4. Regional and international monitoring projects using non-dedicated platforms

The need for repeated surveys to intercept the cryptic, vagile, and long living nature of marine migratory species, as well as the shifting of potential threats, also results in great costs for their performance, which can lead to surveys that are focused at one point in time and/or repeated infrequently. For this reason, the use of non-dedicated platforms (or platforms of opportunity) such as ferries, fishing vessels (López *et al,* 2004), cruise ships (Compton *et al,* 2007), and oceanographic research vessels is being increasingly exploited for conducting research on large vertebrates, as these platforms minimize the costs of such work and enable the collection of valuable data at a finer temporal scale and consider also areas and seasons that would otherwise be difficult to cover, such as offshore areas or winter months (Evans and Hammond, 2004; Berrow *et al*, 2012). So far, data obtained over the years by these networks studied patterns of cetacean distribution (Kiszka *et al*, 2007; Arcangeli *et al*, 2017), changes in their occurrence (MacLeod *et al*, 2009; Arcangeli *et al*, 2013c; David *et al*, 2020; Tepsich *et al*, 2020), fine-scale habitat use (Azzolin *et al*, 2020; Bouveroux *et al*, 2020), and supported the definition of biodiversity hotspots (Wall *et al*, 2006; McClellan *et al*, 2014; Matear *et al*, 2019), and the evaluation of potential risks for marine species caused by the interaction with human activities (Campana *et al*, 2018; Arcangeli *et al*, 2019b).

2.4.1. European projects and networks

Cetaceans, marine turtles, and other threatened marine fauna of European waters have been the focus of fixed line surveys for over three decades to date. Ferry surveys have been carried out in the Bay of Biscay and English Channel since the mid-1990s (Kiszka *et al*, 2007). Line transect methods have also been experimented in the Mediterranean Sea onboard ferries since the late 1980s (Marini *et al*, 1996) and in the Portuguese waters and Macaronesia archipelago onboard cargo vessels since 2012 (Correia, 2020). Several international and regional projects lay behind the organization of monitoring and data collection along these routes.

The Biscay Dolphin Research Programme (BDRP)

In 1995, The Biscay Dolphin Research Programme established a monthly, year-round seabird and cetacean monitoring programme in the western English Channel and eastern Bay of Biscay using volunteer observers onboard the cruise-ferry *Pride of Bilbao* along its route from Portsmouth, on the south coast of England, to Bilbao, in northern Spain (Brereton *et al*, 2001). The BDRP surveys provided a fine-scale picture of changes in the occurrence of common dolphins, striped dolphins, and harbour porpoises along a relatively fixed transect in the English Channel and Bay of Biscay over a period of eleven years, demonstrating the usefulness of passenger ferries as research platforms for the regular monitoring of the pattern of occurrence of these species in specific areas of interest. By using changes in occupancy as an index for changes in occurrence and abundance, these data could also provide an indication of changes in status at the end of each year and thus annual feedback to conservationists, policy makers, managers, and other stakeholders (Hall, 2006).

The Irish Whale and Dolphin Group (IWDG)

The Irish Whale and Dolphin Group has been collecting data since 1991 on the distribution and relative abundance of cetaceans in Irish waters (including Northern Ireland, Fig. 1), performing cetacean surveys on board commercial ferries since 2001, and on board the Irish Marine Institute's offshore research vessel Celtic Explorer since 2003.

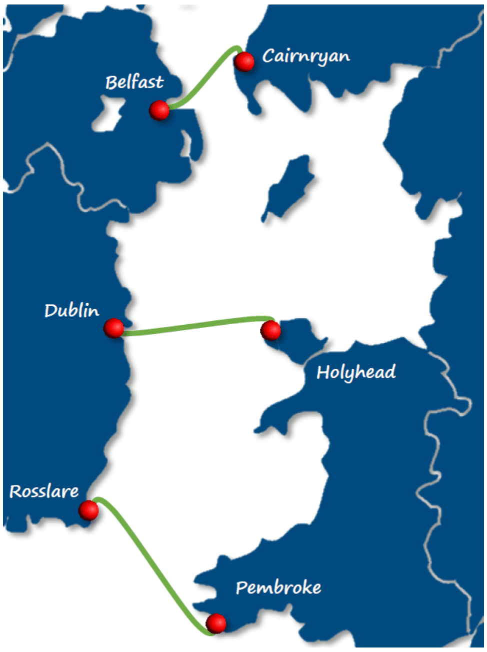


Fig. 1. The IWDG survey effort (https://iwdg.ie/ferry-surveys/)

In 2003, the IWDG initiated the ISCOPE (Irish Scheme for Cetacean Observation and Public Education) to promote better awareness and knowledge of cetaceans in Irish waters by encouraging public participation in cetacean recording. In 2008, in collaboration with the Galway-Mayo Institute of Technology, it started a three-year project aimed to provide scientific data to support conservation policy and provide guidance in implementing national and international obligations, involving the extensive surveying of offshore waters to determine the distribution and relative abundance of cetaceans (PReCAST). By conducting observations on marine species from various platforms involved in military and fisheries research activities in the Irish EEZ and adjacent waters, they successfully achieved specific monitoring goals within the EU legislative framework (O'Brien, 2004; Wall, 2013). The IWDG Ferry Surveys programme conducts line transect surveys for cetaceans on board commercial car ferries using volunteer citizen scientists; it started in 2001 with a route across the Irish Sea from Dublin to Liverpool, to which in 2002 was added the route from Dublin to Holyhead, and in 2004 that from Rosslare to Pembroke in Wales, which are still ongoing. In 2006, a survey route across the north Irish Sea from Larne to Cairnryan was also added, that was changed in 2013 to the Belfast to Cairnryan route with Stenaline, which continues to this day (https://iwdg.ie/, Fig. 1).

The Atlantic Research Coalition (ARC)

The ARC partnership was established in 2001 as a collaborative, pan-European approach to the annual monitoring of cetaceans in western European waters, with the aims of: collecting and analysing cetacean sightings data from fixed-route ferries and other similar monitoring programmes; gathering data on the diversity, distribution, and relative abundance of cetacean species in region; detecting changes in their seasonal, annual, and long-term distribution and abundance in the western European waters; and stimulating the implementation of new similar monitoring programmes in the area. At its foundation, the ARC partnership included the surveys from BDRP and IWDG, the Plymouth to Santander Marine Survey (PSMS), carrying out monthly surveys along the route from southern England to Spain since 1993 and dedicated data collection since 1996, and the Spanish Society for the Study and the Conservation of the Marine Fauna (AMBAR), carrying out surveys on another route from northern Spain to England. All partners undertake fixed-route transect surveys on commercial ferries using effort-related and standardised scientific recording methods (Brereton *et al*, 2001). Since its creation, the ARC membership grew steadily: in 2002 further regular ferry surveys from the IWDG and the University of Aberdeen (in the Sea of Hebrides and the Minch) were established; and from 2004 onward, ferry surveys carried out by several associations (Norcet, Organisation Cetacea (ORCA), Rugvin Foundation and Marinelife) were established in the North Sea (Brereton, 2011). In 2010, all regular ferry surveys for cetaceans in the UK were operated by ARC, which included 12 partners from five European countries: University of Aberdeen (Scotland), AMBAR (Spain), IWDG (Ireland), Marinelife (Biscay Dolphin Research Programme) (UK), NORCET (Scotland), Organisation Cetacea (ORCA) (UK), PSMS (England), Rugvin Foundation (Netherlands), Sea Trust (Wales), Oceanopolis (France), and the Isles of Scilly Wildlife Trust (England) (Fig. 2, Brereton *et al*, 2011).

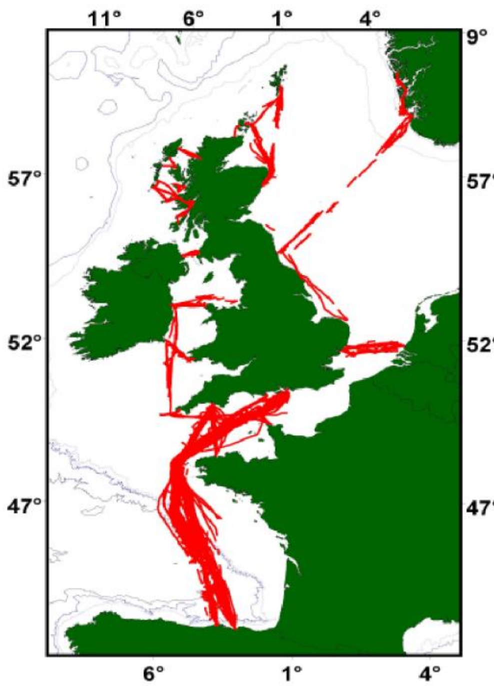


Fig. 2. The ARC survey effort in 2011 (from Brereton *et al,* 2011).

In addition to effort-related cetacean recording, a range of other data was collected by ARC, including the location and number of sharks, seabirds, and, in some instances, fishing activity. The surveys provided vital monitoring data on cetacean density and distribution in the Bay of Biscay, Irish Sea, Celtic Sea and English

Channel, and North Sea, which was relevant to regional conservation issues and to inform the identification of offshore candidate SACs for harbour porpoise and bottlenose dolphin, as required by the Habitat Directive.

The European Cetacean Monitoring Coalition (ECMC)

Developed from ARC, the European Cetacean Monitoring Coalition is a network of European organisations that collect data onboard ferries, with some of the data contributing to the Joint Cetacean Protocol (JCP), an initiative organised by the Joint Nature Conservation Committee (JNCC) to collect and analyse data on cetaceans derived from various sources around the UK. The purpose of these networks is to collate enough spatial and temporal data to gain a comprehensive insight into the occurrence of cetaceans in the studied area. The protocol used by these UK-focussed initiatives is similar to that applied in the Mediterranean Sea by the FLT MED NET.

ORCA

ORCA (https://www.orcaweb.org.uk/) is a UK whale and dolphin conservation charity dedicated to the long-term study and protection of cetacean populations and their threatened marine habitats in UK and European waters (Fig. 3). It was founded in 2001, and after the first stages within the ARC, gradually took control of the UK fixed line monitoring network and now works with governments, research institutions, and other conservation charities to identify and protect critical whale and dolphin habitats and create safer places for them, ultimately promoting the health and well-being of the wider marine ecosystem. ORCA's Marine Mammal Surveyor Teams are made of volunteer citizen scientists that conduct monthly scientific surveys across line-transects on board ferries and cruise ships. Surveys are conducted by a fully trained team of three or four volunteers from the vessel's bridge (or another forward-facing platform) using a standardised survey protocol based on the distance sampling methodology to ensure that data collection is rigorous and comparable. This method has been considered by JNCC for regular conservation assessments of cetaceans in the UK (Brereton *et al*, 2012). The citizen scientists working on ORCA-led surveys are members of the public who are interested in conservation and come from a range of backgrounds and ages, including students, working professionals, and retired senior citizens.

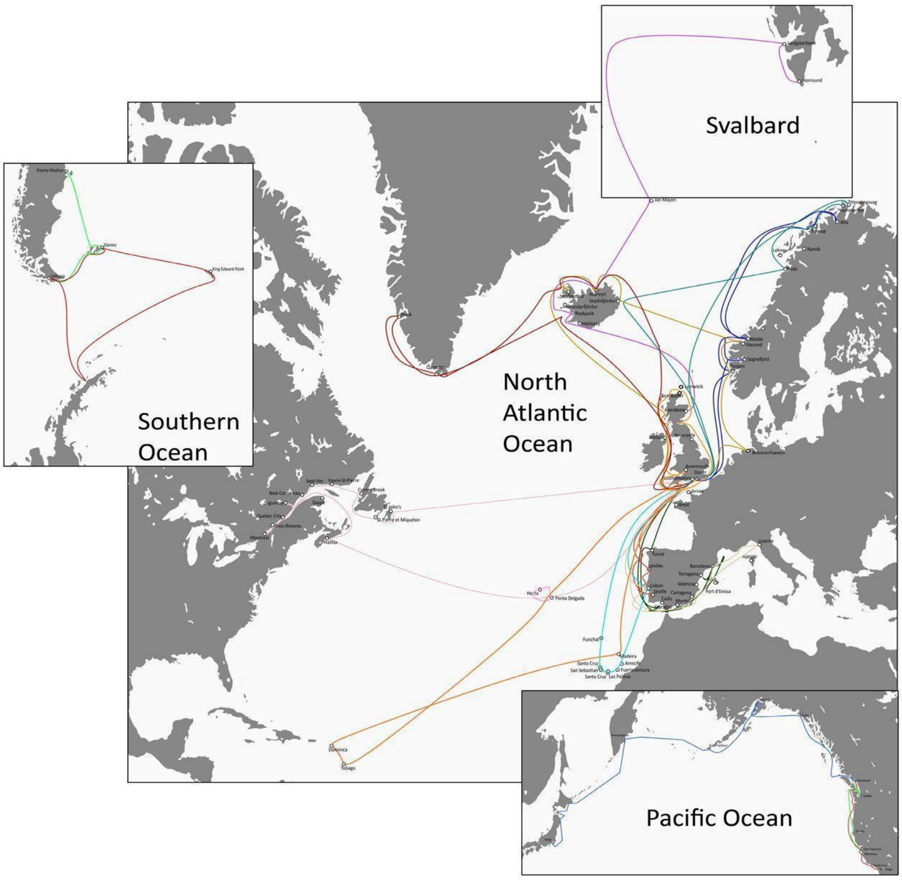


Fig. 3. The ORCA survey effort (from ORCA, 2019)

In addition to the dedicated efforts of volunteer survey members, Wildlife Officers have also been employed by ORCA to collect standardised data since 2014 from the open decks, across a network of ferries. Operating for up to nine months of the year, Wildlife Officers live on board ferries, providing educational content and expert knowledge to passengers and collecting scientific data, often every day for the entire season. This provides fine-scale temporal coverage and combines accessible marine education with conservation activities.

ORCA regularly surveys nine regions: Arctic Waters, North Sea, English Channel, Celtic Sea, Irish Sea, Minches and West Scotland, Bay of Biscay and Iberian Coast, Wider Atlantic, and the Mediterranean Sea (Fig. 3). Since 2006, ORCA has conducted 659 dedicated distance sampling surveys along 22 ferry routes in partnership with eight ferry companies. Additionally, 116 surveys following an effort-based survey methodology have been conducted in partnership with 11 cruise companies, traversing 12 different sea regions within the North Atlantic Ocean, South Atlantic Ocean, North Pacific Ocean, Arctic Ocean, Southern Ocean, and Mediterranean Sea. (Fig. 3, ORCA, 2019). ORCA's report *The State of European Cetaceans* has been published yearly since 2016 to document the results of its survey findings in order to support informed government decisions.

The Fixed Line Transect Mediterranean Monitoring Network (FLT MED NET)

The Italian Institute for Environmental Protection and Research (ISPRA) has been leading the Fixed Line Transect Mediterranean Monitoring Network since 2007. All partners involved in the Network share the same protocol to systematically survey the vertebrate marine species listed in the Habitat Directive (such as cetaceans, marine turtles, and seabirds) and their main threats (such as maritime traffic and marine litter) from ferries travelling along several trans-boundary routes in the Mediterranean Sea (Fig. 4).

The network started along the Tyrrhenian route between Civitavecchia (North to Rome) and Golfo Aranci (Sardinia) and grew with the introduction of new transects in the Central-Western Mediterranean Sea and in 2011 was included in the research program Pelagos-France as tool to monitor cetacean populations within the Pelagos Sanctuary. Currently, the FLT MED NET is extended over 12 routes in the western Mediterranean Sea and includes 16 scientific partners (ISPRA; EcoOcéan Institut, CIMA Research Foundation, University of Pisa, Gaia Research Institute, University of Torino, University of Milano Bicocca, Accademia del Leviatano, University of Tuscia, Capo Carbonara MPA, University of Palermo, University of Catania, MareCamp, University of Barcelona, Nereide association, SZN Anton Dohrn, CNR-ISMAR) from Italy, France, Spain, Tunisia, and Greece, which are involved in the data collection and analysis. The systematic surveys cross high seas and national waters among Italy, France, Spain, Greece, Tunisia, and Morocco (Fig. 4) and are undertaken with a frequency of at least five surveys per season and all year round along most of the routes.

The network benefits from the collaboration of six ferries companies (Corsica Sardinia Ferries; Grimaldi Lines; Tirrenia CIN; Minoan; CTN; GNV; Baleària; Siremar) that host trained researchers on board and allow the collection of data from the command deck (Arcangeli *et al*, 2019a).

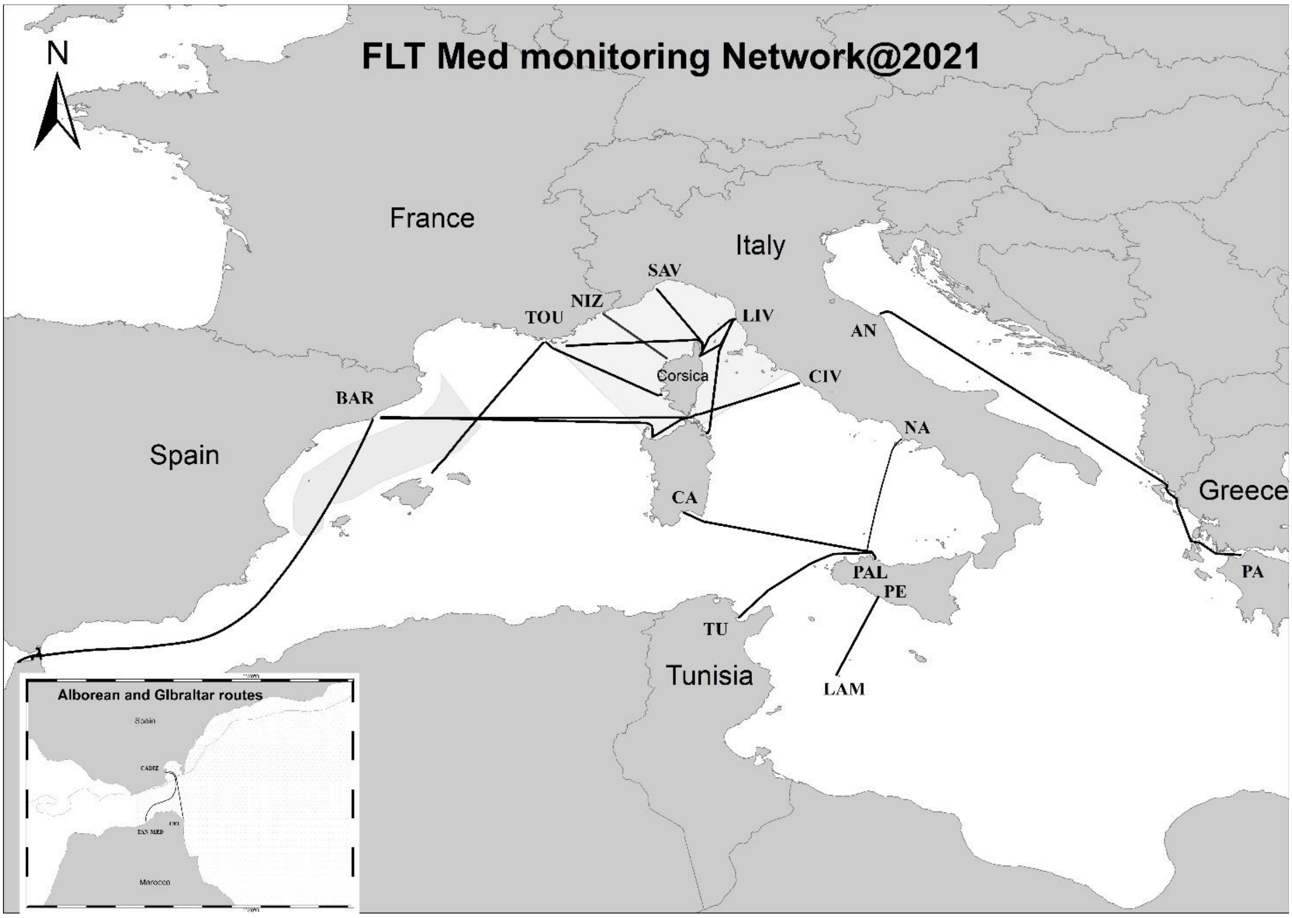


Fig. 4. The FLT MED NET survey effort in 2021.

CETUS

CETUS – the cetacean monitoring program in Macaronesia – is a monitoring program that undertakes surveys of whale and dolphin occurrence onboard cargo ships in the vast Atlantic region between Continental Portugal, the Macaronesian archipelago, and the North-West coast of Africa (Fig. 5). The project is led by the Interdisciplinary Centre for Marine and Environmental Research (CIIMAR - University of Porto) in collaboration with the Oceanic Observatory of Madeira, CIMA Research Foundation (Savona, Italy), and in partnership with the Transinsular cargo ship Company. It addresses several resolutions established by international agreements on the conservation of cetaceans identifying species' spatial and temporal patterns in distribution and areas that deserve priority for conservation efforts (Correia *et al*, 2015, 2020). Since 2012, line transect routes between Continental Portugal and Madeira, Azores, Canary and Cape Verde islands, and North-West Africa have been surveyed by volunteers trained as Marine Mammal Observers to collect data on the presence of cetacean species and other pelagic megafauna, survey effort, weather conditions and marine traffic, among other variables (Correia *et al*, 2019a, Fig. 5, Table 2). Cargo vessels allow sampling large geographical areas during extended periods of time at relatively low cost and the data obtained provide new insights into the distribution and relative abundance of cetaceans, and deliver habitat models to map, explore, and predict cetacean hotspots, in response to international and European conservation priorities and to support management decisions.

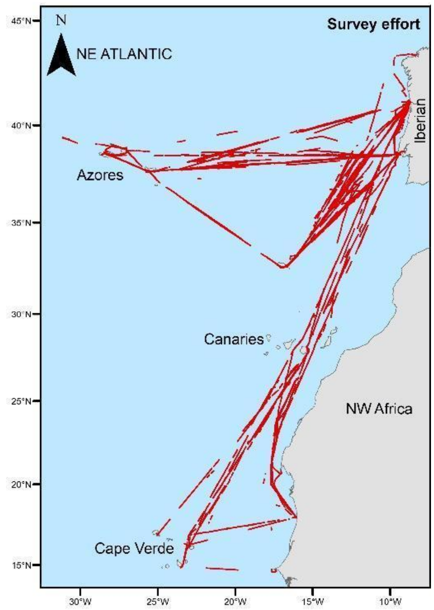


Fig. 5. The CETUS survey effort between 2012 and 2019.

Since 2016, the CETUS project has also been monitoring the ferry routes from Madeira to Porto Santo year-round with a similar protocol and approach to the cargo ships, under the coordination of the Oceanic Observatory of Madeira (OOM) in Madeira (Sambolino *et al*, 2017) - the CETUS project in Madeira. Finally, since 2017, some sporadic surveys along large-scale line-transect were also performed onboard the hydrographic vessels of the Portuguese navy, including trips from Continental Portugal to Madeira and Azores (Table 2).

This monitoring was efficient for improving knowledge about cetacean species in the Portuguese EEZ (Correia *et al*, 2015) and provided new insights into the distribution and diversity of marine mammals and other pelagic megafauna in the eastern North Atlantic, in the poorly studied high seas beyond national jurisdictions (Correia *et al*, 2019b, 2020; Valente *et al*, 2019).

The protocol used by CETUS has been developed based on that applied in the Mediterranean Sea by FLT MED NET, with some modifications to adapt for the different types of platforms used.

Table 2. Temporal coverage of the different monitoring transects performed by CETUS.

ROUTES	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cargoes									
Continental Portugal – Madeira	Jul-Oct	Jul-Oct	Aug-Oct	Jun-Oct	Jul-Oct	Sep	Jul-Oct	Aug-Sep	-
Continental Portugal – Azores	-	-	Jul-Sep	Jul-Oct	Jul-Oct	Jul-Oct	-	Jul-Oct	-
Continental Portugal – Canaries – NW Africa – Cape Verde	-	-	-	May-Oct	Feb, Aug-Dec	Jul-Sep	-	-	-
Continental Portugal – Azores – Madeira	-	-	-	-	-	Oct	Jul-Oct	Jul-Oct	-
Madeira ferry									
Madeira – Porto Santo	-	-	-	-	Jul-Dec	Feb-Dec	Feb-Dec	Feb-Dec	Jun-Jul
Hydrographic									
Continental Portugal - Azores	-	-	-	-	-	Aug	-	Jul-Aug	
Continental Portugal – Madeira – Selvagens	-	-	-	-	-	-	-	May	-

CetAvist

Financed by Fundación Biodiversidad – MAGRAMA (the Spanish Ministry of agriculture, fishing and nutrition and Biodiversity foundation), CetAvist is the network for cetacean and marine bird monitoring in the Canary Islands. It is based on the effort of trained volunteers that collect scientific data from ferries operating in the trans insular channels. Over the past years, the CetAvist network has grown both in the number of volunteers involved as well as in the number of transects monitored, leading to the creation of the web portal www.aviste.me. The portal works as a public national database where all the collected information is stored and pretends to provide a tool that could be applied in other regions to create a national database. The main objective of the project is to study the presence and distribution of cetaceans and marine birds in the Canaries, including marine protected areas (SCI and SAC), to relate them with natural and environmental variables, and provide the scientific framework to develop mitigation measures to prevent collisions with threatened species such as sperm whale (*Physeter macrocephalus*). Also, the project aims to increase the public awareness on marine biodiversity and on the scientific methods to monitor it and to promote science-society interactions (http://cetaceos.webs.ull.es/bioecomac/cetavist/).

