Document: ACCOBAMS-SC14/2021/Doc11
Distribution: 16/11/2021

MONITORING CETACEAN POPULATIONS USING MULTI-DISCIPLINARY SCIENTIFIC SURVEYS

Presented by Charlotte Lambert, ACCOBAMS Expert

Issue: Development of a study on the potential of use of multi-disciplinary scientific Surveys for Monitoring cetacean populations in the ACCOBAMS Area

1. Action requested

The Scientific Committee is invited to:

a. **note** the information provided on the study on Monitoring cetacean populations using multi-disciplinary scientific surveys

b. **advise** on the development of this document.

2. Background

In order to assess trends in population status that will inform decision makers and support relevant conservation measures, monitoring efforts must be replicated systematically and regularly over time, as reflected in the 6-year cycle of marine monitoring regional policies of the region (i.e. MFSD, EcAp). While the ASI 2018 and 2019 surveys provided a strong baseline for regional monitoring, it remains crucial to address the sustainability issue of harmonized monitoring operations to estimate abundance and distribution of cetacean populations in the Agreement Area.

In addition to support long-term monitoring in the ACCOBAMS Area using the ASI framework, it is essential to explore other opportunities for additional data collection on cetacean's distribution and/or abundance. To address this objective, the 2020-2022 ACCOBAMS Programme of Work includes activities to promote the use of multidisciplinary surveys (such as fisheries or oceanographic surveys).

With this in mind, an expert was recruited by the Secretariat early 2021 to develop a study on the potential of use of multi-disciplinary scientific surveys to monitoring cetacean populations.

This synthesis includes an overview of the protocols used by oceanographic and fisheries surveys, the protocols used by cetacean observers as well as of the recurring censuses operated within the Agreement Area.

A set of criteria is proposed for evaluating the feasibility of adding-on cetacean observers on surveys, with a view to prioritizing survey opportunities to be used as pilot studies.

Monitoring cetacean populations using multi-disciplinary scientific surveys

Charlotte Lambert*[1], V. Ridoux[1,2] and G. Dorémus[1]

[1]Observatoire PELAGIS, UMS 3462 La Rochelle Université–CNRS, France
[2]Centre d'Etude Biologique de Chizé, UMR 7372 La Rochelle Université–CNRS, France

Abstract

In continuity to the basin-scale international effort achieved during the ACCOBAMS Survey Initiative, the ACCOBAMS Scientific Committee is willing to implement a long-term monitoring of cetacean species throughout the Agreement Area. One of the opportunity to achieve this goal is to use existing oceanographic and fisheries surveys to add-on cetacean censuses with embarked cetacean observers. Such an approach would foster international collaborations and would incorporate into the current movement towards ecosystem monitoring taking place in marine science. A large part of the Mediterranean and Black Seas is censused by either oceanographic or fisheries surveys on a regular basis (once or twice a year), and opportunities to build-on cetacean monitoring are real and promising. In the present synthesis, we overview the protocols used by oceanographic and fisheries surveys, the protocols used by cetacean observers and the advantages and drawbacks of the approach. We review the recurring censuses operated within the Agreement Area (to our knowledge). Finally, we propose a set of criteria to evaluate each one in regards to the feasibility of adding-on observers and help prioritize opportunities to chose surveys to be used as pilot studies.

Report for the ACCOBAMS Scientific Committee

*Corresponding author, electronic address: charlotte.anne.lambert@gmail.com

Contents

1. Introduction

The ACCOBAMS agreement aims to reduce the threats faced by cetaceans and promote their conservation, in particular through actions designed to improve the scientific knowledge of these species, in the Mediterranean and Black Seas and in the contiguous Atlantic area. One of the most outstanding achievements of the ACCOBAMS has been the successful implementation of the first basin-scale survey of marine mammals and other megafauna species through aerial and boat-based surveys in the summer 2018 and 2019 across the Mediterranean and the Black Sea. Such large-scale monitoring efforts are deemed to be repeated at a six-year interval to match reporting periods of European Union's Marine Strategy Framework Directive (MSFD) and Barcelona Convention's EcAp processes.

In addition to these basin-wide surveys, the use of platforms of opportunity may provide options for additional and continuous monitoring, at least in some sectors of the Agreement's range, and can be extremely valuable complements to basin-wide surveys in a monitoring strategy. These platforms of opportunity include in particular oceanographic surveys (including fisheries surveys) conducted at national levels. A specific advantage of oceanographic surveys is that they produce in-situ environment data. These data can provide insights into possible changes in oceanographic conditions that can help interpreting changes in marine megafauna densities and distributions. This is of major importance for successful cetacean conservation.

Hence the ACCOBAMS Secretariat and the Scientific Committee seeks to build on existing annual or seasonal at-sea oceanographic and fisheries surveys implemented by ACCOBAMS Parties to develop cetacean monitoring programs as add-ons to these surveys. In addition to its value as a complement to the basin-scale surveys, such an approach would foster international collaborations throughout the basin, promote standardisation of scientific approaches and protocols for marine fauna collected from fisheries and oceanographic surveys and permit a thorough assessment and a better understanding of the Mediterranean and Black Sea ecosystem as a whole (from its physical properties to top predators).

This synthesis will be structured in four parts. First, we will detail how multi-disciplinary surveys are used to monitor cetacean populations. This will be achieved by detailing the structure of multi-disciplinary surveys following an ecosystemic approach, using operational surveys from western European waters as examples. Such approaches allow to monitor the entire ecosystem from its physical and biological properties, to communities of plankton, fish and large predators. We will detail the other types of multi-disciplinary oceanographic surveys and provide an example of megafauna monitoring operated on-board such an oceanographic survey in the French Mediterranean waters. Building from those operational surveys, we will summarise the conditions (logistical, technical, scientific) required for successful cetacean monitoring on-board multi-disciplinary surveys. Second, we will exhaustively report on the oceanographic surveys operating in the Mediterranean and Black Seas, describing their nature (fisheries, oceanographic. . .) and their characteristics (sampling scheme for example). Third, we will propose, from the set of surveys operated in the Mediterranean and Black Seas, a set of criteria to be used to evaluate the feasibility of adding-on cetacean observers on each surveys. Those criteria aim at being used to prioritize opportunities and identify which surveys could be used as pilot cases to develop a cetacean monitoring protocol within the ACCOBAMS area. Fourth, we will provide some recommendations to the Scientific Committee.