2.4.2. Non - EU projects and other initiatives

Geological Survey of Ireland

Wall *et al* (2006) described the results obtained from a survey conducted in Ireland on board the R.V. Celtic Explorer as an ancillary project of the National Seabed Survey of the Geological Survey of Ireland (GSI). The vessel travelled at an average speed of 9 knots following track lines that were selected based on predetermined locations chosen by the GSI for multibeam surveys of the seabed. A single marine mammal observer conducted watches from the ‘crow’s nest’ 18m above sea level and recorded environmental data and sightings using Logger 2000 software (IFAW 2000). Due to the nature of the geological survey, implying a variable speed of the vessel and some stationary periods, relative abundance was calculated as the number of animals encountered per hour of survey time, rather than per unit area.

Ecosystem surveys

Another possibility for platforms of opportunity is given by the ecosystem surveys, organized to collect synoptic data on several components of ecosystem, both biological and environmental, and to study their interactions and monitor their changes; in European waters the Pélagiques Gascogne (PELGAS) is an annual integrated survey programme that studies the pelagic ecosystems of the shelf of the Bay of Biscay since the year 2000 (Certain *et al*, 2011; Authier *et al*, 2018; Doray *et al*, 2018), while the Barents Sea Ecosystem Survey is conducted annually since 2004 by joint Norwegian and Russian Institutes (Eriksen, 2015). Both programmes, originally planned for fishing stock assessments, converted into ecosystem surveys providing data on marine species biodiversity and abundance, which are essential for the assessment of the good environmental status of marine waters.

The Marine Mammal Observation Network (MMON)

Founded in St. Lawrence (Canada) in 1998, the Marine Mammal Observation Network is a non-profit organization working on the conservation and promotion of fauna that uses observers, such as park wardens, cruise and whale-watching tour companies, shipping operators, and ferries, to collect whale and seal observation data. In 2015, it teamed up with Green Marine, a voluntary environmental certification program for the North American marine industry, to develop a whale data collection and training program for domestic ship owners/operators. The pilot project has been running from 2015 to 2019, with seven companies collecting sightings of marine mammals and contributing to understanding whale distribution patterns in major shipping channels (Blier and Nolet, 2019). Although based more on opportunistic surveys than on dedicated ones, this program is interesting for the standardized training provided to ship crews to ensure the success of such a data collection project. Indeed, MMON and Green Marine developed quality training and reference tools tailored to adapt to the realities of different ship owners/operators: Onboard crew training (with the instructor onboard for a complete transit or a portion; given in the pilothouse during the different shifts of crew members); Dockside crew training (the instructor onboard the docked ship, without real time practise); Group training during annual seminars for seafaring personnel (when the personnel is gathered at annual meeting organized by the companies). During each training, operators are provided with supporting material, including presentations on the project, whale identification and the data collection method; ID sheets illustrating the species, a Mariner's Guide to Whales in the Northwest Atlantic, a data collection protocol, observation charts, identification sheets, and information on cetaceans species, key species, and those of significant importance (Blier and Nolet, 2019).

Voluntary Observing Ship (VOS) program

This NOAA (National Oceanic and Atmospheric Administration) international successful project is based on volunteer crew members on nearly 1,000 ships travelling around the world that on any given day observe the weather at their location, encode each observation in a standard format, and send the data over satellite or radio to the many national meteorological services that have a responsibility for marine weather forecasts. This data is archived for future use by climatologists and other scientists (https://www.vos.noaa.gov/). Within this project, the use of cargo ships proved to be also a very efficient way to gather data on cetaceans' occurrence.

Bay of Bengal

Smith *et al* (2008) studied the species occurrence and distributional ecology of nearshore cetaceans in the Bay of Bengal through a survey conducted from a locally available salt cargo vessel (length = 19m, width at beam = 6m), using a line-transect, effort-based methodology. The main sighting platform was standing 4.6 m above the waterline, and four trained observers were used, stationing two at the sides, and two at the centre. Throughout the survey, information on sea surface temperature, depth, salinity, turbidity, and the distance covered along the transect line were also noted.

Chilean Patagonia

Viddi *et al* (2010) examined the spatial and seasonal distribution of cetaceans in northern Chilean Patagonia using non-random surveys on commercial tourist and cargo ferries traversing the Patagonian fjords along fixed routes. Daily observations were made by two to four trained observers from the highest vantage points aboard (12 and 10m) covering a strip of 5 km looking ahead to 90º on each side. Data on effort, geographic position, weather, sea state, and cetacean sightings were collected.

U.S. West Coast

Flynn *et al* (2019) report on a pilot program putting observers on ships transiting between U.S. West Coast ports to document sightings along these routes and help quantify the threats caused by these ships to cetaceans and evaluate the feasibility of these platforms as source of sighting reports, as recommended by the JWG (the NOAA Office of Marine Sanctuaries Joint Working Group). The positive findings of the program resulted in plans to conduct further trips with observers to improve the sample size (planned for 2019–2021) with the goal of having the ship personnel conducting their own observations and reporting, after adequate training by experienced marine mammal observers.

2.5. National initiatives using fixed line data to feed legal conservation requirements

Besides the scientific objective of understanding ecosystem processes and functions, the current motivation for the development of biological monitoring programmes is often to respond to a variety of legislative drivers and provide the information required by the local or international policy. According to the requirements foreseen by regional regulations, and particularly by the MSFD, each MS within the EU must provide a detailed assessment of the state of its marine environment, state a definition of GES at a regional level, and establish clear environmental targets and monitoring programs. Most of the monitoring activities in Europe are in fact surveillance monitoring programs undertaken to address national obligations (Patricio *et al*, 2016); despite being mostly carried out by government agencies and institutes, there are a variety of activities developed from local groups' initiatives that can still provide precious information for driving conservation measures. For implementing national and European policy, it is appropriate that the integration and holistic assessment of all monitoring at a Regional Sea level is driven by committed government agencies and funded across MS; however, this is still limited to the capacities of the single country, thus resulting in methodological differences between EU Member States with long monitoring experience and others with budgetary constraints. In addition, the existence of transboundary sea areas controlled by a combination of Member States and Non-Member States still needs strong coordination efforts (Patricio *et al*, 2016;

Hammond *et al*, 2017). Some countries foresee the use of fixed line monitoring methods to perform their assessment.

United Kingdom

In the UK, large marine vertebrates and seabirds in the English Channel and southern North Sea are protected under the UK Wildlife and Countryside Act (1981), the UK Countryside and Rights of Way Act (2000), Offshore Marine Conservation Regulations (2007), the Conservation of Habitats and Species Regulations (2010), and the England Biodiversity Strategy (2012, Biodiversity Action Plan). Among other sources of information, the UK Government relies on ORCA's work to help meet its obligations under the EU Habitats Directive. ORCA's work is guiding cetacean conservation policy across the European Union enabling the development of marine protected areas around the coastline that provide sanctuary for whales and dolphins.

Ireland

With the Whale Fisheries Act (1937), Ireland totally banned the hunting of all cetacean species within the fisheries limits of the State, and in 1991 it declared its waters a whale and dolphin sanctuary, the first European sanctuary within the fishery limits of an entire country. The Wildlife Act (1976) is the principal Irish legislation providing for the protection of wildlife and the control of some activities that may adversely affect wildlife. Ireland also implemented the first National Biodiversity Plan in 2002, with the third now launched for the period 2017-2021. As in other EU countries, the protection of cetaceans in Ireland is regulated by the Bern Convention on the Conservation of European Wildlife and Natural Habitats (1979), the EU Habitats Directive, which was transposed into Irish law with the EC Regulations (94/1997) and Amendment (378/2005), the EU By-catch Resolution (814/2004), the Marine Strategy Framework Directive, the Northern Ireland Biodiversity Strategy, and the National Biodiversity Plan. Ireland is also part of the CMS, the OSPAR Convention, CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora), which forbids the trade of cetacean species or their products beyond international borders, and the IWC since 1985. Among other requirements, these legislative instruments oblige Ireland to designate SACs for harbour porpoise and bottlenose dolphin (O'Brien *et al*, 2009). Cetaceans were recorded on platforms of opportunity in the seas around Ireland between 1994 and 1997 as part of surveys conducted by the JNCC Seabirds at Sea Team (SAST). Since 2001, as part of the ARC, IWDG carried out further surveys onboard ferries crossing the Irish and Celtic Seas, which provided space for researchers for many years and resulted in a better understanding of the distribution of cetaceans along these routes (Brereton *et al*, 2001). The two state research vessels RV Celtic Explorer and RV Celtic Voyager have also been used for cetacean research (Wall *et al*, 2006). Moreover, under the United Nations Convention on The Law of the Sea (UNCLOS), foreign research vessels working in Irish waters should be required to record and submit cetacean sightings as part of their cruise reports. The objective of the IDWG cetacean sighting scheme is "to determine the distribution and relative abundance of cetaceans around the Irish coast and within the Irish EEZ including seasonal and geographical distribution, and to identify critical habitats and potential threats". Data obtained through cetacean sighting schemes have been recognized as a Marine Environmental Impact Indicator and "an important tool for describing trends in cetacean numbers and distribution" (Berrow *et al*, 2010).

Denmark

A cetacean sighting scheme (Projekt Marsvin) run by Carl Kinze from the Zoological Museum, University of Copenhagen, in association with Danish Animal Welfare Society and WWF Denmark was first established in 1983, making use of Danish ferry lines (Evans, 2011). It persisted until 1990, after which there was a gap before a new project (Fokus på Hvaler) started in 2000.

Germany

In the late 1980s, FTZ (the Research and Technology Centre in Kiel) initiated a sighting scheme to collect incidental records from platforms of opportunity such as yachts, customs vessels, coastguard vessels, and passengers aboard ferries. Most of these were harbour porpoises, whose records for the period 1990-2002 were used to review the national status of the species (Siebert *et al*, 2006).

France

From 1976 onwards, the National Natural History Museum (MNHN) in Biarritz, working with the Centre de la Mer Côte Basque (CMCB), has been monitoring seabird and cetacean relative abundance and distribution in coastal waters of the Bay of Biscay from ships of the French customs used as platforms of opportunity, following a line transect procedure. Since 2011, the French Ministry of Environment has been regularly supporting the collection of data from the French partners of FLT MED NET. In 2019, it fully recognised the data collected from ferries regarding cetaceans, sea turtles, and marine litter in the Mediterranean Sea as an official means used within the framework of the MSFD, as recommended in the French final report of the first MSFD cycle (Spitz *et al*, 2017; Simian and Artero, 2018).

Italy

While they are not yet used to provide information on marine species to feed the legislative network, data from the FLT MED NET have been used in Italy for the assessment of D10 (marine litter) of the MSFD. The information on floating marine litter described in the 2018 MSFD Italian assessment is indeed derived by monitoring campaigns carried out within six transects in the Western Mediterranean, Ionian, and Adriatic Seas, under the joint effort of FLT MED NET and the MEDSEALITTER project. Several partners from Italy, France, Spain, Greece, and Tunisia were involved in monitoring, which was performed according to the EU guidelines on Monitoring Marine Litter in European Seas and the relative master list of litter categories (Magaletti and Tunesi, 2018; MSFD TSG ML, 2013).

Spain

In Spain, cetaceans are listed in Annex II and V of the Royal Decree 42/2007 of Natural and Biodiversity Heritage, which sets the Mobile Space of Cetaceans Protection, codes of conduct, and navigation that must be adopted in all Spanish waters. In 2019, the Spanish Government declared a SPAMI covering 46,386 km^2 between the Catalan and Valencian coast and the Balearic archipelago. The area is of high ecological value, also as a migration corridor for fin whales towards their breeding and feeding areas in the north of the Mediterranean. It is currently surveyed by one of the ferry lines involved in the FLT MED NET, travelling between Barcelona and Tangier (Morocco), although the data obtained are not yet used for the species and threat assessment within national regulations. Large commercial vessels (ferries) have also been used in Spain for seabirds and Marine Mammal monitoring around the Balearic archipelago.

Malta

In Maltese waters, within the Environment Protection Act, the Marine Mammals Protection Regulations (Legal Notice 203 of 2003) provide protection to the 19 species of cetaceans as listed in Annex I of ACCOBAMS. The use of ferries connecting the island to other countries has been evaluated for the monitoring of large vertebrates.

3. Methods for data collection: monitoring protocols

3.1.Scope of monitoring

The main questions addressed by wildlife biologists and conservationists when studying animal populations can be summarized as: How many are they? Where are they? Are they disturbed? What do they need? (Williams, 2003). Monitoring is the most effective way to collect relevant data to answer these questions and assess the status and spatio-temporal trends of populations to assure that threat mitigation and conservation measures are efficient (Evans *et al*, 2012). Indeed, the policy framework on marine conservation and the ecosystem-based management approach require information at the community ecology level, including high-resolution species distribution data and information on spatial and temporal variations in species abundance, which combined with information on population structure and direct (*e.g.*, by-catch, entanglement, collisions) and indirect (*e.g.*, pollution and disturbance) anthropogenic impacts, are essential for determining both whether management actions are necessary and effective (Evans and Hammond, 2004).

The definition of the questions to be addressed by a monitoring plan is fundamental for its design: to investigate distribution and habitat use, changes in abundance, changes in life history parameters, or a combination of the above may require the use of a given platform and monitoring approach. However, the difficulty in obtaining such information and the logistical and financial constraints often limit the opportunities for researchers to design adequately tailored monitoring plans and, more often than not, the available sampling design defines the analysis that will be undertaken.

Fixed line surveys from commercial ships allow a systematic and unbiased sampling design, fulfilling the main requirements for the effectiveness of a monitoring plan: representativeness, reproducibility, and repeatability over time (Cominelli *et al*, 2016). These surveys can provide large data sets of fine-scale data covering long-term periods and may be the first step for assessing the geographical and temporal distribution of species in areas that are not typically included in sampling designs (MacLeod *et al*, 2009), where major knowledge gaps have been identified (Mannocci *et al*, 2018), and would help identify areas of high density, which could be further studied in detail through refined survey methodologies (Evans and Hammons, 2004). Identifying areas and times of concentration of the species of special significance for some of their life cycle stages, such as calving or mating or of overlap between their distribution and human activity, is also relevant for focusing management and conservation measures (Evans and Hammond, 2004). Data collected from commercial vessels is also increasingly used to assess relative abundances, as well as to conduct ecological niche modelling (Correia *et al*, 2015; Kiszka *et al*, 2007; Correia *et al*, 2019b).

Line-transect surveys to determine species abundance are conventionally designed in a way that all points in the study area have equal probability of being sampled (Buckland *et al*, 2001). Conversely, the coverage of fixed line surveys from commercial vessels is non-random, strictly limited, and heterogeneous, and while the narrow region covered by the ship's course has a certain coverage probability, the coverage probability everywhere else is zero (Williams *et al*, 2006). However, effort-based data collected with this method would allow surveying several habitat types (shelf, shelf edge, and oceanic ecosystems) and investigating distribution in relation to different habitats and different depths (Kiszka *et al*, 2007). Using spatial models, the animal density along the transect line can be described as a function of the spatial or environmental covariates, which can then be used to predict density throughout the study area. Moreover, it has been recognized that to monitor changes in population size for conservation purposes, absolute population size is not always required, and occupancy data obtained from non-randomized line transects can also provide a suitable index to assess trends in cetacean populations (MacLeod *et al*, 2009).

Indeed, Marine Spatial Planning (MSP) requires information on the spatial extension of species distribution and their hot-spots (*e.g.*, seasonal distribution) and of the temporal and spatial distribution of possible stressors (*e.g.*, fisheries, marine traffic, etc) (Pennino *et al*, 2017). Spatial and temporal analyses are of particular importance when establishing protection mechanisms for migratory and mobile species, such as interconnected MPAs or IMMA (Important Marine Mammal Areas) sites. IMMAs, in particular, have been introduced to better support the specific needs of highly mobile marine megafauna, including cetaceans, and were identified as biodiverse areas of high conservation importance (IUCN-MMPATF, 2016). Information on species distribution and trends can be ultimately used as an early warning system about potential changes in the marine environment and to inform the marine spatial planning of human activities (Robbins *et al*, 2020) and to promote the sustainable use of natural resources and mitigate adverse anthropogenic impacts (Matear *et al*, 2019).

3.2.Spatial and temporal scales of monitoring

In its simplest form, the assessment of a change in a population involves comparing two or more estimates made at different times or locations. Indeed, a larger series of estimates allows fitting a curve to assess the rate/extension of such change, provided the estimates used are relevant and comparable (Evans and Hammond, 2004). However, the definition of a trend as "a long-term change in mean level", is intrinsically subjective, as many issues inherent in trend estimation can cause undesired results (Thomas, 2009). On relatively short time periods, the initial assessment of the state of a population would have a strong influence on any trend; also, sudden population declines would be harder to spot from longer-term monitoring (Thomas, 2009). The length of the series and the precision of the estimates would also influence whether any estimated population change is statistically significant at a given probability, and variations in environmental conditions could also affect estimates (Evans and Hammond, 2004). Thus, to design monitoring programmes that allow the detection of spatial and temporal variations, it is necessary to consider both their temporal and spatial scale of application, as well as the minimum sampling effort necessary to obtain a representative sample (*i.e*., the sampling frequency).

The selection of an adequate monitoring scale is dependent on the question that needs to be answered and the magnitude of variation that needs to be detected: the extent of the investigated process determines the temporal/spatial scale of the monitoring plan. Robust and large-scale surveys provide a snapshot of species occurrence, while infrequent or intermittent sampling can result in low temporal data representativity, limiting the understanding of the causes and impacts of environmental pressures. High-resolution data across a range of spatio-temporal scales can be used to help identify areas of biological importance and temporal changes in species abundance, increasing the likelihood of detecting environmental changes (Matear *et al*, 2019).

When designing a monitoring plan, all the possible sources of variability should be listed and discussed (*e.g*., proximity to cities, seasons, coastal gradients, etc) beforehand, and either excluded or compensated by an adequate sampling design. However, fixed-line monitoring from commercial vessels follows routes that are established opportunistically, and thus the spatial coverage of regions, species, and habitats is biased. Indeed, these studies have limitations related to effort heterogeneity, both in terms of the temporal and spatial resolution of data collection (Correia *et al*, 2015; 2019b). Indeed, temporal changes in density in fixed areas covered by commercial vessels need to be considered conservatively, especially as small-scale movements away from or into the survey area could influence these estimates considerably (Robbins *et al*, 2020), and scales can highly influence model results and application (Correia, 2020).

According to the Habitat Directive, one of the criteria for determining the favourable conservation status of a species is that its natural range is neither being reduced nor is likely to be reduced in the foreseeable future. For highly mobile and migratory species, the quantification of their range may be defined only in terms of probability of presence or in terms of density and should include a seasonal component. Data from fixed-line surveys may be used to produce estimates of range and its changes over time through spatio-temporal modelling (Thomas, 2009). However, to do so, the extent to which marine habitats are representatively sampled and the likelihood that all the habitats in a region are sampled and all species are recorded, must be assessed. MacLeod (2010) provided an approach to the assessment of habitat representativeness through the use of a habitat representativeness score (HRS), designed to help determine whether survey coverage is sufficiently representative of available habitat combinations. This index would allow the assessment of whether the distribution of individual species have been adequately sampled and aid in the identification of new routes to specifically fill in any gaps in survey coverage on a habitat representativeness basis.

Power analysis has also become a standard tool in assessing the potential utility of monitoring programs by addressing questions relative to the survey effort needed to attain a certain power to detect a given trend in (relative) abundance over a defined period, the likely level of change which can be detected for a species in a specific region and season, and the ability to detect trends in species with different levels of occurrence and from data sets collected over different time periods (Thomas, 2009; Brereton *et al*, 2011).

Results of power analyses conducted by Brereton *et al* (2011) suggest that the power to detect trends varies between species and regions and that six surveys per season over ten years may be sufficient to detect a 0.2 annual change in observed abundance for cetaceans, as it is unlikely that similar trends could be detected with acceptable certainty over shorter time periods or with lower numbers of repeated samples within a given period. Results from Thomas (2009) also confirmed that small population trends, such as 1% per year, are difficult to detect in the 6-year reporting period imposed by the EC Habitats Directive, while trends in the order of 15-30% per year may instead be detectable over shorter periods. Smaller per-year trends require a longer time span to detect, while trends with much greater rates of change can be detected with fewer repeat samples and fewer years of data.

However, given the extremely variable distribution of cetaceans, not only determined by static topographic variables but also by dynamic ones such as tides, time of day, and season, as well as by interactions between individuals, the power to detect regional trends may be influenced by the variability of these factors among surveys. It has been suggested that levels of variations below this inherent variability within and between individual transects may be unachievable, even with massive increases in sampling effort (Brereton *et al*, 2011). Therefore, increasing the survey effort above a certain threshold would not provide any substantial reduction in the variability of results, and the threshold to achieve the most accurate estimates within a region has been identified to be around six surveys per sampling period (*e.g.*, year or season), spread as evenly as possible throughout it.

Indeed, most of the monitoring networks considered in the report carry out fixed-line transects with a frequency of at least one return crossing per month over the whole available period scheduled by vessels, with intensified frequency, when possible, during summer months (*e.g*., Arcangeli *et al*, 2014a,c).

3.3. Observation parameters

Even when standardized methods for monitoring are applied, the reliability of sighting data is often challenged by the difficulties of detecting animals, especially at sea (Robbins *et al*, 2020). Marine mammals and marine turtles spend only a fraction of their time at the surface, where they can be identified by the observer, and are less likely to be recorded at increasing distances from the observer, with this probability likely to decrease in worsening conditions (Buckland *et al*, 2001).

However, while the main assumption for assessing temporal and spatial trends in species distribution and relative abundance is that the detectability of the species does not change through time and space (Arcangeli, 2016), the probability of species detection from any survey platform depends on several factors. These can be classified into operational, which are mainly related to the technique (*e.g*., data collection procedure, observers experience) and platform used for monitoring (*i.e*., its height and speed); environmental, which are dependent on weather and visibility conditions; and parameters related to the target species (*e.g*, size, diving time, behaviour, etc) (Cominelli *et al*, 2016). When monitoring from a commercial survey, vessel speed, observer's position, and operating meteorological conditions cannot be adapted to meet research needs. Heterogeneity in such factors can easily lead to biased results, and thus should be recorded either in association with sightings or with the survey effort (Evans and Hammond, 2004), and then be accounted for with a dedicated post-processing of data (Cominelli *et al*, 2016). Consequently, when using sighting data to detect changes in animal abundance, it is essential to take the effect of these covariates into account for the estimations and implement corrections to compensate for the introduced variability.

The following sub-chapters provide a detailed overview of each of these parameters, as they are addressed by the fixed line monitoring networks currently in place in European waters as well as by previous experiences as detailed in scientific literature. A summary of the possible sources of bias and possible solutions proposed by the FLT MED NET is outlined in Table 3. The consideration of each of these monitoring covariates within the implementation of a monitoring protocol would guarantee a consistent and harmonized data collection.

Table 3. List of possible sources of biases affecting detectability and possible solutions identified within the FLT MED NET (Adapted from Arcangeli, 2016)

Possible source of bias	Possible solution
Operational factors	

Type of platform, speed, height	similar types of ferries are used, avoiding fast ferries, taking into account the type of platform in the analyses
Experience of observers	only experienced and trained observers are used in the programme
Observation distance	an estimate of effective strip width is undertaken for a single species/type of ferry
Distance estimation	Preliminary training is performed by the observers to estimate distance; specific tools are used to MEASURE the distance.
Typing and transcription errors	Use of dedicated application; validation by an independent expert after data collection
Environmental factors	
Meteorological conditions	"positive" effort only under Beaufort scale ≤3 (up to 4 for fin whale; ≤2 for *Ziphius cavirostris*)
Target species-related factors	
Species, group identification, count of animals	only experienced observers are used in the program and photos are taken to confirm species identification and group size
Responsive movement of species	Limited by the range of speed of the vessels and the angle of observation

3.3.1. Monitoring platform (height, speed, observer position and angle of observation)

Although the monitoring platforms considered in this report are mainly large commercial vessels, such as cargoes and ferries, these platforms can still markedly vary in their height and speed, as well in the possible locations available for the observers and thus the angle of view. Any possible bias derived by the variable speed, height, and observer position could be avoided if only data obtained from the same platform or group of platforms with similar characteristics are compared, but results may be affected if any comparison is made between different platform types (Evans and Hammond, 2004).