2. Multi-disciplinary surveys as a tool to monitor cetacean populations

2.1. Advantages and drawbacks of ecosystemic multi-disciplinary surveys

Scientific multi-disciplinary surveys host several surveys of different nature simultaneously on a single survey platform, with coordinated efforts. In the marine domain, many of those ecological multi-disciplinary surveys are based on fisheries surveys, aiming at providing indices of commercial fish abundance. For two decades, those fisheries surveys have progressively transformed into platforms for integrated monitoring of ecosystems (Doray *et al.*, 2018a, de Boois *et al.*, 2019), with add-ons of varying nature, from biogeochemistry and physical properties of the water column, to hydrobiology (plankton, productivity, fish eggs) and visual census of megafauna and anthropogenic activities (shipping, fishing, marine litter; Figure 1). This transformation was parallel to the development of integrated maritime policies requiring data collection and monitoring of a range of ecosystem compartments to assess the environmental status. As a result, yearly integrated multi-disciplinary surveys are cornerstones in the implementation of European policies such as the Marine Strategy Framework Directive (MSFD), the Data Collection Framework (DCF), but also the General Fisheries Commission for the Mediterranean (GFCM) Data Collection Reference Framework (DCRF).

Integrated multi-disciplinary surveys present two main advantages. First, they are logistically and economically efficient, as only one vessel and one survey are sufficient to conduct simultaneously several distinct censuses. Such surveys are logistically lighter since arming a single vessel is simpler than arming separated survey vessels, but necessitates a high of level coordination among all involved persons and programs. The use of a single vessel also represents an important carbon footprint reduction, despite the need for large research vessels able to embark large scientific equipments and teams.

Second, multi-disciplinary integrated surveys are characterised by considerable scientific value. By monitoring the ecosystem from its physical properties to the upper trophic levels, integrated ecosystemic studies become possible and links across and between ecosystem compartments can be drawn and better understood (Doray *et al.*, 2018a; Lambert *et al.*, 2019). In addition, trends in ecosystem structure and functioning can be identified based on time series when the monitoring is built upon a yearly survey (Petitgas *et al.*, 2018). The quantification of anthropogenic activities and marine litter through direct visual observations at the sea surface and quantification in trawl hauls also permits assessing exposition of marine life (lower to upper trophic levels) to anthropogenic hazards (Darmon *et al.*, 2017; Lambert *et al.*, 2020).

The main drawback to the implementation of ecosystemic monitoring is organisational, as the flexibility in scheduling and fulfilling the program reduces due to multiple objectives. Those objectives must be prioritized, which may lead to sub-optimal survey conditions for some data collection (for cetacean monitoring, the main risk is to be conducting during bad weather window). Care must be taken in regards to the sampling design of the main survey, as this design must not affect the quality of collected data and the interpretations that could be made of those.

The fisheries surveys used as a basis for integrated ecosystem surveys can either be acoustic surveys, targeting pelagic fish species, or trawl surveys, targeting demersal species. Each single fisheries survey is conducted at particular season to match the life cycle of the target species, resulting in several surveys covering the same area at several seasons with different fisheries survey protocol. However, the other compartments, from physical properties, lower trophic levels to megafauna census, can all follow similar protocols whatever the type of fisheries surveys conducted. As a result, integrating pelagic and demersal surveys conducted at different seasons would permit assessing the seasonal and inter-annual variations of the ecosystem over the entire annual cycle, as well as integrating pelagic and macro-benthos compartments.

Finally, beyond the interest of national stand-alone integrated ecosystemic surveys (i.e. PELGAS, EVOHE or JUVENA cruises in the Bay of Biscay), the standardisation of protocols at the international scale allows Good Environmental Status (GES) and ecosystem functioning to be assessed at the domain scale (i.e. western European seas or Mediterranean and Black Seas). This international standardisation and moving towards ecosystem monitoring is becoming the rule in European Union (EU) countries, driven by the MSFD and DCF requirements, but also by international conventions such as GFCM, ICES (International Council for the Exploration of the Sea) or OSPAR (Oslo/Paris Convention), which are calling for trans-national evaluations of wildlife populations at relevant biological scales and ecosystem approaches. Several scientific projects have been funded recently that aim at building ecosystem assessment and monitoring through such approaches (see ECOSCOPE project in the Mediterranean for example).

This standardisation of protocols also occurs for other oceanographic cruises. Such surveys can be of various types, but most routinely sample biogeochemistry, physical and biological properties of the water columns (temperature and salinity profiles, chlorophyll concentration, plankton...). Those at-sea surveys can also be used to host marine megafauna observations, as is done over multi-disciplinary surveys integrated with fisheries surveys. The in-situ sampling of oceanographic conditions could afterwards be coupled with megafauna observations to carry out partial ecosystemic studies. Those two types of multi-disciplinary scientific surveys are often spatially complementary, as fisheries surveys mostly focus on shelf waters, while many oceanographic surveys are carried out beyond the shelf break. As such, oceanographic surveys can represent highly valuable observation platforms to monitor cetaceans in oceanic basin with restricted shelf, as in the Mediterranean and Black Seas.

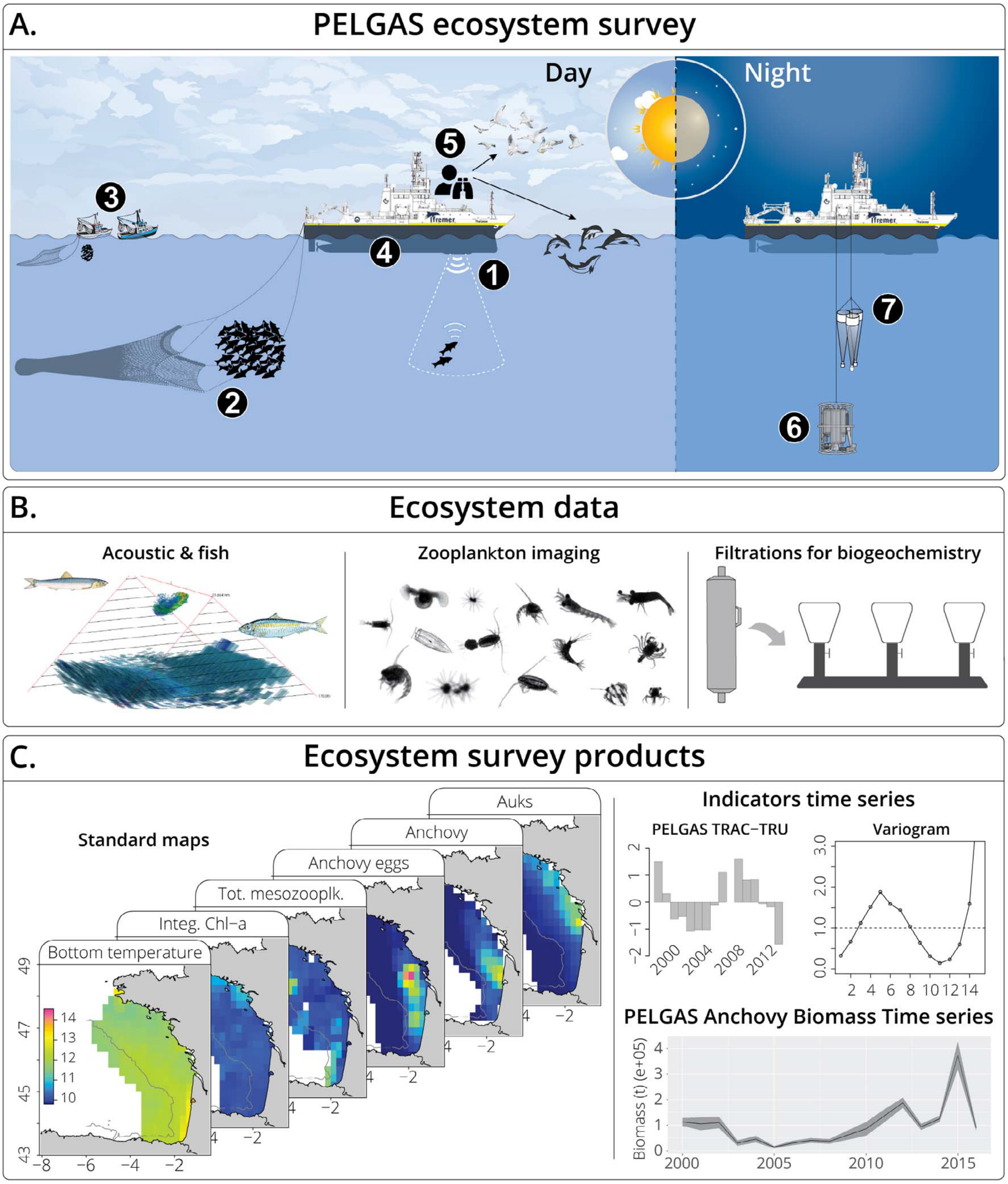

Figure 1. The example of the PELGAS survey model: from ecosystem data collection operated during the survey (A), along line transects during daytime (1. fisheries acoustics, 2. R/V Thalassa midwater trawling, 3. consort commercial pair trawlers fishing, 4. hull-mounted thermosalinometer, 5. megafauna sightings), and at fixed stations during night-time (6. sonde-based hydrobiological sampling, 7. meso-zooplankton nets) ; to onboard ecosystem data pre-processing (B; acoustic data scrutinising, midwater trawl catch sorting, biological parameters recording, zoo and ichthyplankton imaging, seawater filtrations for biogeochemistry) and to final ecosystem products (C) with standard raster maps of parameters in all pelagic ecosystem components, time series of indicators of the state the pelagic ecosystem. From Doray *et al.*, 2018a.

2.2. Ecosystemic surveys

2.2.1. Fisheries surveys

Acoustic surveys Acoustic surveys quantify pelagic fish stocks by converting fish echotraces to abundance and biomass (Carpentieri, Bonanno, Scarcella, 2020; Doray *et al.*, 2018a; Massé *et al.*, 2018; MEDIAS Handbook, 2021). The pelagic fish species are fish living in the mid-water column. In European and Mediterranean waters, they belong to Engraulidae (anchovies), Clupeidae (pilchards, sardines, sprats), Carangidae (horse and blue jack mackerels), Scombridae (mackerels) and Sparidae (bogues). Acoustic surveys are conducted during daytime along predefined transects homogeneously covering the study area (generally from the 10m isobath to the shelf break, i.e. the 200 m contour line), with the inter-transect distance defined based on the largest number of school clusters within a given survey time. The same transect sampling scheme is used every years. The vessel steams at a reduced speed (8-10 knots is recommended) to compromise between travel speed (conditioning survey coverage) and radiated noise from the ship that can impair acoustic detection. The acoustic survey is operated continuously along the transect during daytime through hull-mounted echosounders, but can be complemented with nigh-time acoustic sampling to provide information on the nycthemeral dynamics of the zoo- and meso-plankton sound scattering layer. However, only daytime echotraces are used for fish stock assessments (as schools disperse during the night). Multiple echosounders can be used to allow the 3D views of the pelagic zone and the horizontal and vertical structure of fish schools (shape, density, position), which helps identifying the school specific compositions. Pelagic trawl hauls are conducted adaptively along the acoustic transects to confirm the relative species composition of fish schools seen on the acoustic data, and to inform biological properties such as the length, weight, age, sex, maturity stage of fish. Other species trawled are also recorded (gelatinous macrozooplankton, cephalopods, sharks, sunfishes etc.). Finally, echoes and acoustic densities can be attributed to fish species and associated to trawl catch to derive small pelagic fish biomass estimates over the study area.