Several authors analysed the influence of vessel characteristics, including cruise speed and deck height, on the probability of detection and the recorded sighting distances. Within the FLT MED NET, Arcangeli *et al* (2012, 2014b) and Cominelli *et al* (2016) considered data collected from different ferries of heights ranging 12-15 m, 20-22, and over 25m, and concluded that the height of observation was the main, if not the only, structural factor influencing the sighting distance (effective strip width), with variable significance according to the observed species. On the contrary, no significant changes were detected in sighting rates if the range of speed was within 17 and 27 knots. Therefore, in several studies, the deck's height is used to categorize ferries into different classes and estimate a truncation distance at which it is possible to sight animals from all different classes (*e.g*, Cominelli *et al*, 2016; Morgado *et al*, 2017; Tepsich *et al*, 2020). Indeed, Cominelli *et al* (2016) classified ferries in two categories (12–15m and 20-22 above sea level, respectively), and Morgado *et al* (2017) calculated the maximum detection distances corresponding to observer heights of 15, 20, and 22. As these were 5700, 7500, and 8000m, respectively, all sightings registered above the maximum detectability distance measured from the smaller ferries (≃5000m) were not considered in their analyses. Similarly, Tepsich *et al* (2020) categorized ferries into three types according to the height of the command deck (12-15; 20-22; 25-29m) and average speed (17.3; 23.1; 22.3 knots).

Where the observation conditions can be controlled, most surveys focus on a survey area located 180º ahead of the vessel, excluding sightings made outside this range. However, on large ferries and cargoes, this is often not possible, and independent observers may be forced to watch over two separate areas of 90º, from the bow to port or starboard side (Evans and Hammond, 2004), or smaller angles from the bow to port and starboard (*e.g.*, 60º, Flynn *et al*, 2019). Moreover, in some cases where only one observer is available to perform monitoring, watches are conducted covering a visual angle of 90º ahead the ship and centred on its track to ensure that all animals directly on the track line are spotted as much as possible (Cotté *et al*, 2009);

in these cases, sightings located up to 90º to port and starboard are only occasionally included (*e.g.*, Wall *et al*, 2006).

Data are generally collected from the highest accessible point (Williams *et al*, 2006), which may vary according to the type of the vessel and its structural characteristics. Indeed, when available, the "monkey island", the deck over the ship's bridge, would be the position with the best visual range (*e.g.*, 37m above sea level in Kiszka *et al,* 2007); however, most commercial vessels only allow observers in the command deck, whose height may be also substantially lower according to the vessel type and size (*e.g.*, 10-12m in Viddi *et al,* 2010).

Observations are typically carried out during all daylight hours and are performed either by the naked eye or with the aid of binoculars, or, most often, with a combination of both, generally relying on the naked eye for detecting a sighting and on binoculars to confirm it. The binoculars used are often fitted with a compass and a reticular scale, and have a magnifying of 7x50 (*e.g.*, Kiszka *et al*, 2007; Viddi *et al*, 2010; Flynn *et al*, 2019; Robbins *et al*, 2020) or similar (*e.g.*, 10x50 (Wall *et al*, 2006); 8×42 (Arcangeli *et al*, 2016c).

Within the BDRP, surveys were conducted by a team of three experienced observers (at least two on duty at the same time) from the bridge of ferries travelling at 15-20 knots with an approximate height of 30 m above sea level (Table 4); and were covering the 180º arc ahead of the vessel (Brereton *et al*, 2001).

Within the ARC, commercial ferries travelling at a speed between 15-33 knots, but mostly 15-20 knots, and with a high observation point (15-37m, mean 23m) were used (Table 4). Recordings were made by a team of two to three experienced observers positioned in or above the bridge and scanning the area from 22.5 degrees ahead of the beam on either side, ensuring that near sightings were not missed (Brereton *et al*, 2011).

Within ORCA, different ferries are employed and thus their speed and height may vary, but on average they travel at 20 knots and are 20m in height (Matear *et al*, 2019, Table 4). Observations are conducted from the bridge by a survey team of four members, with two observers, one recorder, and one on rest. The two observers scan 180º ahead of the ship, with the starboard observer monitoring the area from 90º starboard to 10º port, and the port observer searching from 90º port to 10º starboard. Observations are mainly made using 7x50 Opticron binoculars (Robbins *et al*, 2020).

Ferries from several companies are also used within the FLT MED NET. Although the protocol foresees the use of a limited range of ferry types, avoiding for example fast ferries or cruise ships, the range of speeds and heights from the command deck of the platforms used are variable, ranging from 14 to 29 knots and from 12 up to 29m, respectively (Tepsich *et al*, 2020, Table 4). Two to four observers are employed, with at least one of them positioned at each side of the lateral wings of the ferry command deck and monitoring the area included within the 270º in front of the vessel (approximately 130º from the bow towards each side of the ship), with a focus on the 90º/130º arc ahead of the ship and continuously scanning the area by naked eye with occasional binocular scans (Arcangeli *et al*, 2013c; 2016b,c).

Most surveys conducted within the CETUS program use cargoes as monitoring platforms, which are typically over 120-130m long and 20m wide, travel at a varying cruise speed from 11 to 16 knots and have a variable height according to their load. The two observers generally stand each at one side of the vessel in the wings of the navigation bridge, at a height ranging between 13.5 and 16m above sea level, considering the maximum draught, and depending on the ship (Correia *et al*, 2019a, Table 4). When weather conditions are unsuitable, the monitoring is carried out from inside the navigation bridge. The field of view of the observers is approximately 180º in front of the vessel, centred on the ship heading, with each MMO covering 90º at each side (Correia *et al*, 2019a). During resting periods, the observer standing on the observation deck would cover the 180º. Monitoring is performed mainly by naked eye and binoculars (Paralux Nemo deep Sea 7x50 mm, fitted with a scale and compass) were used for occasional scans approximately every 5 minutes, and to support data collection (*e.g.*, to detect vessels and identify species; Correia *et al*, 2019a).

Table 4. Main characteristics (type, height, speed) of the platforms used by the monitoring networks considered within this report.

Network/programme	BDRP	ARC	ORCA	FLT MED NET	CETUS
Platform type	Ferry	Ferry	Ferry	Ferry	Cargo

Platform height (range or mean)	30 m	15-37 m (mean 23 m)	20 m	12-29 m	13.5-16 m
Platform speed (range or mean)	15-20 kn	15-33 kn	20 kn	14-29 kn	11-16 kn

3.3.2. Fixed Strip Transects vs Distance Sampling techniques

Two main observation methods can be applied during visual monitoring: the fixed-width strip transect method, which assumes that all targets are detected within a predefined distance from the observer (Fig. 6); and the distance sampling method, which involves the estimation of the distance to each target to compensate for the decreasing detection probability with the increasing distance to the item. The principal difference between the two approaches is that, while in the first the width strip is defined *a priori* and set constant within the survey, assuming homogeneous detection rate of 100% within the strip (i.e., nothing is missed within the strip), and in distance-sampling methods the width of the strip effectively searched (*i.e.*, the effective strip width, ESW) is estimated *a posteriori*, by fitting a detection function to the measures of perpendicular distances, as the detection probability decreases with increasing distance from the transect line (Buckland *et al*, 2001).

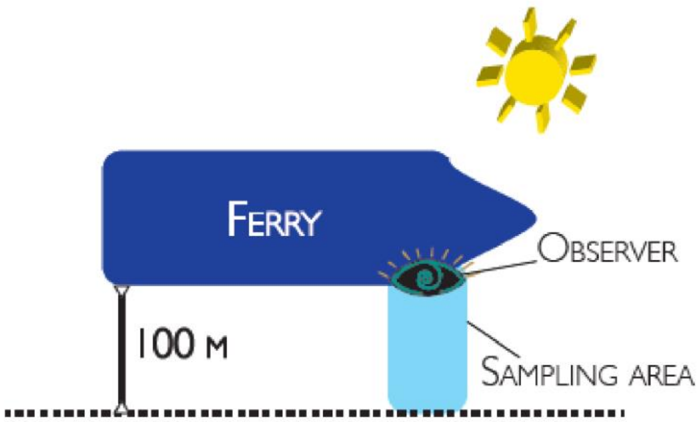


Fig. 6. Schematic overview of a fixed-strip width monitoring approach (from Maffucci *et al*, 2015)

While relatively simple to apply, the fixed strip width method only involves the measurement of one distance at the beginning of the survey and is well suitable for targets that are not visible at large distances, either because of their size or their less active behaviour at the surface, but this is less indicated for cetaceans, given they are highly mobile species that, except from some dolphin species, have little probability of being spotted at a small distance from large commercial vessels.

Indeed, to take the differences in marine turtle detectability with respect to cetacean species into account, a specific protocol for monitoring marine turtles was developed within the FLT MED NET based on the fixed strip width method. It was tested along several routes and is currently implemented within the network. The method involves the use of a dedicated observer, positioned on the side of the ferry bridge deck with the best visibility (Fig. 6), who scans with naked eye a 100 m wide strip and records all turtles encountered within it. Individuals sighted outside the monitoring strip are noted, along with the angle and distance of detection, but they are used only for presence data and not to estimate abundance. Due to constraints in manpower allocation, systematic surveys of marine turtles are performed in association with marine litter monitoring, and information on the estimated turtle size, turtle behaviour, and overlap with litter are collected (Maffucci *et al*, 2015).

On the other hand, the distance sampling method involves the calculation of the sighting angle and distance from each animal spotted and is considered effective for estimating the density and abundance of cetaceans at sea (De Boer, 2013). To ensure that the density estimates obtained with this method are unbiased, four main conditions must be met: all animals or groups on the transect line are detected; animals or groups are distributed uniformly throughout the survey region; no animal movement occurs prior to detection; and distances and angles are measured accurately (Buckland *et al*, 2001). Further practical assumptions require that the animal species is correctly identified and that, if animals are detected in schools, their size can be measured or estimated accurately (Evans and Hammond, 2004). Whereas a randomized study sample would give all areas an equal probability of being sampled and prevent a strong violation of the second assumption that fixed line monitoring from commercial vessels fails to provide equal coverage probability. Moreover, while random movement with respect to the survey platform causes a relatively small bias in abundance estimates if the survey platform travels quickly relative to the animals (*i.e.*, 10 knots is considered the minimum speed to prevent this bias; Evans and Hammond, 2004), movements in response to the survey vessel can be more of a problem and cause a large bias (Williams, 2003). Care needs to be taken to minimize the chance of violating these assumptions. The better solution to avoid accounting for animal responsive movements is to search sufficiently far ahead of the vessel that animals do not respond before they are detected (Evans and Hammond, 2004). Moreover, to cope with the violation of equal coverage probability, data obtained from non-randomized fixed line surveys can be used for model-based abundance estimations that describe the animal density along the transect line as a function of spatial or environmental covariates. This relationship is then used to predict animal density throughout the study area and results can be expanded to spatio-temporal modelling to detect seasonal or annual trends in abundance and distribution. In this way, a non-randomised survey with reasonable coverage would allow the collection of reliable distance-sampling data, provided that all potentially confounding factors are assessed, such as the height of a platform, the response to the survey ship, observer effort (observer experience, length and width of survey strips, etc), and sighting conditions (Williams, 2003).

Indeed, within the FLT MED NET, it was highlighted that different characteristics of the ferries (*i.e.*, the height of the observation point), could determine different ESW, but also the ability of the observers to detect cetaceans at a large distance, and the species detectability had an effect on the ESW size. To take these possible effects into account, the estimation of the effective width that would ensure a 100% probability of sightings within the strip can be undertaken separately for a single species and/or type of ferry (Tepsich *et al*, 2020).

Other programs (*e.g.*, ARC, Brereton *et al*, 2011) instead use a combination of methods with some partners carrying out distance sampling and measuring radial distance and angle to each sighting, and others recording sightings in a defined strip of variable width (500-2000m) depending on the survey route. However, determining which sightings fall within this transect strip can be problematic without measuring distances to the actual sightings, and the data from these surveys may be biased (Brereton *et al*, 2011).

Several potential issues with the use of the distance sampling method were also highlighted within the CETUS program. Being the program based on the use of merchant ships as monitoring platforms, the height of the observation, even from the same vessel, is highly variable as it depends on its draught. Moreover, the binocular's compass is often influenced by the ship iron, giving some errors in the estimate of the angle of observation (although it can and it is being corrected with the route of the ship as recorded by the GPS), and when several containers are transported, they block the observers' view in front of the ship. Though it rarely happens, when a lot of containers are piled up, the front line of the monitored area is difficult to sample, and some animals may be missed. For these reasons, it is not appropriate to perform techniques such as distance sampling with these types of platforms (Correia, 2013).

3.3.3. Distance and angle estimate

Measuring the distance to free-ranging and fast swimming animals from a moving platform is not easy, as methods for measuring distance typically require a stationary platform (*e.g.*, when using theodolites from land) or a stationary target (*e.g.*, when using laser rangefinders) (Williams, 2003). Although considerable efforts have been dedicated to assuring the collection of unbiased distance measures in the field, measuring distance from ship surveys still is an issue. To avoid a systematic bias that may also vary across individuals, observers must be extensively trained to provide visual estimates of range tend (*e.g.*, using fixed points at a known distance to calculate the personal error involved with the measuring method used, Arcangeli, 2016). Alternatively, binoculars marked with reticles can be used to measure distance. The development of photogrammetric methods for measuring range has also reduced errors in distance estimation (Williams, 2003); however, the implementation of this method from large commercial vessels is often not feasible, given the short duration of sightings and the large distance of animals.

Thus, during fixed line surveys from large ferries and cargo vessels ranges of radial distances are either estimated visually (*e.g.*, Williams *et al*, 2006), or with the aid of measuring sticks and reticle binoculars (*e.g.*, Wall *et al*, 2006; Flynn *et al*, 2019). Both methods involve first measuring the vertical angle to the animals through a reticular scale (either the horizontal equally spaced marks inscribed in the binocular lens or the marks on the measuring sticks), by placing the uppermost line of the reticle, or the edge of the stick on the horizon and counting down to the sighted animals. Using trigonometry, this angle is then used along with the estimated observation height to calculate the approximate distance to the animals (Correia *et al*, 2019a). The bearings to sightings are often measured through angle boards, which are often already mounted on the deck of the ships and are not deviated by the iron of the ship as is possible with binocular compasses (*e.g.*, Wall *et al*, 2006; Williams *et al*, 2006).

Observers involved in the ORCA network either assess distances through reticle readings or estimate them by eye; however, these are only included in analyses when closer than 250 m, due the increasing difficulty of estimating distance at sea (Robbins *et al*, 2020).

Within the FLT MED NET, data on radial distance are measured using either a rangefinder stick or a binocular with reticle rangefinder, and the angle between cetacean sighting and ferry course is measured using a compass or a protractor, set with the 0 coinciding with the bow of the ferry (Arcangeli *et al*, 2008, 2013c; Tepsich *et al*, 2020).

Lastly, within the CETUS surveys, the angle to the sighting is measured with the binoculars' compass and then is used to calculate the horizontal angle in degrees between the ship's route and the animal or group of animals. As the binoculars' compasses can be unreliable on platforms containing ferrous metals, they are also used to measure the vessel heading whenever an animal is sighted. Then, during data processing, this measure is compared with the route measured by the GPS, and the obtained value (compass error) is used to correct the registered horizontal angle to the species. The distance to the animals is measured through the vertical angle obtained using reticle binoculars. For distance calculations, a mean estimate of the height of the eye-level of the observers should be added to the platform height measures supplied in the dataset, as exact observation heights may substantially vary onboard cargo vessels (Correia *et al*, 2019a).

3.3.4. Experience of the observers

The experience of the observers could influence several factors involved in data collection, including their ability to detect animals at sea, count and identify them, estimate the distance and angle to sightings, and correctly transcribe the information; all potential sources of error that could bias any further analysis performed with these data. The need to recruit large numbers of observers in monitoring programmes should not be compromised by a poor or variable quality of the data gathered (Evans and Hammond, 2004). Several field experiences confirmed that although the ability of observers to accurately record sightings is highly variable, it usually improves with practice, both acquired from repeated surveys, and aided by suitable identification supports, such as illustrated guides, identification charts or posters, videos, and presentations aimed specifically at the identification of the species (Evans and Hammond, 2004).

Indeed, within the FLT MED NED, the influence of the observers' experience and the vessel characteristics (*i.e.*, height and speed) on the detectability of the species were assessed, considering only observers who had recorded at least 10 sightings over at least 5 different transects. Results showed that the ability of the observers to detect a species became relevant with the increasing height of observation. Thus, the higher the bridge is, the higher is the difference among observers with different levels of experience, leading to a 50% difference in sighting rates between experienced and non-experienced observers (Arcangeli *et al*, 2012, 2016c).

Given the economical and logistic constraints, it is seldom possible to involve only senior marine biologists with long-time experience at sea in fixed line transects onboard commercial vessels, and often volunteers (*i.e.*, "citizen scientists") and students with scarce field monitoring experience are employed. The derived heterogeneity in experience could be partially limited through the application of detailed standardized protocols for data collection (Williams *et al*, 2006), including the aid of standardized forms directing observers to record the essential information, and/or record pictures of the species for subsequent validation (Evans and Hammonds, 2004). Validation of sightings is essential for ensuring that sightings are well recorded, but it can be difficult if no image or video is available; however it could be also performed when i.d. features and behaviour are carefully recorded (Berrow *et al*, 2010). A further partial solution to cope with heterogeneous experience in data collection is to include covariates that may explain the variability of results in the process of data analysis (*e.g.*, observer, observer experience or observer training; Thomas, 2009).

However, most researchers agree that by providing adequate training and species identification material, observers improve their ability to provide reliable sightings and thus improve the quality of data. Studies showed that with adequate training and the proper recruitment of participants, data collected by volunteers can be similar or equivalent to data collected by researchers (Hann *et al*, 2018). Moreover, training is a way to encourage volunteers to keep collaborating with monitoring programs, as they become more involved and engaged (Dalili, 2019), and may provide input for improvements (Berrow *et al*, 2010). A proper training should include the identification of the species, measurement of angles and distances at sea, the protocol for data collection, and should be performed through assisted surveys based on the same rules of regular surveys.

Within the FLT MED NET, to avoid biases due to differences in sighting rate or species identification, only appropriately experienced and trained observers are employed (Arcangeli *et al*, 2014c, 2016c, 2017). All observers undertake a training period with senior observers before being admitted to the monitoring programme (Arcangeli *et al*, 2019a). After a preliminary theoretical training, observers are also trained in the field. As observers are generally in teams of 4, two new observers can be trained during a transect by two expert observers with the task of directing and assisting the volunteers to maximize uniformity of data collection (Cominelli *et al*, 2016). The experience of trainees is assessed by senior observers taking into consideration previous experiences, the number of surveys already completed (specifically on ferries), the number of different species recorded, and the different conditions already sighted by the trained observer.

Within ORCA, prior to embarkation, each observer undertakes a daylong course covering taxonomic identification skills, the survey protocol, and appropriate behaviour on the bridge of ships. Observers undertaking longer surveys usually have greater experience and would have completed at least three ORCA surveys in preparation for data collection. However, teams are made of four observers, to include generally three experienced surveyors, and one with less experience that is trained throughout the survey (Matear *et al*, 2019).

Within its first surveys, the CETUS program employed volunteer students as observers with little experience of sea surveys, who were accompanied in each campaign by a more experienced observer that was present in all surveys. Results from this initial experience showed that experienced observers sighted more animals than less trained students and that sightings from the same non-experienced observers increased with the number of days spent at sea (Correia, 2013). Thus, since 2014, volunteer observers for the program have been selected through an international call, prioritizing previous experience in sea-surveys and marine mammal identification, as well as students interested in participating in CETUS as part of an internship for academic purposes, to guarantee personal interest in the surveys. Each year the MMO team receives an intensive course on the line-transect survey protocol and marine mammal identification before embarking. Each ship then receives a team of two observers, one of them with previous experience in CETUS campaigns. However, to ensure the accuracy of collected data, observers only register the identifications to the taxonomic level they are confident with (Correia *et al*, 2019a).

Observer fatigue

Fatigue is also an important factor to take into consideration during fixed-line monitoring onboard large commercial vessels. Indeed, fatigue may decrease the ability of even the most experienced observers to detect and identify species. For this reason, most monitoring networks foresee a rotation of observers and some resting periods to reduce the observer detection capacity bias. If the team involves more than two observers, the third and/or fourth persons are either involved as data recorders, or having a break, allowing a constant rotation of shifts with a regular resting time. If only two observers are onboard, shorter breaks will be possible (*e.g.*, 30 minutes breaks between observation periods of approximately four hours; Flynn *et al*, 2019).

Within ORCA, observers and data recorders rotate roles every 30 minutes, and observers only undertake searching effort for 30 min at a time, to avoid fatigue.

Within the FLT MED NET, the observer team is composed of four people, allowing shifts of positions, from one side of the ferry to the other and from the observing position to the data recording position every 30 minutes or 1 hour to avoid fatigue (Cominelli *et al*, 2016).

On the other hand, the team of observers employed within CETUS is only made of two people, thus, observers switch sides every 60 minutes and rest in turns for an hour each at mealtimes (lunch and dinner), and optionally for additional periods of approximately 40 min in the morning and in the afternoon (Correia *et al*, 2019a).

3.3.5. Weather and visibility conditions

Various aspects related with environmental conditions could affect the detectability of animals at sea, including the effects of wind, cloud covering and sun reflection, visibility, rain, etc. Indeed, the ability to visually detect small cetaceans at sea and thus the accuracy of density and abundance estimates are extremely dependent on sea state and decrease significantly when sea state increases (Teilmann, 2003).

Within the FLT MED NET and several other fixed line monitoring routes, observations are usually undertaken in fine weather conditions (*i.e.*, avoiding heavy rain, fog, etc) and/or a high sea state with Beaufort Sea State less than or equal to three, because cetacean detection capability tends to be biased downwards in conditions worse than that (Kiszka *et al*, 2007). Indeed, Cominelli *et al* (2016) tested the effect of meteorological covariates that could influence species detectability by the observers (*i.e.*, year, month, Beaufort Sea State, wind speed and direction, cloud cover) to cope with possible biases in the results obtained. The analysis demonstrated that sea state influenced fin whale detection probability with states > four leading to a reduction of the ESW from approximately 2,500m to 1,500m. The environmental variables recorded within the FLT MED NET include wind speed and direction, Beaufort Sea State, cloud cover, and precipitation (*e.g.*, Arcangeli *et al*, 2008, 2019a).

While setting sea state conditions to a limit of three in the Mediterranean Sea still allows several days of “good” effort, finding the same weather conditions in the Atlantic Ocean, North Sea, or the Antarctic might present some challenges.

During their survey across the South Atlantic and Antarctic waters, Williams *et al* (2006) set sea state limits to less than six. Information on factors that could affect sighting conditions, including sea state, cloud cover and precipitation, and a subjective visibility estimated in four ranges (<500m, 500-1000m, 1000-2000m, and >2000m) was collected, as well as information on water depth, sea surface temperature (relayed from the bridge), and the estimated proportion of sea surface covered with ice. Environmental conditions were assessed every 30 minutes, or more frequently when they changed, or if the ship made a marked change in course or speed. Similarly, Wall *et al* (2006) conducted surveys in the NE Atlantic with conditions up to Beaufort Sea State 6 and in moderate to good visibility. However, they used only sightings collected in Beaufort Sea State 3 or less and visibility of 5km or more for relative abundance calculations. Similarly, favourable conditions for ORCA surveys are undertaken under daylight hours, with a swell height ≤2 m, and Beaufort Sea state ≤ 6 (Matear *et al*, 2019).

As the effects of weather conditions may also affect species detectability in a different way according to the species size and behaviour, different limits could be set *a posteriori*, for data analysis. Thus, MacLeod *et al* (2009) used only survey legs conducted in sea states of four or less to analyse common and striped dolphin data and survey legs conducted in sea states of three or less to analyse harbour porpoise sightings. Although these thresholds are still lower than those usually set for these species, the eye height of the observers on the vessel used by these authors was substantially higher than most vessels used for cetacean research (30m), which increased detectability around the vessel, particularly at higher sea states.

Finally, within the CETUS program, monitoring is mostly conducted during summer, when weather conditions in the NE Atlantic are more stable. Surveys are continuous from sunrise to sunset, in favourable weather conditions, and stop when sea state or wind state are higher than four (on the Douglas or Beaufort scales, respectively), visibility is lower than 1 km, or during heavy rain (Correia *et al*, 2015, 2020). Although effort is interrupted under poor weather conditions, the effect of detectability factors is significant when building models (Correia, 2020). Thus, environmental variables related to detectability (*e.g.*, wave height, wind speed, visibility range) are assessed at the beginning and end of each survey leg (defined as a continuous period of sampling), or when any significant change occurs. Observers assess sea state using the Douglas scale, wind speed using the Beaufort scale, visibility on a categorical scale of values from 1–10 (covering visibility ranges from 0 m to over 50,000 m, estimated based on the definition of the horizon line and reference points at a known range, *e.g.*, ships with an AIS system), and the occurrence of rain (Correia *et al*, 2019a).

3.3.6. Species identification, group size, behaviour of individuals

The identification of the species and approximate count of individuals are the minimum information that should be collected during a sighting. While this may seem a relatively easy task for terrestrial animals, it is not at sea, especially for highly mobile species that spend the majority of their time underwater and show only a limited portion of the body when surfacing. Moreover, the high speed of vessels such as ferries or cargo ships, which do not change their course to approach animals, further reduce the time available for the identification and count of individuals.

The precision of the information collected can also be biased by the experience of the observers (Arcangeli, 2016), and for this reason it is common practice that either the same or a second researcher confirm the sighting using binoculars or photographic cameras are used to confirm sightings and assess species and group size *a posteriori* (Cañadas *et al*, 2005).