Bottom Trawl surveys Bottom trawl surveys quantify the distribution and relative abundance of demersal species (all fish species and some invertebrates) and biological parameters of commercial fish species for stock assessment (Carpentieri, Bonanno, Scarcella, 2020; ICES IBTSWG, 2019; MEDITS Handbook, 2017). They proceed on station-based sampling design. The stations can be homogeneously distributed over the study area or distributed following a stratified sampling scheme based on bathymetry, but taking care in avoiding sensitive habitats and being distant of at least 10 nautical miles. Most of the time, the same towing locations are visited each year. Bottom trawl hauls are carried out over the shelf (0-200 m deep) and the outer shelf up to 500 m, during daytime. When fishing, the vessel speed is restrained to 4 knots, which maintains the opening of the trawl and ensures its stability. The total catch composition in number and weight by species is recorded for each haul, retrieving information for bony fish, sharks, rays, cephalopods and crustaceans, but also for marine litter. Other biological parameters such as individual length and weight measurements, sex and maturity stages are recorded for specific target species, and otoliths collected for each 1 cm length groups.

Beam Trawl surveys Beam trawl surveys share the same aims than the bottom trawl surveys (Carpentieri, Bonanno, Scarcella, 2020; ICES WGBEAM, 2019), but provide complementary informations on stocks not effectively sampled in bottom trawl surveys, in particular the quantitative characterisation of the benthos community (flatfish, shrimps, shellfish and other benthic organisms). However, they are limited to the 0-100m depth range. The beam trawl gear is characterised by a rigid mouth being kept opened by a frame. Chains can be attached on it which drag in front of the net and cause the fish to rise from the seabed into the net. Ideally, but not systematically, the vessel drags two gears simultaneously, one having a 15 m more warp than the other to avoid interference. As for bottom trawl surveys, sensitive habitats are not trawled, and the vessel speed is restrained to 4 knots when fishing to ensure the good opening of the trawls. The hauls are carried out at pre-defined stations using a stratified random sampling scheme, during daytime. The catch of each gear is sorted and the weight and total number of bony fish, rays, sharks, cephalopods, shellfish and crustaceans are recorded, as well as marine litter. Other biological parameters such as individual length and weight measurements, sex and maturity stages are recorded for specific target species, and otoliths collected for each 1 cm length groups.

2.2.2. Hydrobiology

The main complement to these fisheries surveys is the hydrobiology compartment, aiming at sampling the bio-physical environment in which the target fish species live (Doray *et al.*, 2018a). As such, the aim of those protocols is to better understand the structure of the water column from its physical properties (temperature, density, oxygen concentration,. . .) to primary productivity and plankton. Several protocols are operated in that respect, with various advantages, limitations and resolutions.

Biogeochemistry Research vessels can be equipped with autonomous and compact system of sensors permitting measurements of surface sea water characteristics. This system comprises hull-monted thermosalinometer to sample continuously (i.e. 30sec intervals) the temperature, salinity and fluorescence of the sea surface waters, but also oxygen optode and pH sensor. All these instruments allows one to describe, on a continuous basis along the vessel track line, the sea surface temperature, oxygen concentration, pH, conductivity as well as algal and chlorophyll concentrations in the surface waters. This system is known as the Ferrybox.

CTD profiles In addition to the continuous sampling of surface waters, CTD casts (for Conductivity Temperature Depth) can be performed at pre-defined stations along the sampling scheme to characterise the vertical structure of the water column. The stations are sampled at night during acoustic surveys, and are chosen based on the transects sampled during the previous daytime period, with the aim of characterising the water column structure synoptically with fish information (obtained through acoustic or trawl surveys). The CTD probe (for conductivity, temperature, depth) is an essential instrument in physical oceanography. Its is operated by cable between the surface and the sea floor. This design allows the sampling of the three above-mentioned parameters in near-real time along the water column to quantify its vertical stratification. The CTD is generally mounted on a rosette (frame) permitting to simultaneously carry water-sampling bottles (triggered at pre-defined depths) and complementary instruments such as fluorometer, turbiditimeter, oxygen sensor or particle counter to further fine-tune the description of the water column structure from physical to biological properties (chlorophyll a biomass, suspended matter concentration, phyto- and meso-zooplankton communities).

Plankton samples The characterisation of plankton communities can also be achieved through two other complementary methods, a near-continuous (Continuous Underway Fish Egg Sampler (CUFES)) and a discrete (plankton nets) method. The CUFES system is designed for counting organisms and eggs in water sample pumped below the surface (Figure 2). During acoustic sampling, water is sampled every three nautical miles (about 18 minutes for a vessel steaming at around 10 knots), during daytime then filtered with adequate mesh and retrieved for analysis. The plankton nets are towed during hydrobiology stations in parallel to CTD casts. The nets are deployed at 100m deep maximum or 5 meters above seabed in areas shallower than 100 m, using adequate mesh to capture the target plankton community. These samples can then be analysed visually through binoculars by a specialised biologist. However, a recent advance has been made towards semi-automated analysis of plankton sampled with the development of the ZooCAM flow imager by Ifremer in 2013. This system is an image-based, time efficient procedure permitting the assessment of ichtyo- and meso-zooplankton at lower taxonomic resolution than with manual identification.

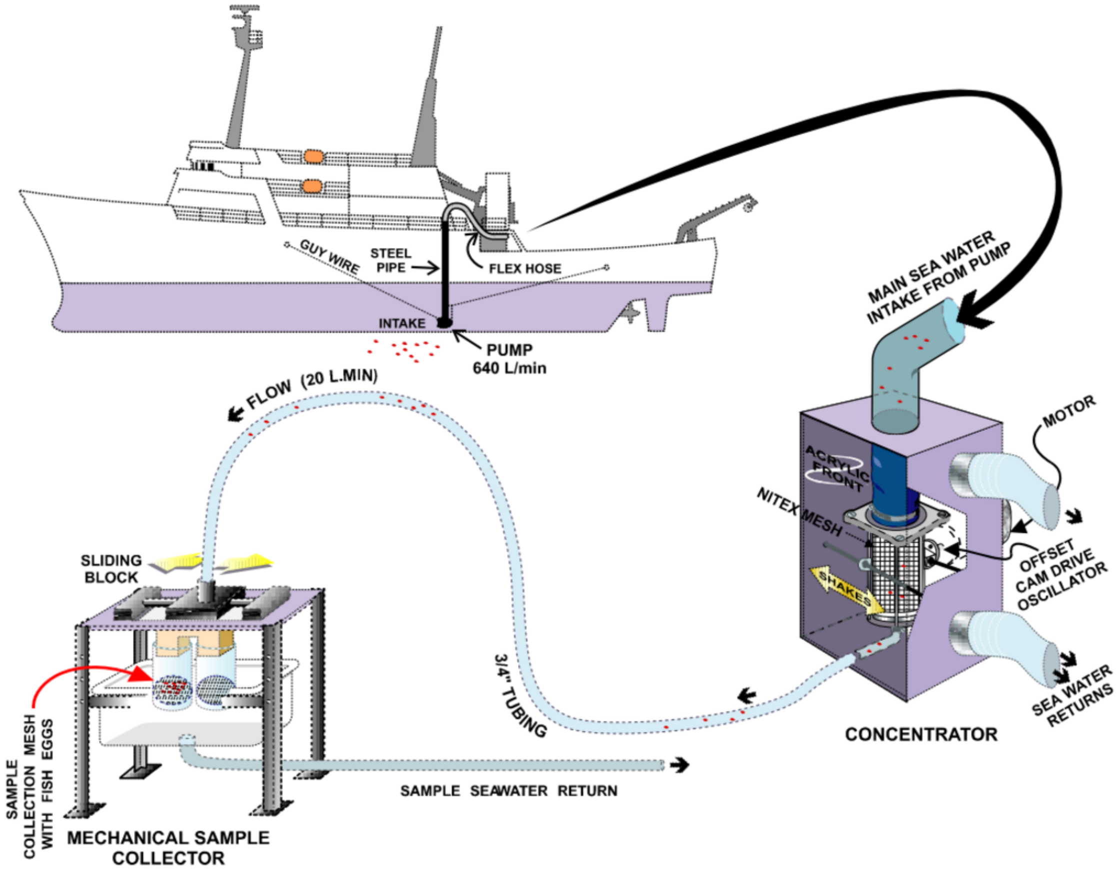

Figure 2. Schematic description of the Continuous Underway Fish Egg Sampler (CUFES) system. From https://www.flotteoceanographique.fr/en/Facilities/Tooling/Ship-Equipment/Measuring-instruments

2.2.3. Egg surveys

The quantification of spawning stocks can either be done as independent surveys (ICES WGMEGS, 2019), but are mostly operated routinely on-board acoustic and trawl surveys. Eggs can be sampled with the CUFES (see above), or using variants of Bongo or Gulf-type high-speed plankton samplers or CalVET-net, with CTD and mechanic or electronic flowmeters attached to the frames to calculate the volume of water filtered on each deployment. Eggs are thus sampled at stations, similarly to CTD casts. The plankton samplers are deployed on double oblique tows, with an even 'V' shaped profile, while the CalVET net is hauled vertically. The retrieved sampled can be processed either manually through binoculars or automatically through ZooCAM, as done with plankton samples. The eggs are identified to species and stages, and daily an annual egg production can be derived to assess spawning areas and spawning stock biomass.

2.2.4. Megafauna surveys

Megascope protocol The Megascope protocol is a standardised protocol used across an array of international fisheries surveys in western European waters and in the Mediterranean Sea (Doray *et al.*, 2018a; Lambert *et al.*, 2018). It relies on the single platform line transect distance sampling methodology (Hammond *et al.*, 2021). This method is fine-tuned to optimise abundance estimations of species from observational data and relies on the principle that detection of individuals is perfect on the transect but decreases with the distance from this transect.

Observations are made from the highest achievable observation point in the ship, which most often is the upper bridge, crow's nest or monkey island, to ensure an unobstructed view over the surrounding waters and detection of animals within several hundred meters (up to 3000 m for an observation platform at 15m above sea level). When the weather deteriorates, the observer retreat to the bridge to carry on the observation effort. The data collection is carried out during daytime from the sunrise to the sunset, along the acoustic transects for acoustic fisheries surveys, or along the travel bouts for demersal trawl surveys, and whenever the boat is en route at a speed around 8–10 knots in order to limit duplicate sightings of animals attracted by the survey vessel. GPS locations of the boat, travel speed and observation conditions (glare, cloud cover, sea state, swell) are continuously recorded along the effort track. Observation bouts corresponds to portion of efforts with homogeneous observation conditions, and each change in conditions, ship activity, ship bearings or observer rotation defines a new observation bout (called a leg). Effort is suspended during trawling operations and sampling stations.

The Megascope protocol can be implemented with either a single, two or three observers, depending on the vessel capacities (Figure 3). When three observers are present, observation bouts of one hour are carried out, with one observer relieved from observation duties and the other two changing observation position to prevent fatigue. The two active observers are positioned on each side of the observation platform, scanning the sea surface with naked eyes within an angle of 90° from the side to the bow + 10°, resulting in the observation effort spanning the 180° in front of the platform. When two observers are present, the same organisation is used, with observers switching their places every hours. When a single observer is present, the observation effort is carried out on a single side of the vessel, covering the 90° from the side to the bow plus 30° on the other side. The observation side is chosen as to use the side with best observation conditions, notably with regards to sun glare.