Generally, sightings should be identified to the species level, but given the constraints described above, it is generally allowed for their identification to "the lowest taxonomic level possible at sea" (Alves *et al*, 2018). Thus, *genera* identification is common for species that cannot be easily distinguished at large distances, as occurs with some dolphin species (*e.g*., Arcangeli *et al*, 2008), or to associate the identification of the species with the certainty of their identification (*e.g*., Kiszka *et al*, 2007). In Wall *et al* (2006), for example, sightings were identified to the species level where possible, and species identifications were graded as definite, probable, or possible; with only definite and probable identifications used in the analysis.

Within the FLT MED NET, where species identification cannot be confirmed, sightings are either downgraded to unidentified dolphin/whale or unidentified small/large cetaceans (Santoro *et al*, 2015) or left in the unidentified category (Arcangeli *et al*, 2008). Similarly, within the CETUS program, species identification is attempted to the species level, although the identity assigned is always at the taxonomic level at which the observers are confident of their identification: identification to the genus level or registered as unidentified dolphin, baleen or beaked whale, or cetacean (Correia, 2020).

To allow density and relative abundance estimates, group size should also be recorded for any sighting. The definition of group size is not straightforward for highly mobile cetaceans, it is often interconnected with the definition of behaviour and may vary. Groups are generally defined as animals seen in close proximity at the same time, showing similar behaviour. Within the CETUS program, the definition of groups also foresees animals swimming in the same direction, other than having the same behaviour, and being in close proximity. However, proximity is also variably defined, being *less than 1000 m from each other* according to Cañadas *et al* (2005), *less than 250* for Alves *et al* (2018), or *less than 5 body widths between individuals* for Kiszka *et al* (2007). Group has also been defined as *individuals in apparent association, engaged in the same activity* (Shane, 1990) and *within 10 m of one another* (Smolker *et al*, 1992), *more than one individual seen at the same time within few body lengths one to the other* (Moulins *et al*, 2007), and *an aggregation of all individuals within visual range* (Pace *et al*, 2015). On the other hand, Viddi *et al* (2010) define a group as *individuals of one species within a radius of 100 m for dolphins or of 1 km for whales* (although no association between individuals in a group is inferred).

Independently of this definition, considering the little time spent viewing groups at sea, it is possible that group sizes recorded may not accurately reflect the real group size and thus group size estimates should provide mean, standard deviation, and range values (Kiszka *et al*, 2007). To limit errors, group sizes can also be classified in categories, such as ``single'' (for sighting with only 1 individual), ``pair'' (2 individuals), ``small group'' (3 to 5 individuals), and ``large group'' (more than 5 individuals) (*e.g*., Tepsich *et al*, 2020).

Both within the FLT MED NET and the CETUS programs, when it is not possible to determine the exact number of individuals, a minimum and maximum number of animals are registered, as well as the most probable number of individuals according to the observer´s perception (best estimate). The best estimate is then used in the descriptive analysis. Biases could also derive from the duplicated count on animals when the observation areas of the two observers overlap on the bow or from re-sighting the same individual that is first sighted at a long distance and then closer to the vessel. To limit the effect of this bias, these sightings are often noted and not considered in the analysis (*e.g*., Tepsich *et al*, 2020).

Further information regarding the general behaviour of the species is collected, often classified in categories, such as travelling, resting, socializing, and feeding/foraging (*e.g*., Alves *et al*, 2018). Both within FLT MED NET and CETUS, the group composition (*i.e*., presence of young individuals) and the behaviour of the animals towards the ship are also registered (*i.e*., indifferent, avoiding or approaching), as well as, for travelling animals, information on the heading of the group and swim speed.

Finally, some further information regarding the species is seldom collected, such as the cue type that led to the sighting (*e.g*., blow, seabird activity, splashes, Williams *et al*, 2006).

4. Methods for data collection: metadata, format and reporting

To obtain comparable data that can be used for assessing long-term trends and comparing information among different marine regions, it is of uttermost relevance that the collection of data happens in the most precise and standardized way. Indeed, most monitoring programs are based on detailed data collection protocols (see ANNEX II for details), which indicate the information that should be collected throughout the survey (effort data) and during sightings (sighting data collection) and on the methods/instruments that should be used to collect such information and compile it. Moreover, within the monitoring networks described in this report, standardized data collection sheets are also used to guarantee that the information recorded by different observers is consistent.

4.1. Effort data collection

Usually, during a dedicated monitoring survey, effort data should be collected, including the time, ship position (latitude and longitude), speed and direction of travel, and environmental conditions, such as sea state (generally assessed through the Beaufort scale), cloud cover, precipitation, and visibility (*e.g.*, Brereton *et al*, 2001; Williams *et al*, 2006; Viddi *et al*, 2010). This information is usually recorded using a hand-held GPS, data collection sheets, and/or dedicated applications, with the support of the instruments of the ship (for obtaining information on wind speed and direction, and the vessel speed and course).

Measures of effort are usually done at the beginning and end of each data collection, at regular intervals (generally of 30 minutes) during the transect, or more frequently, if sighting conditions change or if the ship makes a marked change in course or speed.

Within ORCA, the effort data includes environmental conditions (glare, sea state, swell, precipitation, and visibility) and is recorded at a minimum of 30 minutes intervals or when conditions change, according to the fields of the *Distance sampling effort and weather form* (Robbins *et al*, 2020; Fig. 7, ANNEX II).

ORCA SURVEY: DISTANCE SAMPLING EFFORT AND WEATHER FORM

Route (start & end point)			
Form no.		Vessel name	
Date		Observation deck	
Time zone		Obs. deck height	
Observer name (Team Leader 1st)	Obs. code	Team leader email address	

EFFORT
0 On effort
1 Observer rotation/30 min record
2 Weather change
3 Change of ships course
4 Off effort

SWELL
1 Absent
2 Light (>0-1m)
3 Moderate (1-2m)
4 Heavy (>2m)

PRECIPITATION
1 None
2 Rain
3 Hail
4 Fog/Mist
5 Sleet
6 Snow

GLARE
NA None
P Port
S Starboard
A Ahead
PA Port-ahead
SA Starboard-ahead
All All sides of the ship

Event time	Effort[1]	Watch no.	GPS reading		Speed (knots)	Course of vessel*	Sea state Beauf	Swell	Precipitation	Glare	Vis. (km)	Observer code[2]		Comments
			Latitude (N/S)	Longitude (E/W)								Port	Starboard	

[1] Assumes that effort readings will be taken every 30 minutes
* COG or COW reading
[2] Initials of the surveyor on effort

Fig. 7. Effort and weather data collection form used within the ORCA network.

Within the FLT MED NET, the ferry route is recorded continuously using a dedicated GPS. Weather conditions (including wind speed and direction, sea state, visibility, cloud cover, and precipitation) are recorded at the beginning of a transect and whenever any change of route, vessel speed, weather conditions occur (Morgado *et al*, 2017; Fig. 8, ANNEX II).

Data collection sheet: Meteo

COD_Transect N. **Date** **Ship name** **Observers**

COD GPS	Time	Effort	Sea state	Wind direction	Rain	Visibility	Cloud cover	Lat	Long	Route	Speed	Other			
		BEG=beginning off effort STOP=start of off effort START=start effort; END=end effort;			Mist, Fine, Drizzle	(optimus, good, mean, scarce)	%	Y	X			(es. predator fishing, fishing ship, naval traffic..)	**Sea state**	**Wind (KN)**	**Description**
													0	0	Calm (glassy)
													1	1-3	Calm (rippled)
													2	4-6	Smooth (wavelets)
													3	7-10	Slight
													4	11-16	Moderate
													5	17-21	Rough
													6	22-27	Very rough
													7	28-33	High
													8	34-40	Very high
													9	41-47	Phenomenal
													10	48-55	Storm

Fig. 8. Data collection sheet used within the FLT MED NET for recording environmental conditions.

As mentioned above, also within CETUS all environmental variables related to detectability (*e.g*., wave height, wind speed, visibility range and the occurrence of rain) are assessed at the beginning and end of each survey leg, or when any significant change occurs (Correia *et al*, 2019a) and recorded using a standard form.

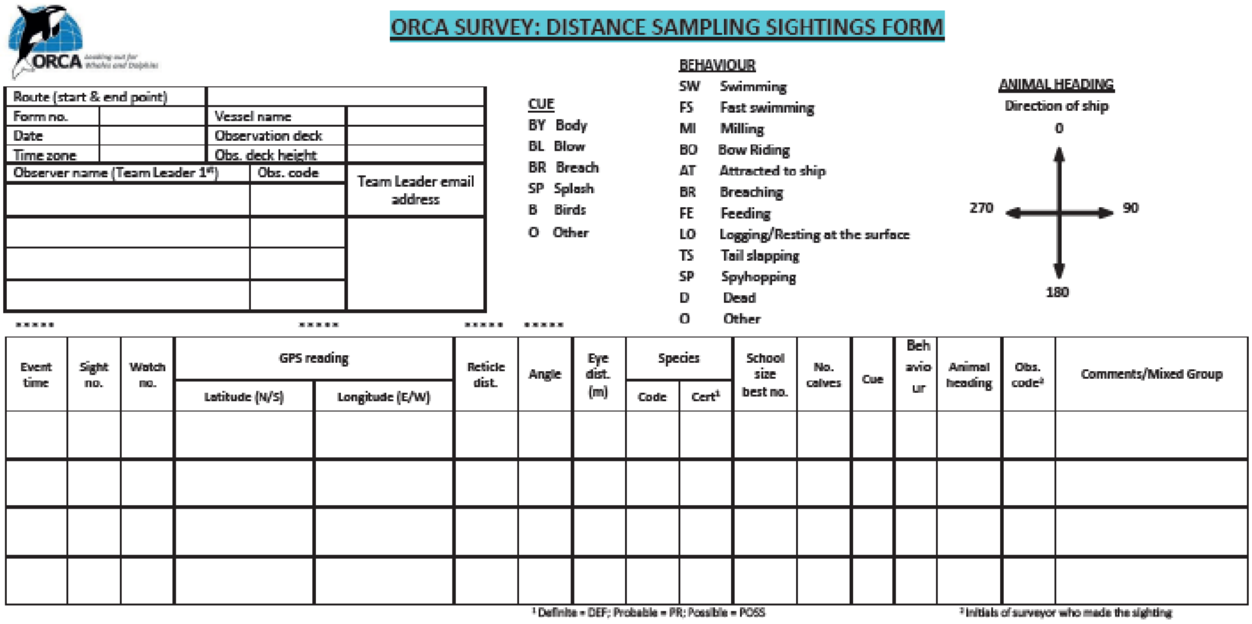
4.2.Sighting data collection

Whenever a sighting occurs, together with the same ship and environmental variables listed above, a further set of data are recorded, which usually includes the time, position of the ship, angle and approximate distance to the sighting (assessed with the available instruments, such a Heinemman stick or reticle binoculars), species identification including degree of certainty, and a number of other variables, such as group size (maximum, minimum, and best estimates), initial and observed behaviour (*i.e*., Fast swim, leap/splash, Breaching, Bow ride, Slow swim, Stationary/milling, Tail slap, Lobtailing, Blow only, or other), group composition (*i.e*., number of adults, juveniles and calves), inter-specific relationships with species, and number of associated animals (Brereton *et al*, 2001; MacLeod *et al*, 2009; Viddi *et al*, 2010; Alves *et al*, 2018).

Within ORCA, species identity, group sizes, distance, and angles from the ships' bow to animals are recorded along with information on the animals' behaviour and cue that led to the sighting, using the *distance sampling sightings form* (Robbins *et al*, 2020; Fig. 9, ANNEX II).

Within the FLT MED NET, during each cetacean sighting, the ship location is marked on the handheld GPS, and data are annotated on a standard datasheet (Fig. 10, ANNEX II) with information about the time, ship's position, observer, side of sighting, angle between the detected group and the track line, and linear distance from the ship, species, number of individuals, direction of swimming, and surface behaviour. Binoculars and photographs are used to confirm species identification and group size. The distance between the ferry heading and the sighting is measured using clinometer, rangefinder stick, or the scale on the binoculars, and is then converted from the reticle values (ranging from 0 to 7) into metres applying the formula by Kinzey and Gerrodette (2003). The maximum range considered for cetacean sightings is of approximately 4 km from the ship, as only large whales can be detected at a further distance (Arcangeli *et al*, 2014c, 2017; Morgado *et al*, 2017).

Finally, whenever a cetacean species is sighted during a CETUS survey, to correctly collect the data, both observers gather on the side of the boat where the animals are spotted and mark the end of an on-effort transect. After registering the sighting, each observer returns to their side of the vessel, and a new on-effort transect starts. Aside from the GPS position, if possible, observers record species identity, the distance and angle of the position of the animal(s) in relation to the ship, the number of animals within the group, their behaviour towards the ship (if any), and information on the heading of the group (Correia *et al*, 2020).



ORCA SURVEY: DISTANCE SAMPLING SIGHTINGS FORM

Route (start & end point)			
Form no.		Vessel name	
Date		Observation deck	
Time zone		Obs. deck height	
Observer name (Team Leader 1st)	Obs. code	Team Leader email address	

CUE
BY Body
BL Blow
BR Breach
SP Splash
B Birds
O Other

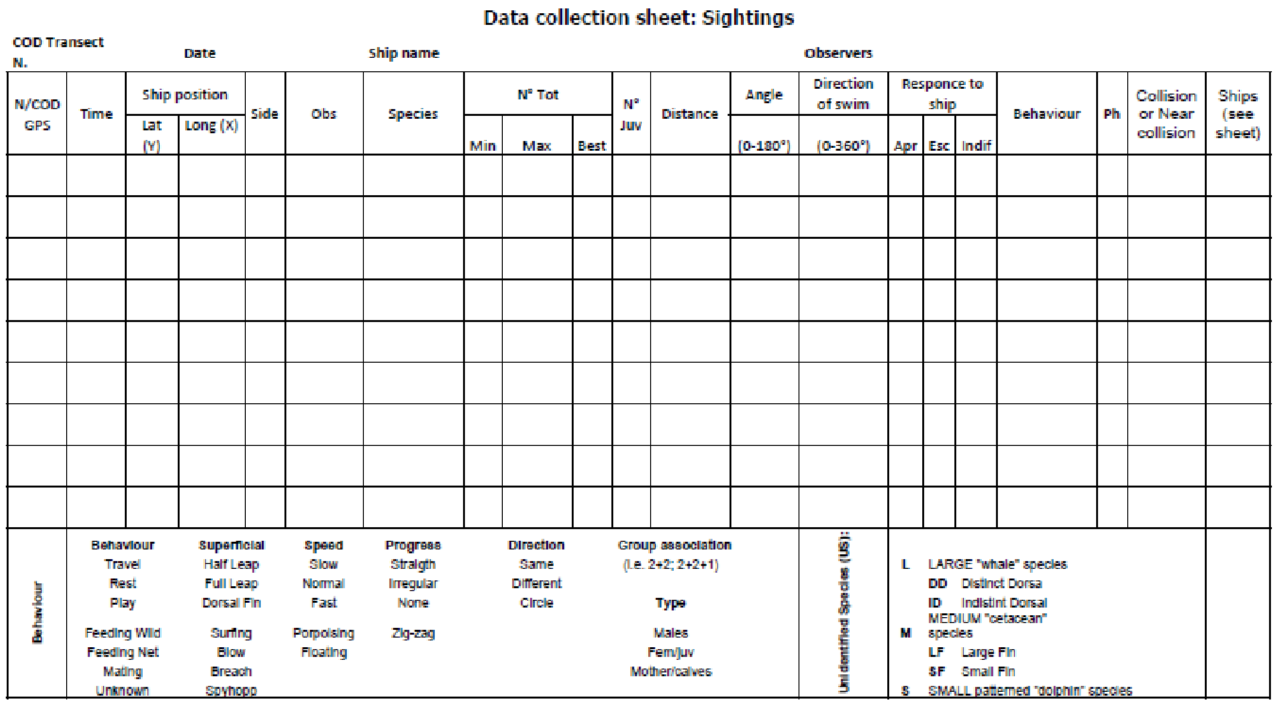
BEHAVIOUR
SW Swimming
FS Fast swimming
MI Milling
BO Bow Riding
AT Attracted to ship
BR Breaching
FE Feeding
LO Logging/Resting at the surface
TS Tail slapping
SP Spyhopping
D Dead
O Other

ANIMAL HEADING
Direction of ship
0
270
90
180

Event time	Sight no.	Watch no.	GPS reading		Reticle dist.	Angle	Eye dist. (m)	Species		School size best no.	No. calves	Cue	Behaviour	Animal heading	Obs. code²	Comments/Mixed Group
			Latitude (N/S)	Longitude (E/W)				Code	Cert¹							

¹ Definite = DEF; Probable = PR; Possible = POSS
² Initials of surveyor who made the sighting

Fig. 9. Sighting data collection form used within the ORCA network.



Data collection sheet: Sightings

COD Transect N. | Date | Ship name | Observers

N/COD GPS	Time	Ship position		Side	Obs	Species	N° Tot			N° Juv	Distance	Angle	Direction of swim	Responce to ship			Behaviour	Ph	Collision or Near collision	Ships (see sheet)
		Lat (Y)	Long (X)				Min	Max	Best			(0-180°)	(0-360°)	Apr	Esc	Indif				

Behaviour

Behaviour	Superficial	Speed	Progress	Direction	Group association
Travel	Half Leap	Slow	Straigth	Same	(i.e. 2+2; 2+2+1)
Rest	Full Leap	Normal	Irregular	Different	
Play	Dorsal Fin	Fast	None	Circle	Type
Feeding Wild	Surfing	Porpoising	Zig-zag		Males
Feeding Net	Blow	Floating			Fem/juv
Mating	Breach				Mother/calves
Unknown	Spyhopp				

Unidentified Species (US):
L LARGE "whale" species
DD Distinct Dorsa
ID Indistint Dorsal
M MEDIUM "cetacean" species
LF Large Fin
SF Small Fin
S SMALL patterned "dolphin" species

Fig. 10. Data collection sheet used within the FLT MED NET for recording cetacean sightings.

4.3. Data on other species

Although the majority of the projects described within this report mostly focus on marine mammal and cetacean monitoring, often in parallel with a systematic collection of marine turtle sightings, several monitoring programs also address other marine vertebrate species, such as marine birds or large fish, to investigate potential multi taxa relationships.

Marine birds have been systematically recorded by the BDRP between 1995 and 2000. Effort-related seabird recordings were collected during all available daylight hours by a team of three experienced volunteer observers. Each seabird observed ahead of the ship and within an assumed 2 km-wide strip on either side ahead were counted. Species name, number, and where possible, age and sex were recorded for each seabird sighting, as well as notes on behaviour, including associations with fishing vessels, cetaceans, and environmental effects, such as oiling and fishing net entanglement. The methodology was further refined after 2000 to enable an estimation of bird density (Brereton *et al*, 2003a)

Even though within the FLT MED NET priority is given to cetacean surveys, data on other marine macrofauna is collected each time it is sighted. Sea turtles are considered a high priority, and systematic data on their presence is collected according to the fixed-strip width methodology by the observer dedicated to marine litter monitoring, when present. Maintaining a consistent effort focused on cetaceans, data on the species listed in Table 5 are also collected opportunistically, including two species of sea birds, selected by considering their priority for conservation purposes, five types of large fish, and jellyfish, for which identification at the specific level is recommended but not always required.

Table 5. List of marine fauna species other than cetaceans recorded within the FLT MED NET.

Species name	Common name
Caretta caretta	Loggerhead sea turtle
Mola Mola	Ocean Sunfish
Mobula mobular	Devil fish
Xiphias glaudius	Swordfish
Thunnus ssp	Tuna
Fam. Istiophoridae	Marlin
Shark	Shark
Jellyfish spp	Jellyfish
Puffinus yelkouan	Yelkouan / Levantine shearwater
Calonectris diomedea	Scopoli's Shearwater

Data regarding these species are collected using a dedicated form, including similar fields as the data collection form for cetaceans (Fig. 11, ANNEX II). For species usually observed in large groups, groups are categorized into small (<10 individuals), medium (10- 100), and large (>100).

Data collection sheet: Sightings other species

COD Transect N. | Date | Observers | Ship name

COD GPS	Time	Ship position		Side	Obs	Species	N° Tot			N° Juv	Distance	Angle	Direction of swim	Responce to ship			Behaviour	Ph	Collision or Near collision
		Lat (Y)	Long (X)				Min	Max	Best			(0-180°)	(0-360°)	Apr	Esc	Indif			

Fig. 11. Heading of the FLT MED NET data collection form for sightings of species other than cetaceans.

Sightings of other large vertebrates (*e.g.*, turtles, sharks, sunfishes) are also registered by CETUS. However, for pelagic megafauna other than cetaceans, data are always collected opportunistically, as sampling effort is dedicated uniquely to cetacean species. In these cases, only taxonomic information and the number of individuals (as well as optional comments about the sighting, *e.g.*, animal behaviours, presence of calves or others) are registered (Correia *et al*, 2019a, 2020).

4.4. Data on main threats: maritime traffic and floating marine macro litter

The geographical distribution of marine mammals is affected by several factors, which should all be taken into consideration when monitoring these species. Ocean currents, abundance of food, sea temperature, the morphology of the coastline, seabed topography, as well as human activities, interact and influence the areas which could be preferred habitats for cetaceans. Indeed, the marine ecosystem is increasingly affected by the detrimental effects of human activities, causing direct (*e.g.*, entanglement, collisions) and indirect (*e.g.*, sublethal effects and loss of habitats caused by pollution, noise, inputs of energy) impacts to the marine fauna. Successful conservation of ocean ecosystems requires adequate knowledge about species presence and distributions, but also requires the identification of areas of potential overlap with threatening factors: year-round spatial density maps of sensitive species can inform marine spatial planning and management to design the adequate conservation measures (McClellan *et al*, 2014; Pennino *et al*, 2017).

The need to understand the severity of these threats on the marine environment and to take action to mitigate them is considered by the legislation of many countries and by a number of international agreements (ICES, IWC, IUCN, OSPAR, UNEP, CMS, ACCOBAMS, ASCOBANS, HD, MSFD, Waste Directive, MSP), which recognize overfishing, habitat loss, acoustic noise, maritime traffic, and pollution as the main human pressures (Halpern *et al*, 2008; OSPAR, 2008; UNEP/MAP, 2017b). Current international, regional, and national regulations (*e.g.*, MARPOL, Habitat Directive, Waste Directive, MSFD) stress the importance of assessing the main threats posed to the marine fauna by anthropogenic activities and require the collection of information through regular monitoring of such anthropogenic pressures (Arcangeli *et al*, 2018).

The HD considers the factors that currently are, or have been, acting during the reporting period as pressures and threats as the factors expected to be acting in the future (DG Environment, 2017); similarly, the IUCN asks for the evaluation of the variations in species range and population due to exposure to risk (IUCN, 2019). The MSFD, instead, requires integrated studies on different ecosystem components, including anthropogenic ones, to assess the GES of marine waters: seven pressure descriptors should be considered in the assessments.

Studies about the overlap between cetaceans and human activities are often limited in time and restricted to local and coastal regions where interactions are particularly visible (Campana *et al*, 2017). However, the synoptic and systematic collection of information regarding the presence and distribution of both the endangered marine fauna and its potential threats identifies areas and seasons in which species are most exposed to risk, and thus setting the basis for mitigation and management actions. Indeed, one of the criteria set by the Habitat Directive to assess the favourable status of habitats, is that “there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis”. While such a definition may involve several aspects of ecosystem ecology and species biology, it surely involves other factors that potentially affect habitat suitability, such as marine pollution or ocean noise (Thomas, 2009). The systematic monitoring of these threats has been already experimented and is currently implemented across several fixed line monitoring routes, while other threats, such as oil spills, the presence of ghost nets, and entanglements are not yet reported in a systematic way within the monitoring network, but they could be in the future as a perspective of the development of monitoring protocols.

4.4.1. Marine Litter

Given its lethal and sublethal impact on marine fauna, pollution by marine litter (including plastics) is addressed among the threats considered within the Habitat Directive (H03.3), the descriptors of the MSFD for the assessment of the ecological status of the European seas (D10), and the ecological objectives of IMAP (*i.e.*, floating marine litter, EO10, CI23). Both legal frameworks require the characterisation of its trends in the different marine compartments and the evaluation of its impacts on the biota (Campana *et al*, 2018).

Monitoring litter at sea has been undertaken by many researchers using large vessels (Suaria and Aliani, 2014; Rothäusler *et al*, 2019). Moreover, based on the methodologies in use by international programs for marine litter monitoring, a specific protocol was adopted by the FLT MED NET in 2013 to allow a complementary data collection on marine megafauna and floating marine litter (Arcangeli *et al*, 2015; Campana *et al*, 2018). The protocol was further tested and improved within the development of the Interreg MED MEDSEALITTER project, and it now includes a detailed list of the parameters that must be considered during monitoring, as well as the categories of litter that should be used for its classification, in line with the MSFD reviewed guidelines for monitoring floating marine litter in the Mediterranean Sea (MEDSEALITTER consortium, 2019; Arcangeli *et al*, 2020). This method is now included in the monitoring programs for MSFD D10 C1 in Italy (Magaletti and Tunesi 2018) and France (Mediterranean waters).