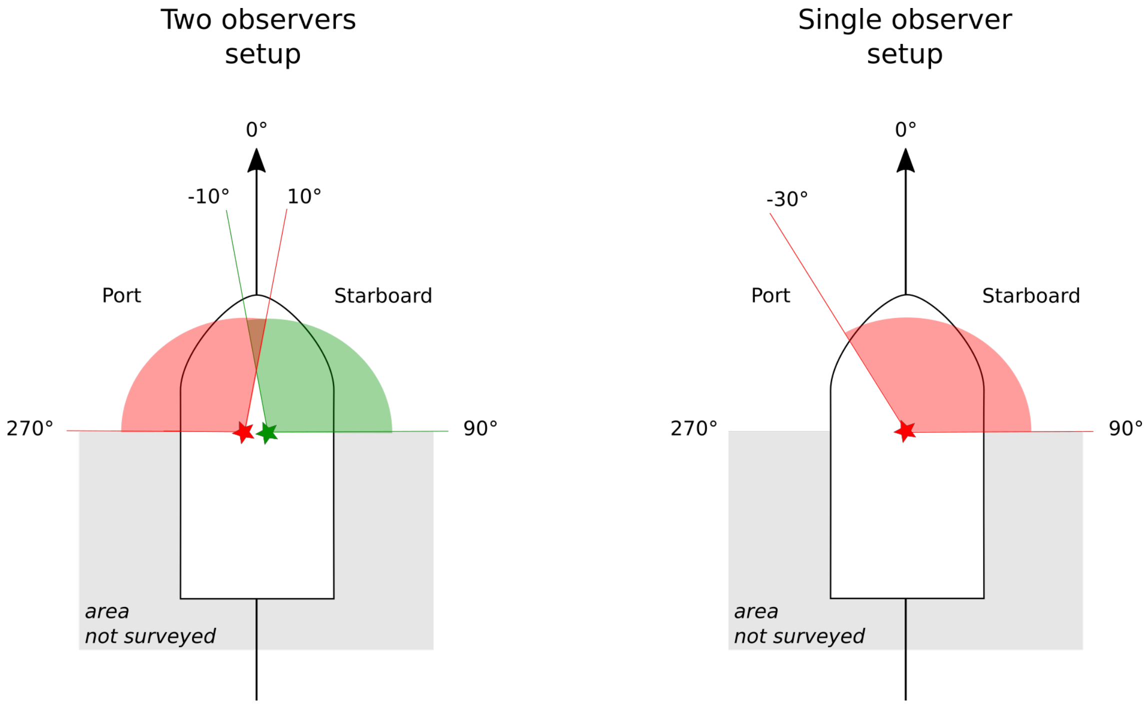

Figure 3. Description of the two possible implementations of the Megascope protocol, with two observers (left) or a single one (right). The vessel steams along the transect line, displayed by the black arrow (0°). The observer positions on-board the vessel are presented by the coloured stars, the area surveyed by observers is displayed in colour between the boundary angles and the unobserved area is shown in grey.

The observers systematically record the distance and bearings from the vessel for all sighted groups of cetaceans, birds (seabirds in majority, but migrating landbirds and shorebirds are regularly sighted), turtles, elasmobranchs, fish, jellyfishes and gelatinous organisms. This information subsequently permit to obtain the distance of animals to the track line and correct data for imperfect detection (distance sampling method). The identification is made at the lowest taxonomic level possible, with binoculars and photographs used to validate species identifications where necessary. Observers systematically record the number of individuals, their position and their angle from the boat. Animals coming from the rear of the boat are not recorded. Observers also record whenever possible the activity and behaviour of the individuals (either foraging, flying, breaching etc.), their direction of movements, whether they are attracted by the boat, any association between species or with fishing vessels, the age, the presence of young (for cetaceans in particular) and any other relevant information (such as entanglement for example). In addition to wildlife, marine litter, fishing gears and ships are also recorded following the same methodology.

This protocol has been routinely used across a wide array of fisheries surveys in south-western Europe as it arose from a joined effort of standardisation of protocols from French, Spanish and Portuguese colleagues surveying the same regions at different periods (in particular, the Bay of Biscay, surveyed in spring and autumn both by French and Spanish teams). Therefore, this protocol is mainly used onboard French, Spanish and Portuguese surveys, namely the PELGAS, EVOHE, CGFS, PELMED and the French section of IBTS for French surveys; PELACUS, JUVENA, BIOMAN for Spanish surveys and PELAGO for Portuguese survey. This standardisation ensured the reproducibility of censuses, comparisons of results across campaigns and the integration of data in joint analyses.

Other protocols Other fisheries surveys carry cetaceans or seabird observers in Europe (mostly north-western), using specific protocols for the two groups. Cetaceans and marine mammal surveys use the distance sampling framework and single platform line transect survey design. The protocol is largely equivalent to what was presented above, with sightings recorded with their location, bearings, number of individuals and other information regarding the sighted animals (age, behaviour, sighting cues, association to other animals or vessels). All environmental parameters related to observation conditions are recorded at regular intervals and whenever they change (sea state, cloud cover, swell, glare). The observations are carried out during daylight from the most elevated place in the vessel ensuring the wider view on the surrounding waters (crow's nest, monkey island or deck), but observers retreat to the bridge when the weather deteriorates. One or two observers operate during surveys, with different observation settings. During IBWAS (International Blue Whiting Acoustic Survey; O'Donnell *et al.*, 2018), two observers concentrate in the area from dead ahead to 60° either side, but can record up to 90°, and operate with 2h rotating shifts and one hour break. During WESPAS (Western European Shelf Acoustic Survey; O'Donnell *et al.*, 2020a), the setting is similar but with a single observer, thus concentrating on only one side (0-60°). During the CSHAS (Celtic Sea Herring Acoustic Survey; O'Donnell *et al.*, 2020b), a single observer concentrates in the area from dead ahead to 45° on each side. Most of these surveys also conduct point sampling during hauls or station-based manoeuvres like CTD casts.

For seabirds, the European Seabird At Sea (ESAS) protocol is most often used, and conducted by specific observers (O'Donnell *et al.*, 2018; O'Donnell *et al.*, 2020a; O'Donnell *et al.*, 2020b). Therefore the above-mentionned surveys embark two independent teams to carry out marine mammal and seabird censuses. The ESAS protocol is designed to compromise between strip-transect and line-transect (Figure 4), as it takes into account the issue of imperfect detection and decreasing detection probability with distance from the observer by recording animals within five strips of fixed widths (Tasker *et al.*, 1984). The strip-transect protocol assumes all individuals present within a band are sighted and recorded, hence dividing the observation area into several strips allows for subsequent corrections of imperfect detection in abundance estimates. This setting is potentially more adapted for seabirds where they are present in very high densities, when recording accurate single individual distance and bearing from the vessel becomes highly complicated. The ESAS protocol thus asks to record all individuals sighted into four strips: 0–50m (band A), 50–100m (band B), 100–200m (band C) and 200–300 m (band D). All sightings recorded within those bands are considered "in transect". Individuals sightings farther than 300 m can be recorded as "off transect". The ESAS protocol also includes "snapshot" recordings. The aim is to derive the density of birds in flight on discrete areas, namely 300×300m quadrats: the total number of birds flying at any height within the four bands are instantaneously recorded whenever the vessel passes from a quadrant to the other (so that the interval between snapshots depends on the vessel speed).