Floating marine litter monitoring from large vessels is based on the fixed strip method, in which a strip of a fixed width between 50 and 100m (or smaller, according to the platform height and speed and the visibility conditions) is defined at the beginning of the effort, and every litter item detected within this strip is recorded by an independent experienced observer. Litter monitoring should be performed from the side of the navigation bridge with better visibility and in the vicinity of the bow to avoid the turbulence generated by the bow itself and only in optimum weather conditions (≤2 of the Beaufort scale). The observer records the GPS coordinates, size class, colour, category of each item larger than 20 cm detected within the defined strip (Arcangeli *et al*, 2018). Such regular, multi-year, synoptic monitoring allows intercepting the great variability in the average levels and trends of marine litter pollution in space and time and helps identify its main sources. The large-scale analysis of floating litter has provided information on plastic accumulation areas in the Western Mediterranean (Arcangeli *et al*, 2018) and potential risk areas for large vertebrate species synoptically observed (Campana *et al*, 2018; Arcangeli *et al*, 2019b; Atzori *et al*, 2021). The larger size class of floating macro litter can also be used as an indicator of areas of litter accumulation that can represent potential risk for the marine fauna (Campana *et al*, 2018), and monitoring plastic objects at sea can be a useful tool for evaluating the effectiveness of other European legislative drivers, such as the Waste Framework Directive (2008/98/EC) and the Directive on single-use plastics (2019/904/EC).

4.4.2. Maritime traffic

Another major source of human disturbance to the marine environment and marine fauna is produced by maritime traffic, which is responsible for underwater noise, pollution, transfer of alien species, collisions, and disturbance towards the marine fauna (Campana *et al*, 2015). Indeed, both the IUCN conservation status assessment (IUCN, 2015) and the EU Habitats Directive report (Art. 17, EC, 2015), confirmed that maritime traffic can affect cetaceans with different effects and risk levels depending on the species, areas, and seasons, and this threat is addressed under D11 (Energy and Noise) of the MSFD. The disturbance from shipping (from fishing and recreational vessels) lies mostly in the fact that noise inputs from these activities can be continuous (MSFD descriptor 11). In addition, ship strikes are recognised as an anthropogenic pressure for large cetaceans, and have to be evaluated when possible for the French sub-regions in the framework of the MSFD (Spitz *et al,* 2017).

Main shipping routes often overlap with critical cetacean habitats, and vessel presence can cause direct disturbance on cetaceans leading to short and long-term changes in their behaviour and distribution (*e.g*., Arcangeli and Crosti, 2009; Campana *et al*, 2015). Individuals could tend to avoid more trafficked areas with small-scale displacements towards patches with relatively fewer vessels or perform larger scale changes in distribution to occupy areas with less traffic. Furthermore, some species could also increase their diving activity where intense traffic occurs (Campana *et al*, 2015). Additionally, the speed and size of vessels are directly related to the risk of collisions, which are particularly dangerous both for large whales and smaller species worldwide (Pace *et al*, 2006). While a wide and multi-species scale approach is needed to provide global conservation and mitigation measures to address this threat, quantitative measures on its effects on different cetacean species in open seas is scarce (Crosti *et al*, 2011, Campana *et al*, 2015). A large-scale comparative approach, such as that provided by fixed line monitoring, covering high sea areas across different seasons provides a better understanding of the extent and varying intensity of anthropogenic impacts in relation to the dynamic characteristics of maritime traffic. In turn, this information would help identify potential areas of increased risk and provide mitigation measures towards this threat at a large scale and international level. Observations on large species taken from vessels travelling along the main shipping routes allow possible events to be directly reported, provides contributions to the IWC Database, assesses the frequency of near miss events (NME) and ship strikes, highlights the most sensitive areas and seasons for this risk considering the important areas for the species, and helps with understanding how and why ship strikes may occur (IUCN MMPATF, 2017; Ham *et al,* 2021; David *et al*, *in press*.); such information can contribute to the Strategic Plan to Mitigate the impacts of ship strikes for cetaceans made by ACCOBAMS and IWC. Detection of NME, in fact, can be a proxy indicator of ship strikes for whales, considering that a record with a dedicated observer is unlikely to occur. The definition of a NME within the FLT network protocol, for example, was established by considering the characteristics of the vessels used, as "when an animal seen in an area located 50-m in front of the vessel's bow and 25-m on the side (David *et al*, *in press*).

Within the FLT MED NET, a sampling protocol was specifically designed and is applied to all transects to provide real-time information on maritime traffic in the presence and absence of cetaceans. Sampling maritime traffic is carried out by counting all vessels longer than 5 m and visible by eyesight all around the ferry at the beginning and end of the survey effort, each time a cetacean sighting occurs (record in presence of cetaceans); and at approximately every hour throughout the transects when animals are not sighted (random record in absence of cetaceans). To avoid pseudo-replication, a minimum interval of 15 min is defined between presence and absence records to exclude sampling performed within shorter time intervals from a sighting (Campana *et al*, 2015, 2017). Under positive effort conditions, all the vessels up to the horizon are counted (about 18 km distance, calculated with onboard instruments), to include both vessels within the range of detection of cetaceans (estimated to be about 7.3 km from similar ferries, Cominelli *et al*, 2016) and a buffer of potential influence, given that ships can cause physical and acoustic disturbance over a large scale.

Vessels are classified as Small (<5m), Medium (5 - 20m, distinguished in: Motor, Sailing, Fishing), and big (>20m, such as cargos, tankers, passenger ships) (Fig. 12, ANNEX II). In this way, the visual monitoring of maritime traffic can provide detailed information on the types of vessels occurring in a specific area/season, which provides more accurate information on traffic composition compared to that obtained only from Automatic Identification System data. In addition, synoptical data collection allows investigating potential risk areas for the co-occurrence of cetaceans and high traffic densities and describes species-specific relationships (Campana *et al*, 2015, 2017; Azzolin *et al*, 2016). As collisions with vessels are one of the main pressures on cetacean populations in highly trafficked marine areas, ship strikes and near-miss events have also been recorded since 2017, defined as animals sighted within the 50m in front of the vessel and 25m on the side, not showing any active approaching behaviour (Arcangeli *et al*, 2016a).

Data collection sheet: Naval Traffic

COD Transect N. **Date** **Ship name** **Observers**

				< 2 NM					> 2 NM					Other
Cetacean Presence/Absence	Time	Ship position		Small	Medium			Big	Small	Medium			Big	
		Lat (Y)	Long (X)	< 5m	5m < X < 20m			> 20m	< 5m	5m < X < 20m			> 20m	
					Motor	Sail	Fishing			Motor	Sailing	Fishing		

Fig. 12. Heading of the data collection form used by the FLT MED NET for collecting data on maritime traffic.

The CETUS program uses a protocol based on that applied by FLT MED NET to monitor maritime traffic: the number of vessels, categorized by size (either smaller or larger than 20m), detected with or without binoculars all around the ship's position are registered at the beginning and end of each survey, at every sighting of cetacean species, and at every hour throughout the survey effort (Correia *et al*, 2019b, 2020).

4.5. Environmental DNA data

The recent development of sophisticated molecular investigation techniques (Next Generation Sequencing, NGS) allows the simultaneous sequence of different DNAs within a single environmental sample (metabarcoding). Thanks to these developments, the analysis of marine environmental DNA (eDNA) has become widespread and has been proposed as an alternative approach to monitor the status of biodiversity and its variations over time (Valsecchi, 2021). However, as it happens with visual monitoring, the collection of environmental samples in offshore areas could be extremely costly when using dedicated vessels. The use of commercial vessels travelling along fixed routes offers the opportunity of eDNA sampling for systematic surveys on marine biodiversity with several benefits. Similarly to what happens with visual surveys, commercial vessels travelling across fixed transects allow repeatable, sequential sampling and thus temporal comparisons of samples between seasons and across years; areas that are usually difficult to access can be accessed; linear sea sections of several km per sample can be analysed; samples can be collected at any time of the day, allowing the assessment of differences in species composition between nocturnal and diurnal samples; costs are drastically reduced (MeD for Med project, 2020). A pilot project using this technique has been carried out in 2018 in the Mediterranean Sea, along the Livorno - Golfo Aranci route of the FLT MED NET, crossing the Pelagos Sanctuary for Mediterranean Marine Mammals. Results of the analysis of water samples collected on board the ferry showed that the markers successfully detected most trophic levels of vertebrate marine communities and classes, including bony fish, rays, cetaceans, and birds. Interestingly, cetaceans were detected in correspondence with visual sightings made by the FLT MED NET researchers on the command deck (whenever a sighting occurred, supplementary samples were collected) (Valsecchi, 2021). Also, DNA traces of the endangered monk seal were detected in the Tuscany archipelago (Tyrrhenian Sea) long before visual observations witnessed its presence in the same area (Valsecchi *et al*, 2021). The pilot study demonstrates that commercial shipping can provide a platform for eDNA marine sampling, potentially allowing regular systematic sampling transects that can contribute to evaluating and monitoring marine biodiversity (Valsecchi, 2021).

4.6.Practicalities for data collection - tools and apps

Several researchers still rely on pen and paper forms to collect and store data while in the field and then transcribe it manually to some digital format to store it. While this method is often the easiest way to collect data in the absence of other tools, it is time consuming and often not precise due to potential typing and transcription errors (Liébana Bernárdez *et al*, 2016). To improve data quality, dedicated mobile applications have been recommended as an easy way to collect field data, as they can include fields like date, time, location, species ID, description, and sometimes prompt the observer to take a photo and markdown how confident he or she was in the sighting (Hann *et al*, 2008).

A good example of the potential of these apps for collecting sighting data is provided in Hann *et al* (2018), who used an Android-based mobile app called Whale mAPP (www.whalemapp.org, Fig. 13) to record opportunistic marine mammal sightings made by a citizen scientist in Southern Alaska. The app accounted for observer effort by automatically recording the user's location every 30 seconds and was tailored to this region, limiting possible species selection to those commonly found in the area. Upon a sighting, users were asked to identify the species using a drop-down menu, to record the number of individuals (categorical options), distance and direction to the animal(s) (0–500 m, 500 m–1 km, 1–2 km, 2–5 km, 5+ km), the animal's behaviour (feeding, logging, milling, socializing, thermal regulation, travelling, other, unknown), weather conditions (cloud cover and wind), and a confidence rating scoring the user's confidence in the accuracy of the data entered for each sighting (1 to 5 stars). Upon completion, a recorded sighting was noted on the map with an icon on top of the black track line. Since many areas do not support cellular reception, the app stored data locally on a base map that was accessible offline, and automatically transmitted them to a geodatabase once reception was available. The quality of data was also improved by training citizen scientists on the use of the app and marine mammal identification. The app received positive feedback by users and provided valuable scientific data, highlighting the potential of a marine mammal citizen science app to support both scientific and education objectives. Indeed, aided by sufficient training and accurate protocols, a large enough data sample size and spatial coverage would enable this citizen science method to become scientifically valuable for gathering broad scale and marine mammal data.

Fig. 13. Screenshots from the mobile application Whale mAPP

During monitoring activities from cargo vessels, Flynn *et al* (2019) also collected data using an app, called SpotterPlo, installed on a tablet. However, they also used datasheets or a laptop. The combination of data collection systems was useful to test the app and demonstrate its use to the crew.

Within the FLT MED NET, Liébana Bernárdez *et al* (2016) used software that allows creating programs and exporting them to different platforms (Windows, Linux, Android, iOS…) with little programming knowledge to build customized applications for field data collection. "Scirra's Construct 2" was used to create the first version of the application "CetoSee" and "Tasker" was used to create an Android 4.2 or above version of it (Fig. 14). Both programs created an external file in .csv format with the data in the format and order required for analyses. Although not suitable for too complex tasks or programs, this low budget software can be designed to fulfil the exact research needs and be very useful for data collection. Creating the software as customizable as possible makes the initial development longer and harder, but then data changing and maintaining or updating the software becomes easier, and researchers can do it without external help.

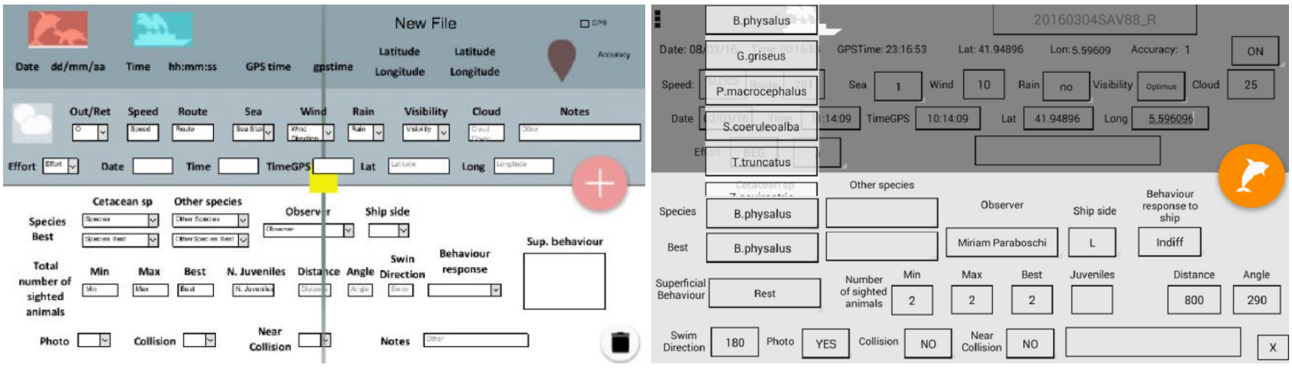


Fig 14. Application designed with Construct 2 (left); storing a sighting with the last updated Android version made with Tasker (right); from Liébana Bernárdez *et al* (2016).

Currently, the FLT MED NET partner EcoOcéan Institute collects data along its routes using level 3 (expert observers) of the app ObsenMer (https://www.obsenmer.org/, Fig. 15) installed on a tablet (Ipad) with an inbuilt GPS. The GPS positions are recorded every 30 seconds, and the fields considered by the app are intended for a line transect method, including the beginning and end of the effort, meteorological conditions, sightings, and associated angle and distance measurements. Specific pages include all parameters needed for the different sightings, such as marine mammals, marine turtles, rays and sharks, pelagic fishes, macro-plankton, birds, etc. Maritime traffic and marine litter data can also be recorded. The app is customisable, with a dynamic interface to add groups of species or easily improve the protocol. All data can be validated afterwards and are automatically uploaded on a user's private space in the ObsenMer database when the tablet is connected to a wi-fi network.

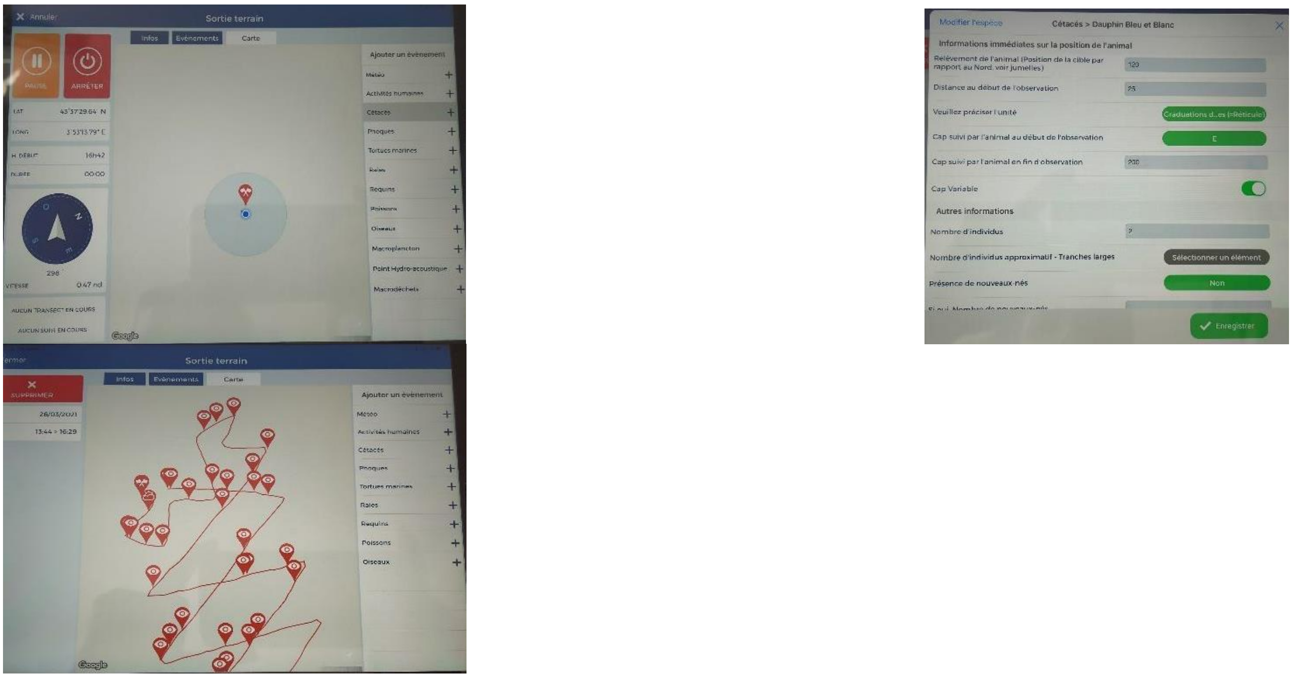


Fig. 15. Screenshots from the app Obsenmer used within the FLT MED NET by EcoOcéan Institute: (left) metadata, time, real time GPS position and heading of the vessel, with all events (meteo, cetacean, birds, sharks, turtle, maritime traffic) listed on the right; (center) page appearing when a cetacean event is open; (right) during the survey, the effort line and each sighting appear in real time on the map.

CIMA Research Foundation used the mobile application “LocusMap” (Asamm Software, s. r. o., https://www.locusmap.app/) installed on an Android tablet with built-in GPS. The app allows for customization of interest points and a schema for the different categories (effort, meteo, cetacean, maritime traffic, etc) was created. The app provides the entire track and all the recorded points, as separate .csv files, allowing faster and effective data storing into databases. Since 2019, CIMA RF is using the app "IlogWhale", developed following the criteria of ACCOBAMS Resolution 6.20 Annex 4 (https://wwhandbook.iwc.int/en/case-studies/the-accobams-high-quality-whale-watching-certificate) and installed on android Tablets with built-in GPS. The app ILogWhale allows for the simultaneous recording of track and specific data, and it has been customized for monitoring from different platforms (ferries, whale watching, and for research vessels, Fig. 16). The app has been already customized for direct import into SQL Databases: precompiled fields with multiple choice, minimize typing errors by users, reducing post-processing effort. The app allows for the download of different .csv files for tracking (recorded every second) and for each type of point, which can directly be imported in QGis or in SQL Databases.

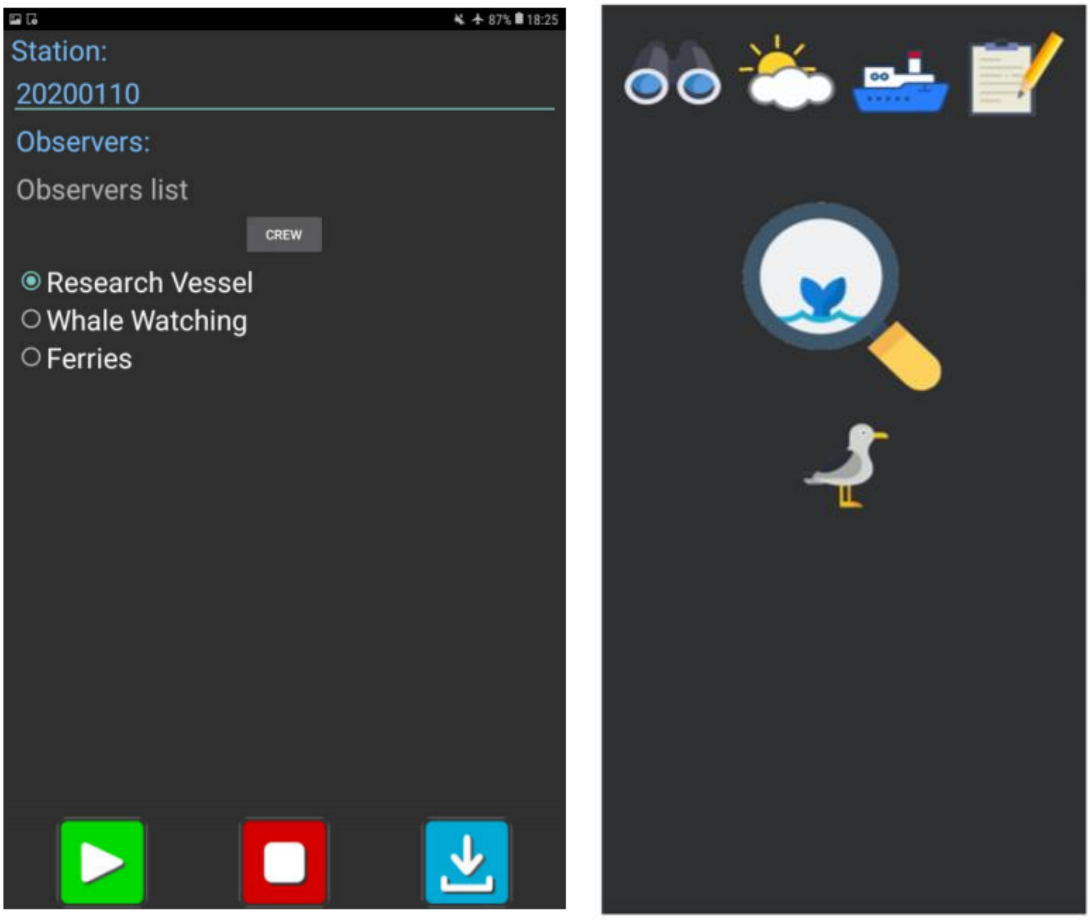


Fig. 16. On the left, Landing page of ILogWhale, allowing for the choice of observers (already entered and remembered in the app) and the type of survey. On the right, Landing page when "Ferries" is chosen. Different icons allow for recording specific data: from left to right: effort, meteo, maritime traffic, generic note, sighting of cetacean, associated species. Further customization (*e.g.* for marine litter) are available.

Along its cargo routes, CETUS use the mobile application "My Tracks" (Google, 2013 https://my-tracks.pt.aptoide.com) installed on a smartphone or a tablet with an inbuilt GPS to record the coordinates of the effort transects and to register sightings and other sampling points. This application registers, among other variables, the date and time, the speed (in m/s) and direction (in °) of the vessel and the GPS coordinates (in decimal format, WGS84 coordinate system). The recommended recording settings (every 10 seconds or 10m, whichever the smallest, and minimum precision of 50m) are maintained and occasionally changed to overcome battery life issues. Although working efficiently at sea, on rare occasions the application generates errors in the date and time of recording (with the time going forwards and backwards), an issue demanding a careful verification process during data entry. An adaptation of the protocol was made during the first year of the project (2012 campaigns), in which a Garmin GPS with similar settings was used, with positions being annotated by hand and later imported into Microsoft Excel spreadsheets (Correia *et al*, 2015, 2019a).

Within the Madeira routes onboard ferries, the same methodology of CETUS cargoes (with small adaptations to the ferries) was used until June 2018. Afterwards, the team developed an app called MadeiraWhale (https://cloudapks.com/app/com.aaa.MadeiraWhale/) to collect both effort (tracks) and sighting data, including the gps position, species, number of individuals, presence of calves, and general behaviour (Fig. 17).

Fig. 17. Screenshots from the mobile application MadeiraWhale, currently under improvement.

4.7. Data quality control, storing and accessibility

The results obtained within marine monitoring programs, such those described within this report may be of fundamental use to guide management decisions. Data employed for decision making, potentially resulting in the implementation of often costly measures, need to fulfil quality standards. As environmental monitoring through commercial vessels travelling along fixed routes is mostly based on operationally defined parameters, the quality of measured data needs to be assured by the precise application of agreed protocols and be supported by training, joint parallel surveys, photographic documentation, and ground truthing approaches. It is necessary that consistent data are collected according to the parameters described above and reported using standard formats.

To fulfil data quality requirements, all data recorded within ORCA undergo checks by trained scientists to ensure a high level of quality control. All data are systematically checked using set protocols to ensure that records are accurate and that spatial data are correctly formatted. Additional checks are completed annually for any data collected within that year, to reduce the potential for erroneous data being archived (Matear *et al*, 2019). Similarly, CETUS researchers make verifications and validations of data at several stages during their processing and the development of the final dataset, including the digitalization of the data to excel files, within the MySQL database, in ArcGIS and in R after structuring the final dataset (Correia *et al*, 2019a).

Once their quality is assured, it is also crucial that data collected within large scale monitoring efforts are stored in common portals so that they can be available for their use, *e.g.*, in the assessment of long-term trends and for transboundary comparisons of a species relative abundance and density. Regional Sea Conventions and other international organisations may provide the necessary IT infrastructure for collecting, hosting, and managing data, but it should be emphasised that only common data formats, structures, and metadata can provide data comparability and interoperability of databases.

However, after being collected in the field, data are usually first stored in individual project-based repositories or national databases. Indeed, separate databases are kept by each institution involved in the FLT MED NET with data regarding each of the transects surveyed within the network, which are then combined for the purpose of large scale/regional analyses. All sightings recorded by IWDG are stored on a database held on the web server to enable access to sightings data through the public website (www.iwdg.ie). Data retained by ORCA are also stored in both physical and digital formats through archives, log sheets, and

ESRI ArcGIS Geodatabases and relational databases (Matear *et al*, 2019), and data collected within CETUS are logged into an Excel database and then structured using MySQL internal database (Correia *et al*, 2019a).