Figure 4. Example of the implementation of the ESAS protocol. The vessel steams along the transect line (black arrow), observers record all birds sighted sitting inside the four distance bands and all flying birds within discrete snapshots quadrats. From Johansen *et al.*, 2015.

Conclusion The main constraints on the protocol to be applied in a given campaign are, first, the number of observers that can be embarked on the vessel (depending on the other operating teams in the survey and on vessel size), and, second, the target. Embarking megafauna observers, as in the Megascope protocol, is logistically and scientifically more relevant than having separate teams. It permits maximising the observation area and platform, since the team is not split into two different platforms (as in CSHAS or IBWAS), and the whole protocol for all items can be carried out by a single observer, in case places on-board the survey vessel are limited. But, more importantly, the main advantage of the Megascope protocol is to provide information covering the entire megafauna compartments with a similar method, allowing comparisons between and across taxa to be easily made.

2.2.5. Examples of synoptic analyses resulting from ecosystemic survey

The integrated monitoring surveys provide information about all compartments of the targeted ecosystem, from its physical properties to top predator distribution and abundance. Such integrated approach can be used to identify the spatial entities of the ecosystem (integrating hydrological properties of the water column, phyto and zooplankton, pelagic fish and predators; Petitgas *et al.*, 2018). The described seascapes alongside their temporal variability then provide maps of the spatial structure of the ecosystem and can be used as indicators for ecosystem assessment.

A classical approach conducted with ecosystemic monitoring is to combine in-situ measured oceanographic variables to the observed distributions of various trophic levels, from plankton to fish and megafauna (Astarloa *et al.*, 2020; Dessier *et al.*, 2018; Doray *et al.*, 2018b; Lambert *et al.*, 2018; Louzao *et al.*, 2019). The combination of observations and in-situ variables permit to model the ecological niche of species, and derive distribution maps. The approach can be implemented at various scales and be used to describe the multi-species assemblages structuring the ecosystem (Doray *et al.*, 2018b; Louzao *et al.*, 2019). Taking advantage of one of the main strengths of this kind of dataset, namely the time series built for every monitored compartment, the approach can also be used to determine the variability of the niche across time or space (Lambert *et al.*, 2018) and highlight the ecological strategies used by species through time (stability or flexibility of preferences).

Using in-situ measured oceanographic variables to describe and model the niche of marine species is often more efficient than using remotely-sensed variables, when measured simultaneously with the fauna observations. This is one of the main strengths of ecosystem monitoring and explains the success of such approaches.

Integrated monitoring surveys are increasingly used to disentangle prey-predator relationships in marine systems. This fundamental aspect of ecosystem functioning is often poorly known in marine environment, due to the inherent difficulty in conducting dedicated studies in such dynamic and remote systems. Therefore, the simultaneous sampling of predator and prey on-board ecosystemic surveys represents a unique and unprecedented opportunity to explore in-depth those aspects. Combining those data of very different nature can be challenging, but recent studies have successfully achieved coupling acoustically sampled fish biomass and visually recorded predator distribution. Those works provided evidence for predator-specific avoidance in pelagic fish (Lambert *et al.*, 2018), and described the interaction networks and their drivers in the pelagic system (Astarloa *et al.*, 2019), highlighting positive and negative associations, but also the environmental and biotic factors shaping species co-occurrence patterns in the predator-prey networks.

Where anthropogenic threats are also monitored alongside ecological compartments, specific studies could also be carried out to describe and monitor the impact of those threats (in particular marine litter) on the various trophic levels monitored, from plankton to fish and megafauna (Galgani *et al.*, 2019). This can be done at various levels: litter recorded in fish hauls can be related to fish biomass and the spatial distributions of the two compared; biological samples collected from hauled fishes can be used to quantify the amount of litter in species, potentially segregating age and sex; the distribution of litter monitored visually can be related to that of megafauna to derive risk maps and estimate exposure.

Finally, the most promising perspective for those integrated monitoring arises from the standardisation of protocols across surveys and countries. This effort was undertaken under the EU dynamic for EU-wide comprehensive assessment of ecosystems, and pave the way for international studies at the ecological domain. For example, the French, Spanish and Portuguese acoustic surveys all use similar protocols for the same array of compartments (as described here, from oceanographic parameters to megafauna) and could be merged to assess the pelagic ecosystem structure and state at the scale South-Western European Seas.

2.3. Other oceanographic surveys

2.3.1. Types of oceanographic cruises and operated instrumentations

Fisheries surveys are only one type among several of research surveys conducted over the oceans. Oceanographic surveys range from seismic surveys aiming to characterise the sea floor and geological substrate to physical oceanographic surveys aiming to characterise the physical structures of the water column and its properties. They can either be systematic or occasional, and range from shelf to pelagic waters. A large choice of instruments is used during these surveys, such as buoys (fixed or deriving), moorings, gliders or profilers, trawls and CTD, which conditions the design of survey routes: some surveys having recurring fixed sampling design (stations, in particular), others not. Surveys can either be conducted to monitor fixed stations and transects or to set and replace instruments (buoys and moorings).

Such oceanographic surveys are of interest to cetacean monitoring, as they often sample oceanic waters and are not restrained to the shelf, as fisheries surveys often are. Although purely ecosystemic approaches could not be implemented with such platforms, cetacean monitoring could still be coupled with the monitored parameters of the associated surveys (in particular regarding the water column biogeochemical properties). Cetacean monitoring could be done in two ways in association with such surveys, either through visual or passive acoustic observations. Visual monitoring is similar to what can be implemented on fisheries surveys, with trained observers carrying out observation protocol on-board the research vessel. Passive acoustic observations could be carried out by hydrophones towed directly behind the vessel (as done during the ACCOBAMS Survey Initiative on-board the R/V Song of the Whale), or could be carried out by equipping instruments used during oceanographic surveys with hydrophones, such as moorings, buoys or gliders.