Subsequently, data on marine fauna can be shared publicly using international repositories.

EMODnet, the European Marine Observation and Data Network, is a network of organisations that work together to observe the sea, process the data according to international standards, and make the obtained information freely available as interoperable data layers and data products. This long-term marine data initiative allows sharing data and using them to create and make available multi-resolution maps of the European seas covering seven thematic areas, including biology (*i.e*., temporal and spatial distribution of marine species and species traits from all European regional seas), and human activities (https://emodnet.eu/en).

OBIS SEAMAP, the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations, is a spatially, temporally interactive online archive for marine mammal, sea turtle, seabird, ray, and shark data that was established by a group of researchers in 2002 as a thematic node of the Ocean Biodiversity Information System (OBIS). OBIS was one of the projects of Census of Marine Life and now under IOC-UNESCO's International Oceanographic Data and Information Exchange (IODE). The network aims at increasing the understanding of the distribution and the ecology of marine mammals, seabirds, sea turtles, rays, and sharks, which is made possible by data sharing from contributors all over the world. Along with the spatial database, it provides useful mapping and graphical tools to explore species occurrences across the globe (https://seamap.env.duke.edu/).

INTERCET is a Web-GIS platform developed by Acquario di Genova for Regione Liguria in 2009, with the aim of promoting data aggregation and integrated analysis between Mediterranean research partners on a long term basis (Gnone *et al,* 2011). With the TursioMed project (2014-2017), this tool was used to support networking on bottlenose dolphins at the Mediterranean level by involving 29 partners that shared data on cetacean species collected between 2004 and 2016 (Gnone *et al,* 2020). It further developed into the InterMed project, running between 2020-2022, which was conceived to support the finalization and implementation of the Conservation and Management Plans for *T. truncatus*, *D. delphis,* and *G. griseus* at the Mediterranean level (www.intercet.it).

5. Methods for data analysis

5.1.Spatial and temporal scope

As spatio-temporal scales are relevant for long-lived and far-ranging species, monitoring surveys are required to be carried out across basins, seasons, and preferably over sufficient time periods to allow the detection of temporal trends, modelling seasonal and annual movements of animals, and gathering supporting evidence for the definition of management and conservation measures (Evans and Hammond, 2004).

When processes interact at different scales, the long-range, long-term process acts as a boundary for the short-term, short-range process; in order to intercept these variations, the monitoring should be cost-effective and coordinated over sufficient time (Patricio *et al*, 2016). Brereton *et al* (2003b) estimated that an 18-year monitoring period would detect a significant population trend for *D. delphis* with the current fixed-survey method.

Monitoring programmes have to deal with two potential sources of errors: the first due to the inability of surveying the entire area of interest, the second due to the inability of detecting all individuals or species within the surveyed area (Katsanevakis *et al,* 2012). Results of monitoring must consider this uncertainty and separate any natural (temporal or spatial) variability from the uncertainty due to lack of information (UNEP/MAP, 2017b; IUCN, 2019). Indeed, despite large scale programmes performed over decades to provide robust population estimates and assess changes in abundance (Hammond *et al*, 2013, 2017), surveys carried out with a higher frequency (yearly-monthly) exclude uncertainties due to annual variations, better characterize spatial distribution (Kiszka *et al,* 2007; Certain *et al,* 2008), detect low density species (Williams *et al*, 2002; O'Brien *et al*, 2009; Robbins *et al*, 2020), and assess seasonal variability (Arcangeli *et al*, 2013a, c, 2017; Vella, 2014; Azzolin *et al*, 2016). For this reason, in 2013 ACCOBAMS co-funded the monitoring activities of cetacean and other macro-fauna species along ferry routes from Tunisia to Italy, within the FLT MED NET, with the aim of contributing to understanding the marine ecosystem complexity in the Strait of Sicily (Aissi *et al*, 2014). In fact, by abating the costs of monitoring through the use of commercial vessels, the fixed-route networks provide year-round sightings data on a long-term basis, which contributes to the assessment of large marine vertebrate distribution and abundance in large marine ecoregions (*e.g.*, OSPAR, MSFD, UNEP/MAP).

5.2.Data analyses

As reported by Palialexis *et al* (2019), survey-based assessments are suitable methods for assessing the distribution of species, even with the constraints of imperfect detectability. To date, many published studies have addressed presence, abundance, distribution, and trends of large vertebrate species using data collected from fixed-route vessels.

To prepare this chapter of the document and provide a detailed overview of the analyses performed, all the scientific production derived by the monitoring networks using ferries and cargos (i.e. ORCA, FLT MED NET, CETUS) was considered. In addition, complementary information by any other similar programme in European waters was obtained by searching for more bibliographic references in Google Scholar and Researchgate. As a result, almost 60 international and national research papers, 7 technical reports and over 14 conference abstracts and proceedings were consulted. The largest proportion of the scientific production derived from the FLT MED NET and the experiences in the North Atlantic (ORCA and IWDG), while the CETUS project contributed a smaller proportion, according to the more recent development of this programme (see Annex I).

The following sections report the analyses that are performed on data collected from large vessels, reviewed from published papers, in order to respond to the policies requirements.

5.2.1. Preliminary analyses

Data exploration is performed prior to any deeper investigation to evaluate the representativeness and robustness of the datasets, in order to detect possible biases and ensure data homogeneity.

a To inspect the community composition, **sightings frequencies** are computed, representing the proportion of each species sightings in the entire effort dataset (MacLeod *et al*, 2005; Wall *et al*, 2006; Aissi *et al*, 2015; Correia *et al,* 2020). Data can be split into years/seasons to verify the number of records available and plan subsequent analyses.

b To evaluate the effect of observation conditions on species detection:

platform characteristics have been tested with a linear model including cruise speed and deck height by Cominelli *et al* (2016), showing the main influence on sighting distances by height;

weather condition effects have been considered in generalised models on abundance index (GLM, Cominelli *et al*, 2016; GAM Bouveroux *et al*, 2020), or multiple covariate distance sampling on the density index (MCDS, Cominelli *et al*, 2016). In order to get sampling units representing a continuous period of effort under the same meteorological conditions, a single transect can be divided into several sampling units (Cominelli *et al*, 2016).

c To assess spatial and temporal **auto-correlation** of data collected along the fixed routes, Spearman's rank correlation test has been applied to estimates computed from transects of the same area and sampled within the same day or consecutive days, or within the same week (Arcangeli *et al*, 2013c, 2014c, 2016c; Tepsich *et al*, 2020).

d In order to avoid biases due to poorly surveyed areas/seasons, a **minimum sampling** effort criterion has to be set. Preliminary exploratory data analysis (Kuletz *et al*, 2015) has been done by plotting effort with ER and Z score values, finding the limit of effort per cell when the variance of the ER does not appreciably change (Arcangeli *et al*, 2016c, 2017).

The number of sightings and number of species observed in relation to the sampling effort have been also modelled with GAM (Correia *et al*, 2020).

5.2.2. Population (MSFD D1 C2; IMAP EO1 CI4)

Effort data collected simultaneously with sightings data enables the calculation of standardised estimates for each species at various spatial/temporal scales. The **relative index of abundance** (as IUCN, 2019) can be inferred through a visual census but does not provide an absolute estimate of population size (Palialexis *et al,* 2019). It is the only method applicable for non-commercial species that cannot be captured with fishery-dependent methods and provides a tool for long-term monitoring to help identify the population status and early signs of changes, in order to drive marine management policies. This parameter can be reported as:

a **Encounter Rate (ER) - Sightings per Unit of Effort (SPUE)** calculated as:

*N sightings/km effort (*10, *100)* (MacLeod *et al*, 2005; Kiszka *et al*, 2007; Aissi *et al*, 2015; Correia *et al*, 2015, 2020; Arcangeli *et al*, 2014c, 2016c, 2017, 2019b; Cominelli *et al*, 2016; Morgado *et al*, 2017).

N sightings/ hour effort (Arcangeli *et al*, 2013c; Santoro *et al*, 2015)

N animals/ hour effort (Wall *et al*, 2006, Wall 2013)

N animals/1000 km effort (Brereton *et al*, 1999)

Specific <u>occurrence Index</u> can be calculated as ER relative to each sub-region by the overall ER calculated for the entire study area at the same temporal scale (yearly/monthly, Morgado *et al*, 2017).

b **Species density (D)**, computed by <u>strip-transect</u> framework analysis applied to the dataset (Cominelli *et al*, 2016; Tepsich *et al*, 2020). In order to take into account possible biases for imperfect detection, distance sampling analysis have been applied by computing the Effective Strip Width (ESW) for each different type of ship used, in order to set the total width of each transect for each species (Cominelli *et al*, 2016; Robbins *et al*, 2020; Tepsich *et al*, 2020; Arcangeli *et al*, 2021; David *et al*, *in prep*.). The density is calculated, after fitting the detection function with the number of individuals and perpendicular distance from the transect, as:

*D = N/2ESW L*100*

where N, number of individuals; 2ESW, total width of the transect; L, length of the transect (km).

Another method to estimate density is based on modelling distances between detections, called waiting distances, because in areas of high density the waiting distance between detections is short (Cotté *et a*l, 2009).

c Abundance can be estimated also through the detection function, using data from the length of all the transects, with distance sampling analysis.

d Univariate analysis is carried out on these indices stratifying the data per year, sector, season, testing for intra-annual differences or differences across the study period prior to pooling data.

e Composite index, *i.e.* an aggregation of indicators into a single representation (Teixeira *et al*, 2016), has been developed as a way of describing change in cetacean populations (Brereton *et al*, 2003b) that can be applied at a country level.

5.2.3. Range (MSFD D1 C4; IMAP EO1 CI3)

The spatial resolution of data improves the understanding of large vertebrate distribution/movements and enables a more informed evaluation of the relative importance of pelagic regions for marine key species.

Spatial reporting may be variable according to the study area, the species and the objective of the study: for example 1x1 km or similar was applied to investigate fine scale habitat preference (Lambert *et al*, 2011; Arcangeli *et al*, 2013c, 2016c; Correia *et al*, 2015; Bouveroux *et al*, 2020), 4x4 km for coherence with resolution of remote sensing data (Arcangeli *et al*, 2014c; McClellan *et al*, 2014; Zampollo *et al*, *submitted*), 5x5 km was used for bottlenose dolphins in the Tuscany Natura 2000 site (Arcangeli *et al*, 2021) or in wider areas (Leeney *et al*, 2012; Arcangeli *et al*, 2017, 2019b; Morgado *et al*, 2017; Robbins *et al*, 2020), 10x10 km, according to the HD reporting scale was used by Brereton *et al* (2012) and Matear *et al* (2019), 14x14 km (MacLeod *et al*, 2009), and larger grids (ICES grid cells, Brereton *et al*, 1999, 2003b; Aissi *et al*, 2015; 100x100 km, Correia *et al*, 2020). In the latter cases, it would be difficult to include such information in policy reports requiring finer scales (DG Environment, 2017; IUCN, 2019). A multiple-steps process taking into account effort and sightings first on 1km and then on 5km grids has been used by Ham *et al* (2021) and Grossi *et al* (*submitted*).

Grid mapping has been used to represent the following information:

a To represent species distribution, the proportion of surveyed cells where a species is detected defines the species occupancy (presence/absence), while the distribution area is the sum of the areas of cells where the species is present. It represents a simple alternative to abundance in particular for large scale surveys (Brereton *et al*, 2000; MacLeod *et al*, 2009; Katsanevakis *et al*, 2012).

b To define the minimum range of the species, interpolation techniques are used (Arcangeli *et al*, 2016c, 2021).

c To identify the locations of statistically significant hotspots and coldspots for the species, spatial records are tested to highlight whether data showed random or clustered patterns using the Average Nearest Neighbour and the Morans I index, and data with clustered patterns are investigated by Getis-Ord Gi* analysis (Getis and Ord 1992; Arcangeli *et al*, 2017, 2019b).
To define hotspots for a species, an aggregation index has been computed as the number of sightings/animals, standardized by the mean and by the standard deviation of that sub-region (Morgado *et al*, 2017). Grossi *et al* (*submitted*) looked at hotspots persistence over a 10-year period, after classifying cells as occasional, regular or hotspot on a yearly basis.

These analyses have been performed also on abundance indices, both SPUE or density, computed on grid cells, to also investigate seasonal patterns (Kiszka *et al*, 2007; Brereton *et al*, 2012; Arcangeli *et al*, 2017, 2019b; Valente *et al*, 2019).

5.2.4. Habitat for species (MSFD D1 C5)

Even with a good spatial coverage, data from fixed routes may not acquire sufficient information on all species, especially the wide-ranging, low-density or deep-diving ones. Therefore, data may be limited to just a set of presence values of each species, and the distribution is mainly based on extrapolation from the limited amount of data from surveyed transects (Palialexis *et al*, 2019). By using information on auxiliary datasets, such as environmental variables, it is possible to predict the probability of occurrence of the species in areas where no data are available and analyse fine scale habitat use through different techniques:

Species Distribution Models

A Species Distribution Model (SDM, or environmental envelopes) can be defined as a statistical and/or analytical algorithm that predicts (either actual or potential) distribution of a species, given field observations and auxiliary maps (Hengl *et al*, 2009). These techniques help define the habitat features which species show a preference for and provide estimates of uncertainty (standard errors; confidence intervals) that have to be critically reported, analysed, and interpreted.

When the goal is to encompass habitats or features that will benefit a larger community, the use of species assemblages or guilds, such as top predators, may be a practical option.

a. <u>Models based on "occurrence-only records":</u>
   Kernel smoothing techniques (Arcangeli *et al*, 2013c, 2016c, 2021), Maximum Entropy method (McClellan *et al*, 2014; Azzolin *et al*, 2020; Zampollo *et al*, *submitted*), Ecological-Niche Factor Analysis, Genetic Algorithm for Rule-Set Prediction, Multinomial Logit models, Regression-kriging method (Monestiez *et al*, 2006). In some cases, the abundance index has been used as occurrence data, so also the information on the sighting effort can be included in the analysis (Monestiez *et al*, 2006; Azzolin *et al*, 2020).
b. <u>Models based on "presence/absence records":</u>
   The repeated sampling over the same route allows the definition of 'absence' data, setting a minimum effort threshold (Arcangeli *et al*, 2016c, 2017); when large sightings datasets are available, presence points of a species can be compared to absence points considering the sightings of other species as absence points sightings data (Lambert *et al*, 2011; Valente *et al*,. 2019). The main models used are:
   GLM (Arcangeli *et al*, 2013c; Bouverox *et al*, 2020), GAM (Correia *et al*, 2015, 2020; Arcangeli *et al*, 2016c; Valente *et al*, 2019; Azzolin *et al*, 2020; Ham *et al,* 2021; Grossi *et al, submitted*), Logistic regression, Neural Networks, ordination, and classification methods (Lambert *et al*, 2011), Bayesian models, Density surface modelling (corrected for uncertain detection via distance sampling methods).

Quantile analysis

To compare the habitat where the species are present to the available habitat in the study area, a quantile analysis (boxplot) has been performed, through a set of equidistant points created along the effort tracks (Correia *et al*, 2015, 2020) or across the study area (Arcangeli *et al*, 2016c; Azzolin *et al*, 2020).

5.2.5. Trends

Long-term datasets are needed for reliable trend estimations, and 10 years has been identified as a suitable interval for short-term trend assessments (IUCN, 2019; Palialexis *et al*, 2019). The effectiveness of collecting long-term data from fixed routes is demonstrated by the robust results reported by several papers, also allowing quantitative predictions of how the ranges of species is changing and how it may respond to the changing environment (pressures, climate change).

Trends in abundance

- Population trends have been assessed considering different measures of relative abundance (SPUE, density) (Cominelli *et al*, 2016; Arcangeli *et al*, 2013c, 2016c, 2021; Tepsich *et al*, 2020).
- Long-term population trends have been assessed by linear modelling (poisson regression) on relative abundance by Brereton *et al* (2003b), or GAM on species density (Tepsich *et al*, 2020).

Trends in range

- Range trend values have been estimated through the simple assessment of the species occupancy over a defined period (MacLeod *et al*, 2009), by calculating the percentage differences in species occupancy between two investigated periods (Arcangeli *et al*, 2021).
- Trends in distribution have been also assessed by comparing mapping of sightings frequencies and relative abundances (MacLeod *et al*, 2005), or sighting densities (Arcangeli *et al*, 2021).
- Further investigation has been done through spatial analyses comparing core areas of presence obtained with Kernel smoother based on sighting densities/abundance (Arcangeli *et al*, 2013c, 2014c, 2016c, 2021).

Trends in habitat for species

- Trends in habitat for the species have been evaluated by comparing suitability models computed for different periods (Arcangeli *et al*, 2016c) or combining predictions from a habitat niche with climatic niche models (Lambert *et al*, 2011, 2014) or other risk factors.
- Power analysis was used to help assess the sensitivity of current monitoring and to identify survey design improvements (Brereton *et al*, 2003b).

5.2.6. Biodiversity hotspots

Visual census surveys obtain a quite complete species list (Palialexis *et al*, 2019). To identify key areas that support a high diversity of marine species and satisfy criteria to be qualifyed for IMMAs, MPAs, or SACs, as required under the current conservation policy, the spatial reporting of species <u>diversity/richness</u> is a useful method (Leeney *et al*, 2012; McClellan *et al*, 2014; IUCN MMPATF, 2017; Matear *et al*, 2019; Correia *et al*, 2020; Campana *et al*, *submitted*).

In order to characterize species diversity for the marine community and the allocation of individuals over species, diversity indices are used (McClellan *et al*, 2014): Simpson's diversity index, Shannon diversity index, Evenness (Aissi *et al*, 2015; Arcangeli *et al*, 2017; Matear *et al*, 2019; Campana *et al*, *submitted*).

To spatially highlight the conservation priorities, a <u>sensitivity index</u> has been developed by Arcangeli *et al* (2017), based on the factors that could determine higher magnitudes of risk for species, such as the areas/seasons of higher species diversity, the presence of juveniles, and higher abundance (Arcangeli *et al*, 2017; Campana *et al*, *submitted*).

5.3. Example of data analyses in protected areas

Data obtained from the fixed-routes monitoring programs are useful for answering different legislative criteria, so they can be also considered as a tool for the surveillance activity in protected areas, such as large SPAMI or Natura 2000 sites (David *et al*, 2020). Some recent papers demonstrate the usability of these data, bringing comparative elements in space and time, for the purposes of assessment and reporting under the HD and MSFD; in addition, the possibility of further monitoring conducted within these networks could provide integrative information for the next reporting intervals, in order to confirm the significance in trends or not.

Cetaceans in the Pelagos Sanctuary

Cetacean species presence has been investigated by David *et al* (2020) along one route of the FLT MED NET on the eastern side of the Pelagos Sanctuary through analyses on spatial distribution, encounter rate, and species richness, compared between two study periods (2014-2016 and 2011-2012). In addition, these results were compared for striped dolphin and fin whale to another route on the south-western part, showing fin whales arriving in spring from the east whereas they are present all year-round on the western part; although no marked migration patterns were detected, the results showed a different seasonal use of the sanctuary, which can provide useful information for management implications.

Fin whale trends in the Pelagos Sanctuary

Within the FLT MED NET, many ferry routes cross the large SPAMI of the Pelagos Sanctuary, where data on cetacean species have been collected every summer since 2008. The density of fin whale recorded along the sampled transects allowed Tepsich *et al* (2020) to investigate interannual variability and intra-basin differences over an 11-year period, which is considered an appropriate temporal scale to detect changes in abundance (IUCN, 2019). Through GAM modeling, short-term trends in abundance were investigated during two 6-year periods (2008-2013, 2014-2018), almost coinciding with the HD reporting periods, allowing for the interpretation of these results within the framework of the main EU directives.

Bottlenose dolphin trends in the Natura 2000 site

Following the designation of the Natura 2000 Network at sea Sites in Italy, the Tuscany Region confirmed a new marine SCI specifically for the protection of *Tursiops truncatus*. Within the Tuscan Archipelago, two routes have been monitored within the FLT MED NET since 2008, continuously covering years and seasons. A study conducted by Arcangeli *et al* (2021) showed the capacity of the dataset collected from the research network in the area of the SCI during two HD reporting periods (2007-2012 and 2013-2018) to investigate short-term trends of bottlenose dolphin in the protected area: population trend values were estimated through SPUE and density analysis, while range trends were assessed through spatial analyses on occurrence and core areas.

6. Gaps, research needs and future developments

With national and international directives increasingly demanding information on the status of the marine environment and threatened species, commercial vessels travelling along fixed-line transects are a practical, inexpensive solution for obtaining extensive spatial and temporal data for regional-scale population monitoring and for the development of management priorities, providing often much larger datasets than dedicated marine platforms (Pace *et al*, 2019). Indeed, the more scientists can access remote areas and provide information on trends and abundance as inexpensively as possible, the more they are likely to gather the information needed to prioritise conservation strategies (Williams, 2003). The contents of this report further highlight the importance of these platforms of observation for long-term, large-scale and cost-effective monitoring programs (Arcangeli *et al*, 2012; Santoro *et al*, 2015). However, as any other methodological approaches, this one has its advantages and disadvantages too, and to guarantee its further development and implementation, it is necessary to consider what are the main limitations and which issues should be addressed for its improvement. The main challenges highlighted within the literature considered in the report are related with analytical and data collection methods, technological developments, the access to open-source datasets, and international cooperation and data-sharing.

Improving data availability: increasing spatial and temporal coverage and frequency of surveys

Current regulations have led to great efforts by Member States to improve monitoring activities and coordinated assessments (Alessi *et al,* 2017). However, spatial gaps still exist, due to the uneven distribution of research effort during the last decades (Patricio *et al*, 2016). In particular, the south-eastern portion of the Mediterranean Sea is amongst the areas with the most limited knowledge on marine megafauna presence and distribution (Mannocci *et al*, 2018; UNEP/MAP, 2017a). There is the need to develop/adopt cost-effective and innovative methods for monitoring, while giving priority to lesser known areas. The use of large vessels as monitoring platforms can surely be convenient to survey these areas, even to overcome economic or logistics constraints (Aragones *et al*, 1997; Berrow *et al*, 2012; Aissi *et al*, 2014), and has the potential for extensive temporal coverage.

However, where a limited range of commercial platforms can be used to perform surveys, the spatial distribution of biodiversity cannot be extrapolated beyond their routes (Matear *et al*, 2019). Adding more routes would increase representativeness and enable the data to be used to provide robust abundance indices and trends for individual species and species groupings (Brereton *et al*, 2011). A larger sample size would mean that stricter criteria could be used to compile indices (*e.g*. to avoid pooling data collected with different sea states), allowing the reduction of biases and leading to more realistic trend estimates (Brereton *et al*, 2011; Arcangeli *et al*, 2012).

Existing monitoring programmes can also improve survey frequency, for example with Citizen Science approaches (Robbins *et al*, 2020) or by integrating other methodologies on board the platforms used for visual surveys. Novel non-invasive and cost-efficient sampling methods to derive population size like eDNA metabarcoding (Palialexis *et al*, 2019) to detect marine vertebrates (*e.g*., Closek *et al*, 2019; Valsecchi *et al*, 2020) also demonstrate the feasibility of non-dedicated survey cruises as platforms for eDNA marine sampling (Valsecchi 2021).

The integration of species surveys can also be planned in other marine monitoring programmes, through the mutual use of platforms and observers, resulting in an optimisation of logistics and costs: for example, the monitoring of other species included in MSFD D1, such as sea turtles or sea birds, can be implemented on the same platforms already employed for cetacean monitoring, in order to provide effort-related data on these marine species at sea (Eguchi *et al*, 2007; Arcangeli *et al*, 2019b; Zampollo *et al*, *submitted*). Another example is the monitoring of jellyfish, conducted along some routes of the FLT MED NET: these animals are included by Italy within the functionally important groups as indicators of GES in the MSFD descriptor 4 'Food webs' (Tunesi *et al*, 2013).

Operational parameters: the need for standardization

The weakest aspects of all visual survey methods have been often identified in poor standardisation of data and methodologies, and observational biases, which can directly impact the accuracy and reliability of findings, (Matear *et al*, 2019). Indeed, as mentioned above, to detect variations in presence, abundance and distribution of species and to understand the effects of anthropogenic factors, monitoring programs need to collect data in a standardized and accurate way (Santoro *et al*, 2015). However, given the variability among potential platforms in some operational parameters, especially those directly related with the structural aspects of the platform, some of the observational parameters may change. For this reason, data should always be standardized for platform type, and operative conditions should always be recorded. In addition, specific analyses for the different species /platform / sighting conditions should be done for intra and inter-routes. The implementation of rigorous line-transect protocols on all surveys, allowing detectability to be determined independently from density variation, would help standardize results from different surveys, and obtain reliable spatio-temporal trend estimates (Thomas, 2009). Following a standardized protocol improves data management, sharing, and integration, and allows comparisons of spatial and temporal distribution of species and the detection of changes, providing reliable information for their management (Cominelli *et al*, 2016).

Quality assurance and data validation

For them to be used for conservation purposes, the reliability and quality of data must be constantly improved (Dalili, 2019). To assure the quality of data, it is important to identify incomplete data or errors early in their “life-cycle”. An early identification of errors facilitates a timely communication with the data collectors to correct data or to provide them further training. To maintain their quality, data should be checked for accuracy as they are collected in the field, with further exploration for broader patterns soon after the survey (Robbins *et al*, 2020). Further precautions to guarantee the quality of data include allowing short cross-over periods between observers/recorders, so that when the survey team cycles through roles, environmental conditions or other factors could be discussed between the old and the new observer to ensure consistency. An experienced individual should be responsible for checking that data collected by less experienced observers are logical and accurate. In addition, photographs of animals could be taken to confirm identification skills.

The importance of training

To further allow a consistent and accurate data collection, observers must be professionally trained on how to collect information, identify individuals, take the necessary measurements at sea, and report the information in a standardized way. Training should include field sessions with experienced observers during which less experienced individuals could discuss their questions and their surveying techniques could be evaluated for accuracy by experienced researchers (Robbins *et al*, 2020). Also, experienced recorders should undergo periodical training with peers to avoid developing bad habits that vary from the intended protocol and to get updated on any modification or improvement in data collection protocols.

Improving the data collection process: tools and mobile applications

To guarantee that data are collected in a consistent and precise way in the field, the use of tools and mobile applications is also encouraged. Thus, instruments such as reticle binoculars and angle boards should always be used by the observer to precisely assess angles and distances at sea; to understand the implications of a poor data collection, observers need to be aware of the assumptions of line transect methods (Brereton *et al*, 2011). The development of dedicated mobile applications, with strict criteria for the input and incorporation of data regarding effort, species ID, behaviour, and other necessary information, provides further support for obtaining structured and consistent sighting data (Pace *et al*, 2019).

Improving data integration

Future efforts to manage and conserve marine resources would benefit from the application of new monitoring technologies to improve capabilities to monitor species abundance, diversity, and distribution patterns in marine ecosystems. The complementarity of methods and data at different spatial and temporal scales is encouraged, as no single method will be enough to monitor all parameters and all species (Southall *et al*, 2005; Berrow *et al*, 2012; Katsanevakis *et al*, 2012; UNEP/MAP, 2019). In particular for oceanic species, the combination of methodologies can fill the gaps between different approaches, delivering useful information for the species assessments; as previously shown, abundance estimates can be calculated for the observed species when dedicated survey design and monitoring is performed (Hammond *et al*, 2017), which is difficult for ferries/cargos where fixed routes are not decided by researchers. On the other hand, monitoring programmes on fixed routes can sufficiently cover a defined study area with a higher survey frequency and deliver complementary information on fine-scale habitat use and seasonal patterns.

The use of different platforms can also balance the pros and cons of the different types of monitoring; the line transect method applied from observation platforms with different characteristics, such as sailing vessels, ferries, or airplanes, can provide complementary data over the same area. This is particularly relevant for areas of conservation interest, such as MPAs or SACs where different scales of information are needed; for example, ferry-based surveys can be adopted to monitor adjacent waters beyond the boundaries of a protected area to inform on the management of biodiversity, including migratory species (David *et al*, 2020), while small-scale surveys, land-based observation, or stranding data can report details on local populations (Leeney, 2007; Berrow *et al*, 2012; Cinti *et al*, 2014; Matear *et al*, 2019).

Other complementary data can be obtained, for example by citizen science (Vella, 2015; Robbins *et al,* 2020), satellite tracking (Southall *et al*, 2005; Cotté *et al*, 2009), acoustic monitoring (Leeney, 2007), aerial surveys (Leeney *et al*, 2012; Vella, 2013), photo-ID (Brereton *et al*, 2018), and stranding records (MacLeod *et al*, 2005; Lambert *et al*, 2011).

The combination of different datasets, collating information from different research groups, represents a powerful way to fill gaps at a regional/basin scale and understand species trends to drive coordinated conservation policies, as confirmed by the numerous publications where data from fixed-routes have been included (Druon *et al*, 2012; Cañadas *et al*, 2018; Pace *et al*, 2019; Valente *et al*, 2019).

Such data can flow into wide biological web databases, such as the OBIS, EMODNet Biology (*e.g*., Correia *et al*, 2019a) or the Intercet Platform (Gnone *et al*, 2011, 2020), to enhance the sharing and availability of data on these species.

Defining targets and indicators: synoptic monitoring of other species and threats

Commission Decision (EU) 2017/848, laying down the criteria and methodological standards on GES of marine waters and specifications and standardised methods for their monitoring and assessment, requires that, for marine mammal species, both state and pressure indicators are developed. However, the abundance and conservation status of several cetacean populations, as well as pressures and potential threats, are still under assessment (Pace *et al*, 2019). Continuous effort should be allocated to defining monitoring metrics and realistic targets and to develop and test methods for spatio-temporal trend estimates (Thomas, 2009). Effort-based relative abundances obtained within fixed-transect surveys could be used as indicators for management purposes and to construct a long-term dataset. Given the influence of the seasonality of oceanographic processes over the distribution and habitat use of cetaceans, conservation targets for these species should account for this dynamism and capture the entire life cycle (*e.g*., seasonal migrations; Valente *et al*, 2019). To obtain more robust data to feed management and conservation, monitoring programs should be encouraged to systematically monitor ecologically relevant species and threats. Synoptic data should be collected regarding other endangered species, or species that are relevant for the assessment of the health of the marine ecosystems (*e.g*., jellyfish), as well as their potential threats, including reporting *e.g*., oil spills, driftnets, entanglements, or any other potentially relevant pressure for marine species.

Science-policy-society interactions

The willingness of commercial companies to welcome scientists onboard commercial vessels highlights that most seafarers are interested in conserving the marine environment. Also, the involvement of adequately trained volunteers in these monitoring programs increases public awareness of marine environmental issues, which in turn could enhance the perception of the value of marine conservation (Brereton *et al*, 2011). Indeed, although the science-policy-society interactions are evolving positively, the encouraging results of the experiences described in this report could be used to further push the use of the obtained data for conservation and management purposes and build environmental responsibility into maritime companies and the society. Dedicated initiatives should be developed to increase local public awareness and knowledge regarding the effects of human activities on cetacean species and environmental education and outreach programs (Pace *et al,* 2019; Dalili, 2019).

Integration with other approaches and new technologies

While the scientific value of data obtained from fixed-line surveys is undoubtedly recognised, these platforms cannot replace dedicated platforms for the collection of specific data, such as photo-ID, or biopsies. In this case, the integration of different survey methods is recommended (Matear *et al*, 2019). Moreover, in regions and seasons that are not currently surveyed given the limitations derived by commercial companies' schedules or weather conditions, other technologies less dependent on factors affecting the human capacity to detect animals could be used to achieve year-round monitoring (Correia, 2020): these include the use of passive monitoring techniques, the use of autonomous vehicles, or the aforementioned technique of eDNA analysis.

Data sharing, cooperation and coordination

The protection of international waters requires international agreements and depends on the capacity to work in cooperation towards conservation and management goals (Correia, 2020). To obtain such ambitious results, international collaborations are powerful tools for enhancing large-scale monitoring for the conservation of key species (Robbins *et al*, 2020). To increase spatial coverage among smaller-scale research initiatives, it is necessary to gather their data in a shared database. To do so, data must be collected in a shared format. An extensive dataset where open-source data is shared across countries would allow researchers, governments, NGOs, and other stakeholders to have access to data for conservation and management projects (Dalili 2019).

Coordinated research activities such as those promoted within the IMPEL project FLT EUROPE underlying this report are essential. Gathering monitoring networks to share experiences and identify gaps is necessary to substantially improve the scale and quality of data obtained and thus the power to detect spatial and temporal trends. Coordination is particularly important to further standardise data collection methods and data format, create central databases, identify new potential routes, organise standard regular training, and regular meetings for partners and key stakeholders to provide feedback (Brereton *et al*, 2011).

7. Conclusions

The wide European legislative framework requires information at different levels and scales in order to respond to specific conservation goals. The use of systematic surveys performed using fixed-route vessels, such as ferries and cargos, has demonstrated to be a cost-effective methodology for carrying out efficient data collection on large marine vertebrates, as well as on different components of the pelagic ecosystem, such as other marine species or human pressures.

The amount of scientific literature produced with data coming from these kinds of surveys, spanning throughout a variety of topics, is surely an indication of the robustness of the data collected, especially when considering multiple routes that share a common monitoring protocol to overcome methodological differences. These data are improving the knowledge on marine species and delivering essential information that can be used not only to address local conservation requirements in the Mediterranean Sea and North Atlantic, but also to assess and evaluate the different parameters indicated by the main EU policies. Table 8 summarises the data analyses applied with respect to the legislative criteria. These results confirm that networks developed on platforms of opportunity travelling along fixed routes represent a valuable tool for the monitoring activities that must be implemented within the scopes of the environmental legal framework.

Table 8. Data analyses applied with respect to the parameters/criteria of the main EU policies.

HD	MSFD Descriptor 1	OSPAR JAMP 2014–21	Barcelona Convention Ecological Objective 1	CMS	IUCN Red List
Population	C2	Population abundance	Common Indicator 4	Population distribution and abundance	Population size
Relative index of abundance (SPUE, density) - Trends					
Range	C4	Geographical range and distribution	Common Indicator 3	Species range, population distribution	Range
Occupancy, interpolation techniques, species hotspots - Trends					
Habitat of species	C5				Habitat quality included in the range
Species distribution models, quantile analysis - Trends					

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1 Websites

Legislation and organizations

ACCOBAMS *https://accobams.org/*

ASCOBANS *https://www.ascobans.org/en*

Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution *https://www.unep.org/unepmap/*

Biodiversity strategy for 2030 *https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en*

Commission on the Protection of the Black Sea Against Pollution *http://www.blacksea-commission.org/_convention.asp*

Convention for the Protection of the Marine Environment of the North-East Atlantic *https://www.ospar.org/convention*

Convention on Biological Diversity *https://www.cbd.int/convention/*

Convention on the Conservation of European Wildlife and Natural Habitats *https://www.coe.int/en/web/bern-convention/presentation*

Convention on the Conservation of Migratory Species of Wild Animals *https://www.cms.int/en*

Convention on International Trade in Endangered Species of Wild Fauna and Flora *https://cites.org/eng/disc/what.php*

Convention on the Protection of the Marine Environment of the Baltic Sea Area *https://helcom.fi/about-us/convention/*

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Directive 2014/89/EU of the European parliament and of the council of 23 July 2014 establishing a framework for maritime spatial planning
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0089

International Council for the Exploration of the Sea
https://www.ices.dk/about-ICES/Pages/default.aspx

International Union for Conservation of Nature's Red List of Threatened Species, IUCN 2021 (last accessed March 2021) *https://www.iucnredlist.org/*

International Whaling Commission *https://iwc.int/home*

Pelagos Sanctuary *https://www.sanctuaire-pelagos.org/en/*

RAMOGE *http://www.ramoge.org*

United Nations Conference on the Environment
https://www.un.org/en/conferences/environment/stockholm1972

United Nations Convention on the Law of the Sea
https://www.un.org/Depts/los/convention_agreements/texts/unclos/UNCLOS-TOC.htm

Monitoring networks websites

FLT Mediterranean Monitoring Network
https://www.isprambiente.gov.it/it/attivita/biodiversita/lispra-e-la-biodiversita/attivita-e-progetti/flt-mediterranean-monitoring-network-marine-species-and-threats

ORCA Network *https://www.orcaweb.org.uk/*

CETUS Project *https://www2.ciimar.up.pt/projects.php?id=59*

9. ANNEXES

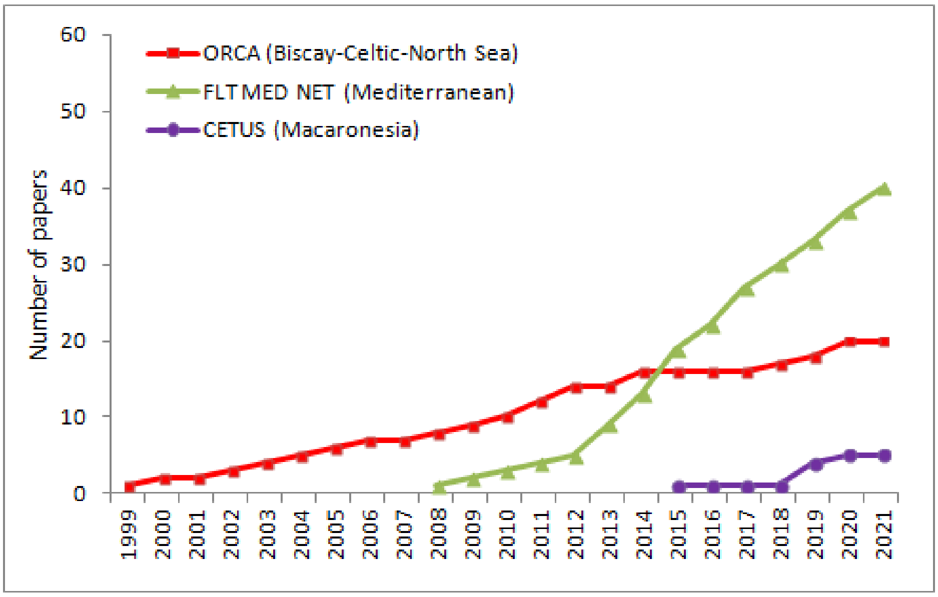
ANNEX I. Analysis of the publications produced by the monitoring networks along fixed routes in EU waters

A total of 68 peer-reviewed publications made by the research networks ORCA, FLT MED NET, and CETUS between 1999 and June 2021 have been consulted for this report in order to describe protocols and data analyses performed. A deeper analysis was made to describe and quantify the evolution of these research efforts and identify the main focal areas and species. For each paper, information on publication year, regions, and species studied was collected.

The geographic scope of the studies has been compared with the MSFD regions and subregions and is obviously reflecting the coverage of the networks; in particular, ORCA operates in the Bay of Biscay and the Iberian Coast, Greater North Sea, and Celtic Seas, the FLT MED NET in Western Mediterranean Sea, Adriatic Sea, and a small portion of the Ionian Sea, while CETUS covers the Macaronesia subregion.

The number of publications by year has been driven by the work of ORCA between 1999 and 2009, then it significantly improved after 2013 with the research from the FLT MED NET with a continuous positive trend; the start of the CETUS monitoring programme has also contributed to the number of papers in the last five years (Fig. A). Considering the species studied, all networks have provided data on a large variety of cetaceans, with the majority of the studies regarding fin whales and the most common dolphins species (*D. delphis, S. coeruleoalba* and *T. truncatus*). Large datasets available from these monitoring networks also studied the less distributed species, such as Cuvier's beaked whales or killer whales. On the contrary, publications on sea turtles are still few, even if these animals are included in the observation protocols of the monitoring networks.

This analysis highlights the important contribution of these monitoring groups in enhancing knowledge about large marine vertebrate species across the different regions of European waters.



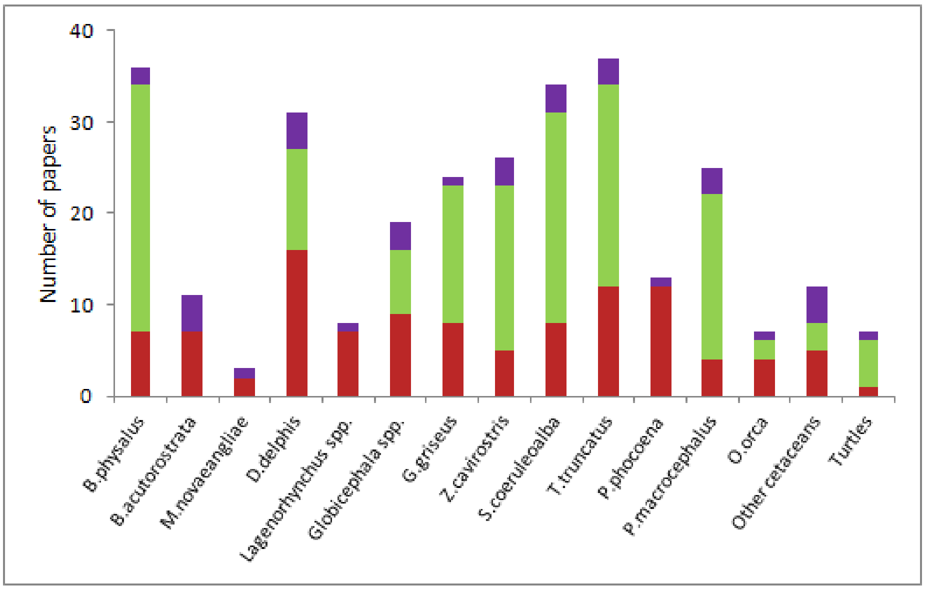


Fig. A. Number of papers published between 1999 and June 2021 by the three European monitoring networks using large vessels travelling along fixed routes, reported by year and species studied.

ANNEX II. Field monitoring protocols used by ORCA, FLT MED NET, CETUS

1. ORCA distance sampling cetacean survey protocol

AIMS OF THE PROTOCOL

This protocol describes the survey methods applicable for cetacean single platform distance sampling surveys on board platforms of opportunity (i.e. ferry and cruise ships). It is suitable for surveys that aim to collect data to determine species distribution, sightings rates, and density. You will be collecting effort data (which tells us how long you searched for cetaceans), environmental data (which tells us what the weather and sea conditions were like whilst you were searching), and sightings data (which tells us about the animals you sighted).

CONDITIONS FOR SURVEYING

General

When you arrive on the ferry your Team Leader will introduce the team to the reception staff no sooner than 30 minutes after departure – on some routes 45 minutes where there is still a lot of activity. The Team Leader will ask them to clear it with the bridge that you can go up and start the survey. Only go onto the bridge directly if you've been told it's ok to do so – you will usually be escorted.
Taking breaks during extended periods of surveying is strongly recommended, as observer fatigue will affect observers' sighting ability. Please listen to your Team Leader regarding this.
To make the most of surveying opportunities when at sea, observers should start surveying as soon as it gets light and end when the light starts to fade, weather permitting.
Always vacate the bridge well before arriving in port (this may be up to 1 hour prior to arrival on some routes) and in thick fog (<300m) to allow the ships' crew to work without hindrance. If you are requested to depart the bridge by the bridge crew at any point during your survey you must do so with immediate effect.

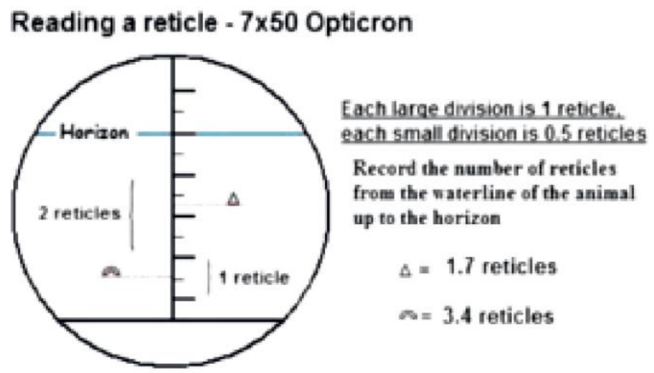
Weather

The weather has a huge effect on observers' ability to spot cetaceans. In general, as sea state increases and visibility decreases, the probability of detecting a cetacean decreases (i.e. large waves and fog hide surfacing dolphins). The problem is particularly acute for small and/or undemonstrative species, such as the harbour porpoise. However, on vessels of opportunity where you have no control over where the ship goes or the length of the observation period, there is always a trade-off between wanting to spend as much time observing as possible with collecting valuable data. On platforms of opportunity, it is recommended that observers only collect survey data up to a sea state six. Any data collected in a sea state seven or above will generally be discarded. Survey effort in poor visibility will be treated similarly.

SURVEYING

Distance and Angle

An important part of the sightings data is recording distance and angle to the sighted cetacean (distance sampling methods). To record distance, you will use the reticle binoculars provided by ORCA in the on board survey equipment. These have a scale marked on the left eyepiece. When you look through, you will see something like the picture below.



Each division (the distance between two horizontal markings) represents 0.5 reticles. Count the number of divisions from the waterline of the animal up to the horizon. For example, two divisions equals one reticle, and 3 divisions equals 1.5 reticles. When the animal is between two markings, use your judgment to best estimate the approximate number of reticles from the horizon. Remember, do not round numbers, be as accurate as possible.

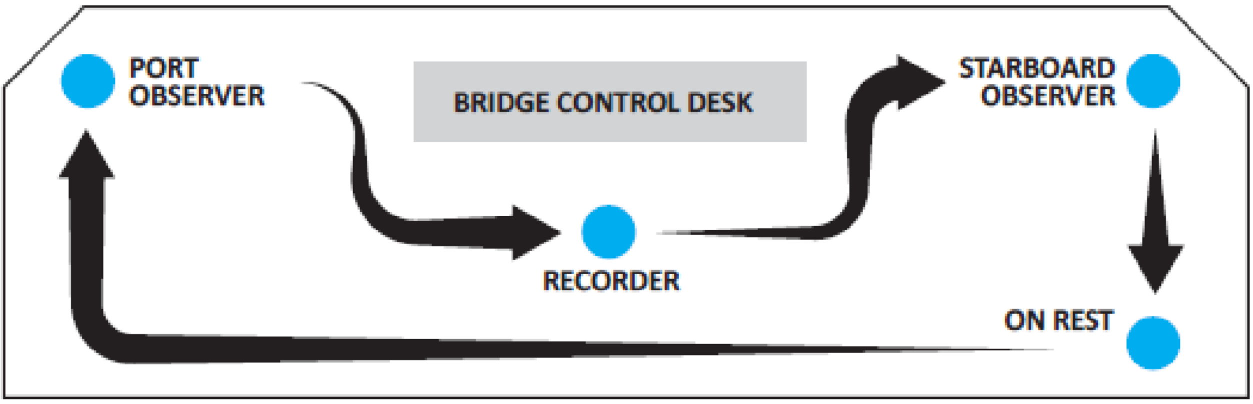
Angles are measured using an angle board. Each port and starboard observer will have an angle board positioned in front of them on the bridge. The 0 (zero) should be facing forward and the angle board should be horizontal. When you see an animal, bend down level to the angle board (or hold it at eye level if you have a bad back) and turn the pointer so that it points to the position of the animal. Stand up, and give the angle reading to the recorder. When taking an angle reading do not look at the angle board - this will avoid you inadvertently 'choosing' a rounded figure.

- Do not take the board to the observer – it should always remain in front of you.
- Do not round figures up or down. Exact degrees are required.

A larger version of the angle board diagram above can be found at the back of this protocol for your practice only – just put one end of a pen in the centre of the circle to use as a pointer.

How to Survey

- The survey team will consist of three or four surveyors.
- When surveying, two observers will be on watch at the same time.
- One observer will stand on the port side and one on the starboard side of the observation platform.
- The starboard observer will scan an area from 90º off the starboard side (right) to 10º to port (left). A total area of 100º will be surveyed.
- The port observer will scan an area from 90º off the port side to 10º to starboard. A total area of 100º will be surveyed.
- Both observers will have a pair of reticle binoculars and should use them to scan distant waters for animals between periods of searching with the naked eye, arcing from side to side and near to distant.
- The third surveyor will be the data recorder. The data recorder will fill in the effort and sightings sheets.
- The data recorder must not cue the observers to a sighting. If the data recorder (or another member of the team) makes a sighting, then it must be recorded as 'incidental' with sighting distance and angle by eye and recorded as such in the 'comments'.
- The fourth surveyor will be on rest.
- The four (or three) surveyors will rotate through each position (in the order of port observer, data recorder, starboard observer, rest) every 30 minutes (see rotation diagram below).
- For long periods of surveying it is highly recommended that surveyors all take a 30-60 minute break. Your Team Leader will advise on breaks, but please let them know if you require a break.



Rotation diagram

When a cetacean is sighted:

- Let the data recorder know by stating 'sighting' loudly enough for them to hear but not so loud as to disturb the ship's crew. The recorder should immediately record the GPS position and time. (If this is disruptive to the bridge officers, then stand closer together).
- Immediately take a distance and angle board reading. Distance and angle measurements should be taken to:

1. the first sighting cue (e.g. blow or back) of single animals.

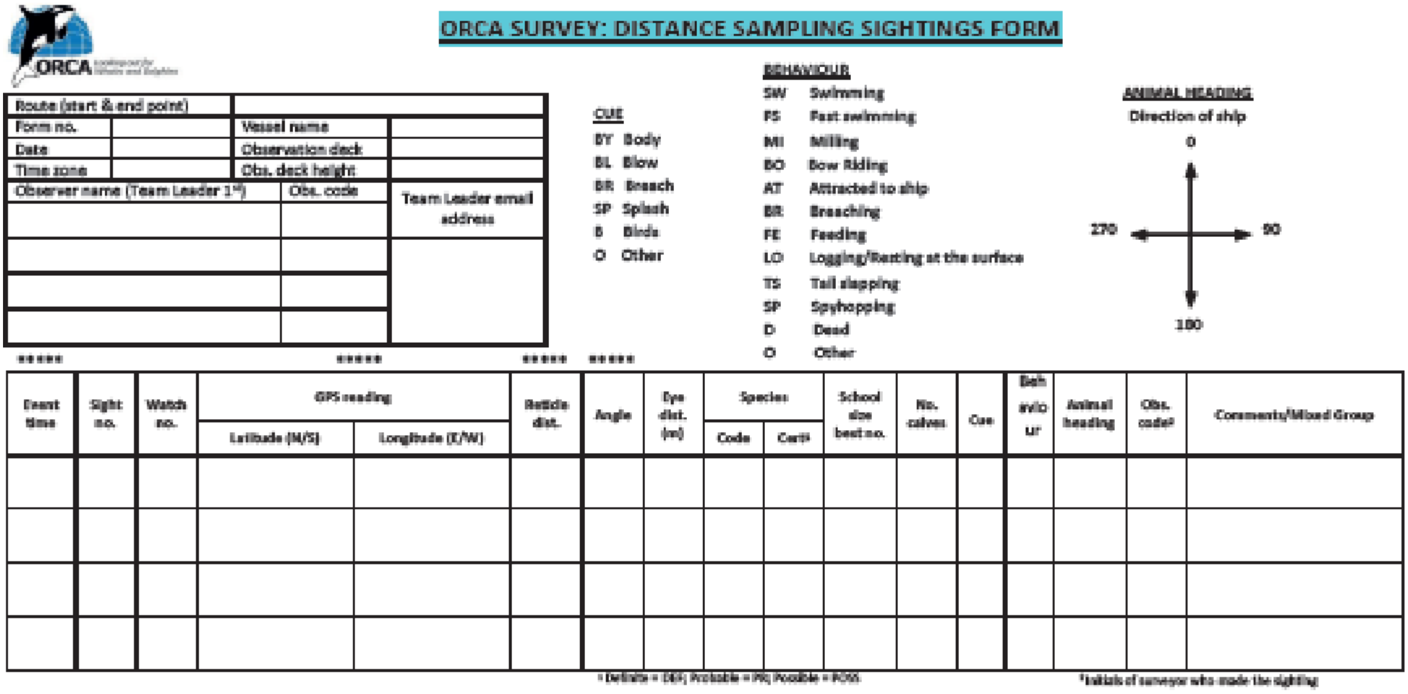
2. the ‘best-judged’ centre of schools of animals.

• Be as accurate as you can with the reticle binoculars – they are not always easy to use. If you cannot use the reticle binoculars (i.e. no visible horizon or animals are too close to the ship) you should estimate distance by eye, but do not round to nearest 10s, 50s or 100s. You can always practice your distance estimating ability by estimating the distance to passing ships and then ask the Team Leader to ask the bridge officer to tell you how far away it is using the ships radar (1 mile [nautical, UK] = 1.853 kilometre).

• Record angles to the nearest degree – do not round to the nearest 5º or 10º. This is particularly crucial when sightings occur ahead of the ship and small angles of 1º or 2º to the port or starboard of the track line should be measured and not rounded to 0º.

• Record the species code and the certainty of your identification, the complete school size (best guess estimate) and all other columns in the sightings form.

Sightings Form Explained



ORCA SURVEY: DISTANCE SAMPLING SIGHTINGS FORM

Route (start & end point)			
Form no.		Vessel name	
Date		Observation deck	
Time zone		Obs. deck height	
Observer name (Team Leader 1st)	Obs. code	Team Leader email address	

CUE
BY Body
BL Blow
BR Breach
SP Splash
B Birds
O Other

BEHAVIOUR
SW Swimming
FS Fast swimming
MI Milling
BO Bow Riding
AT Attracted to ship
BR Breaching
FE Feeding
LO Logging/Resting at the surface
TS Tail slapping
SP Spyhopping
D Dead
O Other

ANIMAL HEADING
Direction of ship
0
270
90
180

Event time	Sight no.	Watch no.	GPS reading		Reticle dist.	Angle	Eye dist. (m)	Species		School size best no.	No. calves	Cue	Behaviour	Animal heading	Obs. code²	Comments/Mixed Group
			Latitude (N/S)	Longitude (E/W)				Code	Cert¹							

¹ Definite = DEF; Probable = PR; Possible = POSS

²Initials of surveyor who made the sighting

Make sure you fill in the top left table on every form. Number forms sequentially.

EVENT TIME: Time of the sighting. Complete as hh:mm in the 24 hour clock format.

SIGHT NO.: Each unique sighting should be given a sighting number. Start at one and increase.

WATCH NO.: Relates to the period of effort on that survey. This is sequential.

GPS READING: Read from the ship’s GPS if you are observing from the bridge or the handheld GPS provided if on another platform. This is continuously changing so record it as quickly and accurately as possible as soon as ‘sighting’ is called. Ensure you specify N/S and E/W.

RETICLE DIST.: The number of reticle divisions between the horizon and where the body of the animal meets the water. Be as accurate as possible, do not round up/down.

ANGLE: Use the angle board to record the angle from the bow of the ship (zero) to the animal or centre of a group of animals. Be as accurate as possible, do not round up/down.

EYE DIST. (M): Estimated radial distance from the ship to the sighted cetacean in metres. Estimating distance by eye is very difficult. As you can see from the photo to the right, due to the shape of the earth, perspective means that there is a foreshortening of distance towards the horizon – ie: what looks like being halfway to the horizon is not actually half the distance. In reality, there is little visible difference between the horizon and 2 km. Please note that distance changes depending upon your viewing height – check with your Team Leader and refer to the information in your on-board survey equipment if unsure.

SPECIES: Record the species using the codes provided in your on-board survey equipment (see the inside front cover). If there is not a code for the species you have seen, then write the species name in the comments column. Record the certainty (cert.) of your identification using ‘DEF’ (definite), ‘PR’ (probable) or ‘POSS’ (Possible).

SCHOOL SIZE: Record the complete school size (adults, juveniles, and calves) by counting how many animals you see above the water at any given time.
NO. CALVES: Record the number of calves (about half the size of the other dolphins/whales) and usually closely swimming with the adult.
CUE: Use the codes on the top of the form to record how you detected the animal, for example did you see the body first (it may have been just the dorsal fin) or did you see a big splash.
BY Body
BL Blow
BR Breach
SP Splash
B Birds
O Other
BEHAVIOUR: Use the codes on the top of the form to record the animal's behaviour at the time that you first sighted it. You may use more than one code.
SW Swimming
FS Fast swimming
MI Milling
BO Bow Riding
AT Attracted to ship
BR Breaching
FE Feeding
LO Logging/Resting at the surface
TS Tail slapping
SP Spyhopping
D Dead
O Other
ANIMAL HEADING: Use the drawing at the top of the form to record which way the animal or school of animals were heading in relation to the ship.
OBS CODE: Please record which observer made the sighting. Fill in the table at the top left of the form and give each observer a code based on the initial of their first and surname e.g. Lucy Babey = LB. **COMMENTS/MIXED GROUP:** Record any additional relevant information here. This gives context to the sighting and you can never write too much. Also use this section to specify if the sighting was part of a mixed group.

Effort and Weather Form Explained

At the start of the survey period:

- Note the watch number (each period of surveying is one watch; if you break and then restart, this is a new watch), effort, and event time and take a GPS reading and enter into the first line of the survey effort sheet. Record all associated environmental information.
- Update the survey effort form every 30 minutes or if sighting conditions change using a new row. Use the 'effort' column to note the reason why you are filling in another record e.g. weather change or observers are changing position/30 min record.
- For each survey effort record, ensure associated environmental data (e.g. sea state, visibility) is recorded.

At the end of the survey period:

- Note the watch number, effort, and event time and take a GPS reading. Record all associated environmental information.
- The survey period ends when all observers are off effort, whether for lunch break, poor weather, dusk, etc. Ensure that you re-start with a new watch number after you go back on effort as a team.
- At the start of a new day for the same survey, the watch numbers continue sequentially from the previous day of surveying. Make sure you fill in the top left table on every form. Number forms sequentially.

ORCA SURVEY: DISTANCE SAMPLING EFFORT AND WEATHER FORM

Route (start & end point)			
Form no.		Vessel name	
Date		Observation deck	
Time zone		Obs. deck height	

Observer name (Team Leader 1st)	Obs. code	Team leader email address

EFFORT
0 On effort
1 Observer rotation/30 min record
2 Weather change
3 Change of ships course
4 Off effort

SWELL
1 Absent
2 Light (>0-1m)
3 Moderate (1-2m)
4 Heavy (>2m)

PRECIPITATION
1 None
2 Rain
3 Hail
4 Fog/Mist
5 Sleet
6 Snow

GLARE
NA None
P Port
S Starboard
A Ahead
PA Port-ahead
SA Starboard-ahead
All All sides of the ship

Event time	Effort[1]	Watch no.	GPS reading		Speed (knots)	Course of vessel*	Sea state Beauf	Swell	Precipitation	Glare	Vis. (km)	Observer code[2]		Comments
			Latitude (N/S)	Longitude (E/W)								Port	Starboard	

[1] Assumes that effort readings will be taken every 30 minutes
* COG or COW reading
[2] Initials of the surveyor on effort

EVENT TIME: Time of the effort line being recorded. Complete as hh:mm in the 24 hour clock format.
EFFORT: This must be completed at the start and end of every transect, every 30 minutes (observer rotation), and if there are any changes in weather or the ship's course. Use the codes on the top of the form.
0 On effort
1 Observer rotation/30 min record
2 Weather change
3 Change of ships course
4 Off effort
WATCH NO.: A watch is survey effort in an unbroken observation period. Start at 1 and increase.
GPS READING: Read from the ship's GPS if you are observing from the bridge or the handheld GPS provided if on another platform. This is continuously changing so record it as quickly and accurately as possible. Ensure you specify N/S and E/W.
SPEED (KNOTS): Read from the ship's GPS if you are observing from the bridge or the handheld GPS provided if on another platform.
COURSE OF VESSEL: This is the course that the vessel is taking and will be the COG or COW reading from the ship's GPS equipment; if there is a choice, please use the COG reading. It will be a numerical value between 0 and 360.
SEA STATE BEAUF: This is recorded using the Beaufort Sea State scale. Use the chart provided in your on board survey equipment (as below) to determine the sea state force.
SWELL: The height difference between the trough of a swell and the top of the next swell. Use the codes at the top of the form.
SWELL
1 Absent
2 Light (>0-1m)
3 Moderate (1-2m)
4 Heavy (>2m)
PRECIPITATION: This is a measure of the local meteorological conditions. Use the codes on the top of the form.
PRECIPITATION
1 None
2 Rain
3 Hail
4 Fog/Mist
5 Sleet

6 Snow

GLARE: This is a measure of the extent to which the sun shining off the water limits observations. Use the codes at the top of the form to complete.

GLARE
NA None
P Port
S Starboard
A Ahead
PA Port-ahead
SA Starboard-ahead
All All sides of the ship

VIS. (KM): Visibility is how far you can clearly see from the observation platform (maximum visibility is to the horizon). Horizon distance differs from platform to platform due to the height of the platform; a document detailing the horizon distances for each ship can be found on the ORCA Surveyor Network. Each on board survey equipment will detail the platform heights and distances to horizon for that specific platform of opportunity. The visibility can be gauged from this information.

OBSERVER CODE: When you complete a new row, fill in which observer is on the port side and which is on the starboard side. Use the observer codes detailed in the table on the top left of the form.

COMMENTS: Record any additional relevant information here. This gives context to the survey, and you can never write too much.

2. FLT MED NET Protocol for data collection

Only dedicated and expert observers (DO) are used in the study to avoid bias due to differences in detectability. There is not a comprehensive method to evaluate the experience of the observers as it depends on a mix of personal characteristics, previous experience, the number of surveys already done, specifically on ferries, and number of different species and in different conditions already sighted. So, the experience of the observer in training is established by the senior observer, who has the responsibility of deciding the stage of the experience of the specific observer. There are at least three stages for the observers: senior, experienced, in training.
Cetacean Dedicated Observers are located on the two sides of the command deck of ferries and collect data on cetacean presence continuously from both sides. DOs rotate between side every 1-2 hours.
DOs collect data on cetacean presence in "passing mode" (continuous search effort, with schools or animals not being approached) following the distance sampling protocol.
Each DO focuses primarily on a 130° arc ahead of the ship and continuously scan the area by naked eye with occasional scans by binoculars. The back of the route is scanned only occasionally to avoid the risk of recounting of sightings.
Height on the horizon and exposure of the command deck of the observation platform, as well as observer expertise can affect the detection capability along the transect. Consequently, to be able to properly compare the different routes, it is important to compute the "effective strip width" through the distance sampling detection function so the density values along the transect is able to be calculated (for each species). Consequently in the survey sheet, it is important to always quote the name of the ferry/ship and list the name of the more experienced observer of the team first. Transect width must be computed for each platform/more expert observer/species.

Effort data:

All data concerning ferry track (position, speed, and heading) are recorded by a dedicated GPS all along the ferry route. GPS resolution should be set as the best possible resolution according to GPS memory capacity and trip duration. In case there are problems with the personal GPS, coordinates of marked points along the transect are recorded at least every 20 minutes and each time the route is changed. All data can be collected by means of electronic dedicated applications assuring that all data within the "meteo - sight – maritime traffic – other species data collection sheets" are collected.

GPS positions to be recorded

BEG Beginning of effort Beginning of the survey
STOP Beginning "off effort" Pause during survey
START Start "effort" During survey
END End effort At the end of survey
WP Way Point Positions along track
METEO Change of meteo conditions
Sight Sighting Position of sightings
OS Other species sighting Position of sightings
NAV Naval traffic Position of systematic scan samplings in absence of cetacean sightings

Metadata and data on meteorological conditions

At the beginning of the on-effort period, all data regarding date, transect number, name of the ship, and names of the observers are recorded. Data on meteorological conditions are collected in the 'meteo data sheet' (on the data collection file Annex I) at the beginning of the "on effort" period, at the end,; and each time a change occurs. Data on meteorological conditions is recorded by one of the DOs for both sides of the command deck. The off effort period, change in side of the Dos, and changes on the effort conditions are eventually recorded on the same data-sheet. Meteo condition is indicated as Beaufort scale by taking in consideration both the wind speed and the sea state condition. Data are collected under all weather conditions even if only data collected in good weather conditions (Beaufort ≤3) are used for the analysis. The definition of the Beaufort scale is done through descriptive observation of the sea and range of wind speed when available (both described in the data collection sheet). Survey data and sighting data are recorded through a datasheet or through a software device and/or specific applications, assuring that all the data required in the data collection sheets are provided.

Sightings data

During sightings, data are collected on the "sight data collection sheet" (Meteo; Sighting; Naval traffic; Other species; Annex II). For each sighting, species, number of individuals, presence of juveniles, behavior, and vessel presence are recorded. Sightings are reported recording the time of sighting by one of the DO, avoiding the risk of recording the same sighting twice (if eventually sighted from both sides of the observation points). A sighting done by a crew member or an in-training observer or people other than DO is recorded only if confirmed by a DO.

Binoculars and photos are used to confirm sightings and assess species and group size. Non-identified species are registered using "US" followed by the indication "large whale species"(L), "medium cetacean species" (M), "small dolphin species" (S) (see Annex VI for more detail). Coordinates of sightings are marked in the personal GPS and reported in the data sheet (see Annex VIII for more detail on the GPS settings). Data on radial distance and angle between the detected group and the track line are recorded by clinometer, rangefinder stick, reticle binoculars, and a goniometer.

Mixed species

If mixed species are sighted in a single group, they are recorded as a single sighting, and all species are recorded. If multiple groups of the same species are simultaneously recorded over a large area, they will be recorded as a single sighting if they are assessed to be "sub-groups" (according to the definition of group).

Collision

Particular focus is given for recording possible events of collision, or more realistically, near collision events in order to contribute to the comprehension and the definition of mitigation measures for ship strikes. Cases of collision or near-collision are clearly reported with details of the dynamic of the event. A "Near collision event" is when the animal is sighted in front of the ship at a minimum distance of 50m in front of the bow and 25m on the side, with animals not showing evident approaching behavior (e.g. bow riding in front of the ship) but instead being unaware of the boat approaching. The behavior of the animals is an indicator that DOs are required to warn a ferry's crew about cetacean presence in order to avoid ship strikes.

Maritime traffic

The potential relationship between maritime traffic and cetacean presence is investigated; systematic scan samplings of the horizon, in concurrence with cetacean sightings, are undertaken in order to quantify the number of vessels (sailing boats, fishing boat, ferries, cargo etc), detectable from the observation platform (in the same area scanned by naked eye). In the absence of cetaceans, scans are undertaken randomly at a minimum distance of 45 minutes or 10 NM. An alarm clock should be set in order to avoid collecting data in concurrence with the sight of a ship that "reminds" us that is time to do it. Always keep at least 15 min intervals between a sight and a random scan (if the sight is done soon after the random data, delete the random data). Vessels are divided in X<5m (S); 5m<X<20m (M); X>20m (L). The number of vessels, hour, and GPS position is registered for each scan. Ship and maritime traffic data, if possible, will be also gathered from the ship's AIS system.

Other species

Potential multi taxa relationships are investigated. Even though priority is given to cetacean surveys, data on other marine macro-fauna is also collected each time it occurs in order to be used for presence only analysis. Potential macro-fauna data collected with regards the species are listed in table 3.

In order to maintain a consistent effort focused on cetaceans, only two species of sea birds were selected for opportunistic data collection (Levantine shearwater and Scopoli's Shearwater), chosen in consideration of their role for conservation purposes. Sea turtles are considered a major priority for data collection and the opportunistic data collection is strongly recommended in all routes. Systematic data collection on sea turtles (as well as Jellyfish, Ocean sunfish, and Devil fish) is required only during the application of the Marine litter protocol (see Protocol for marine macro litter data collection). For species usually observed in big groups (*e.g., Tuna* and *Velella sp.*) as it is not possible to count individuals, the groups are categorized into small (<10 individuals), medium (10- 100), and big (>100). Data on jellyfish, also outside the standard protocol (litter and megafauna protocol) are reported to prof. Ferdinando Boero (Univ. Salento/CoNISMa/CNR-ISMAR).

List of potential other species of marine megafauna to be recorded.

##Other Species names##	**English name**	**Italian name**
Caretta caretta	Loggerhead sea turtle	Tartaruga marina
Mola Mola	Ocean Sunfish	Pesce luna
Mobula mobular	Devil fish	Manta
Xiphias glaudius	Swordfish	Pesce spada
Thunnus ssp	Tuna	Tonno
Fam. Istiophoridae	Marlins Marlin,	pesce vela
Shark	Shark	Squalo
Jellyfish	Jellyfish	Meduse
Puffinus yelkouan	Yelkouan or Levantine shearwater	Berta minore
Calonectris diomedea	Scopoli's Shearwater	Berta maggiore
Other		

Data storage

Each team is responsible for storing data for each ferry trip and to prepare shape files (.shp) to be shared with partners of the network at least seasonally. Data could be shared as excel or .shp file, including all the information and under the format indicated in Annex IX.

3. CETUS Protocol

1. We will use an Android app on a tablet to log our GPS data and all information. It allows us to record GPS data (time, position, elevation, and speed) and our sampling data. It is more accurate than GPS/sheets and pen system.

2. The tablet should have all applications and wireless mode off. Moreover, it should be in airplane mode. Double--check.

3. Check if the radios are on the same channel and working.

4. Batteries on the tablet and radios/walkie--talkies should be full, so charge them every night.

5. Adjust the focus on the binoculars. You do that one eye at a time, covering the other lens.

6. Bring the folder with white sheets and pens to the navigation bridge. The tablet system will be used. Sheets will only be used in an emergency (e.g. tablet does not work or does not have battery).

7. MMOs will have a wrist watch. Set the 2 clocks to the same time (to the second). Have the wrist watches in UTC time, so it never changes even if the local time does.

8. We will sample 180 degrees on the front of the ship. Each volunteer will be on one side of the ship surveying 90º. Try to be outside, with the exception of during uncomfortable weather such as heavy rain.

9. The tablet will always be on the same side, and the MMO on that side is in charge of the records. They have to communicate with the other MMO by radio. MMOs switch side every 60min.

10. Prepare everything. Put on sunglasses, sunscreen, a hat, binoculars, etc.

11. Start recording the trip.

12. Wait for GPS signal.

13. Check if the other MMO is ready.

14. Add an effort point.

Marker name: ef **Marker type:** MMOs **Description:** on/off
ef – effort
MMO – observers

Example if Ágatha Gil and Mafalda Correia are surveying:
Marker name: ef **Marker type:** ag;mc **Description:** on

15. Add a meteo point with weather data. You will take this data at the beginning, end, and every time the weather changes.

Marker name: me **Marker type:** me **Description:** s;w;wd;v;c;r
me -- meteo
s – sea state
w – wind state
wd – wind direction
c – cloud cover (%) v – visibility
r – rain

Example:
Marker name: me Marker type: me Description: s2;w3;wd320;v8;c50;r0

* To access wind direction, use the binoculars and look against the waves.

* Cloud cover is the percentage of clouds covering the sky.

16. Add a vessel point with the vessels. You will take this data at the beginning, end, and every hour. Do not count ships at the port or stopped (not navigating – at anchor). Count vessels all around (360º). The best option is to switch sides when taking the vessels (every hour for both situations).

* It is quite hard to access the size of the vessels from our platform of observation, so: Small – vessels under 5m: very small fishing vessels or sailing boats.

Medium – vessels between 5 to 20m: normal catamarans, sailing, and fishing vessels.
Big – vessels bigger than 20m: big catamarans, sailing and fishing boats, cargo ships, and ferries.

Marker name: v **Marker type:** v **Description:** s;m;b v – vessels
s – small (<5m)
m – medium (5m--20m)
b – big (>20m)

Example: **Marker name:** v **Marker type:** v **Description:** s0;m1;b3

17. When you spot an animal:

17.1. The first thing is to call the other MMO, using the ring button on the radios.
17.2. If you have the tablet, you need to add the points. If the sighting is on your side, your partner should be arriving to help. If the sighting is on your partner's side and you have the tablet, then you need to add the points and meet them on the other side as soon as possible.
17.3. Adding the points:

* Probably when activating the tablet, a message "Waiting for GPS signal" will appear. Wait for this to disappear (it takes a couple of seconds) before adding points.
* Since the position is only added when you click on the "Add" button and not by just pressing the "Waypoint" button, you should press "Waypoint" and "Add" buttons straight, and you will edit the points after with the help of the other MMO.
* The MMO that spotted the animals has to keep looking at the animals (only stopping to add the points if the tablet is on his side), while the other MMO is in charge of editing the points.

17.3.1.1. The first added point is a distance sampling point with data on the distance and angle of the sighting.

Marker name: ds **Marker type:** l/r;MMO **Description:** d;a;v
ds – distance sampling l/r – left/right
d – distance a – angle
v – vessel angle

Example:
Marker name: ds **Marker type:** l;ag **Description:** d30;a120;v140

* Remember that you or the other MMO will be editing this point afterwards, so the MMO spotting the cetaceans should access distance sampling information and memorize it as soon as he spots the animals.
* Access this information with the compass and scale of the binoculars.
* If distance is less than 10 on the 0 to 80 scale, put 0 or 10 (whichever is closer).

* Vessel angle is accessed by looking to the front of the ship, in the direction of the route. This is needed to access the error of the binoculars (by comparing it to the GPS data which has the accurate vessel direction).

17.3.2. Take a cetacean point for the rest of the sighting information.
Marker name: ce Marker type: sp Description: ;;;t/f;h;ap/in/av;s;m;b;comments ce – sighting
sp – sp code
;;; -- min;max; best; t/f – true/false (not sure of the sighting) h – heading
ap/in/av – approach/indifferent/avoiding (behaviour towards the ship) s;m;b -- vessels

* Put only important comments like an unusual behaviour, presence of calves, foraging, etc.
* To access heading, look with the binoculars towards the direction the animals are moving.
* Count all the vessels within 360º as done in the vessel point.

Example:
Marker name: ce
Marker type: d
Description: 10;20;18;t;h300;ap;s0;m2;b3;calves, feeding, probably dd.

18. As soon as you put a "ds" point, it is considered off effort as you will be looking at the animals and not paying attention to the rest of the surveying area. So, after adding and editing all the points and returning to your positions, add an effort point (indicating on):

Marker name: ef **Marker type:** ef **Description:** on
19. If you see any top predator species with or without the cetaceans: tunas, turtles (for example, *Caretta caretta*, swordfish, shark, etc), add an associated point (do not call you partner, just talk with them on the radio if they have the tablet so they can add the point).

Marker name: as **Marker type:** sp **Description:** ;… as – associated
sp – common or scientific name
Example:
Marker name: as **Marker type:** shark **Description:** 1

20. To finish, take the meteo and the vessels and put an off--effort point.
21. All the codes and meteo scales will be on the phone cover.
22. Always put the code in every field, otherwise I will assume you forgot to access the data (except behaviour which is optional for unusual behaviours). If you tried, but can't access the data, put a code with no value.
23. Save the track as follows:

YearBoatinitials – TripNumber – DateTraveloftheday Example: 16mb--001--1307011
* If you recorded several sections due to GPS failures, just save them like: 19mb--001--1907121--01

19mb--001--1907121--02
19mb--001--1907121--03

24. Export to csv file. Once the track is saved on the file manager of the tablet and on your pc, please delete it from the app. It can be deleted from the file manager as well when you sent it to me.
25. Shut everything off.
26. Do not leave anything in the navigation deck!