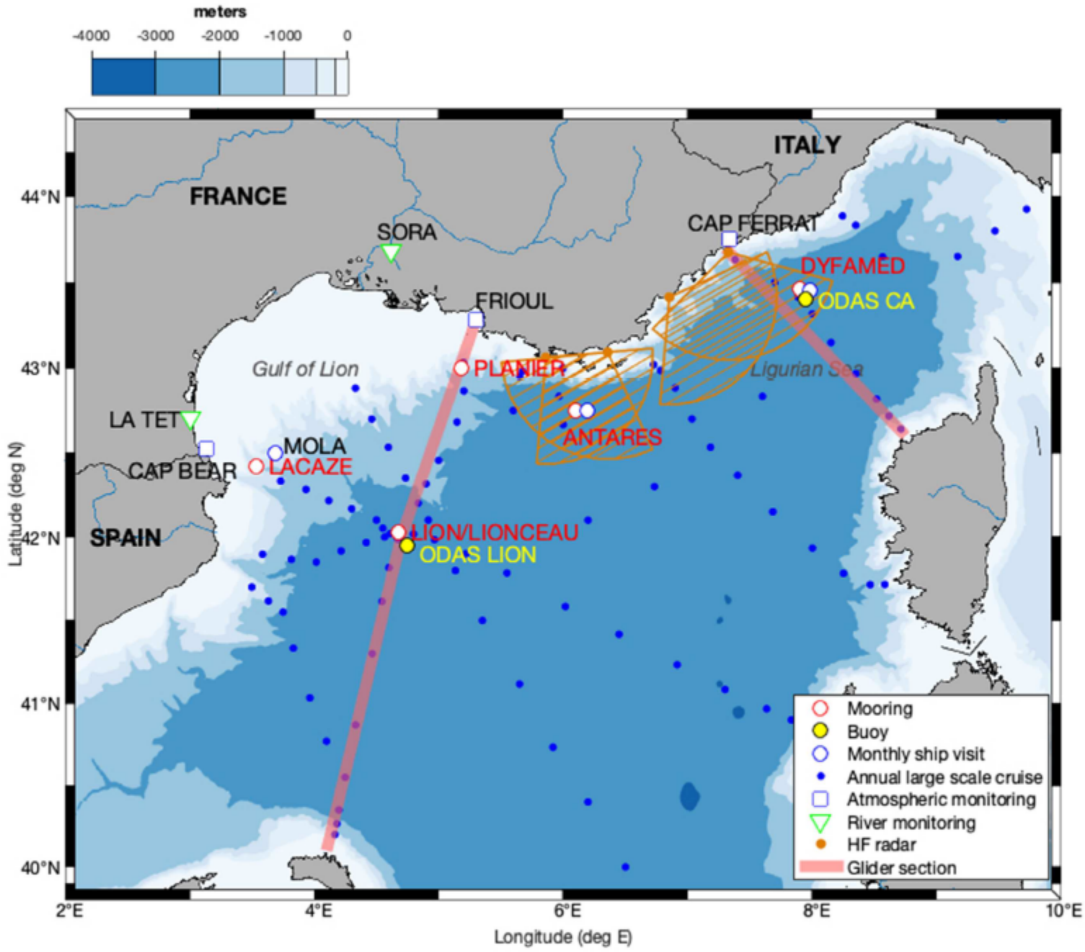

Figure 5. MOOSE settings, displaying the various components of the observation system: moorings, buoys, ship visits and cruises, glider sections and monitoring. From Tintoré *et al.*, 2019.

2.3.2. Example of visual cetacean monitoring on-board oceanographic cruise

In France, the Mediterranean Ocean Observing System for the Environment (MOOSE; operated since 2015) has been set up to monitor the seasonal and inter-annual variability of the Mediterranean Sea, and in particular its evolution under current climate change and anthropogenic pressure (Cocquempot *et al.*, 2019). This multi-disciplinary and multi-platform network is integrated within the Mediterranean Operational Network for the Global Ocean Observing System (MONGOOS; `http://www.mongoos.eu/`; Tintoré *et al.*, 2019). MOOSE is built as a network of permanent stations distributed from the coast to the deep-sea combining fixed observatories (moorings, radars, hydrological stations) and autonomous platforms (gliders and profiling floats; Figure 5). Since the rationale behind this network is to monitor the entire ecosystem and its biodiversity, those observatories record information from physical properties to the biological processes occurring in the Mediterranean waters. In addition to data transmitted by the moorings, radars, gliders and buoys, monthly and annual cruises are carried out with dedicated research vessels to sample oceanic stations (CTD and plankton nets), and as well record geochemical parameters, chlorophyll and plankton concentration en route. These cruises therefore allow assessing up to the zoo- and phytoplankton communities.

Since 2019 however, the range of parameters monitored by the MOOSE network was extended by hosting on-board the annual cruises a marine megafauna observer (2019 and 2021), using the single observer Megascope protocol. This platform of observation (the R/V Thalassa) provides a unique opportunity to complement the monitoring of marine megafauna in oceanic habitats. Indeed, up to now, visual boat-based monitoring of marine fauna in the Mediterranean French EEZ was restricted to the shelf, on-board the PELMED fisheries surveys (the French component of the European MEDIAS surveys)

Such deep-water transects are indeed of high interest for cetacean monitoring, as deep, offshore waters are known to host a different cetacean community than shelf waters. In the French Mediterranean EEZ, the bottlenose dolphin is the main species observed within the shelf, with barely any other species recorded (occasionally, common dolphins and pilot whales on the very edge of the shelf). Yet, during MOOSE, the 1192 km sampled outside the shelf provided a total of 60 cetacean sightings (316 individuals) belonging to eight cetacean taxa (Figure 6). The striped dolphin, well known to be abundant in oceanic areas, was by far the most sighted species, along with pilot whales, Risso's dolphins,

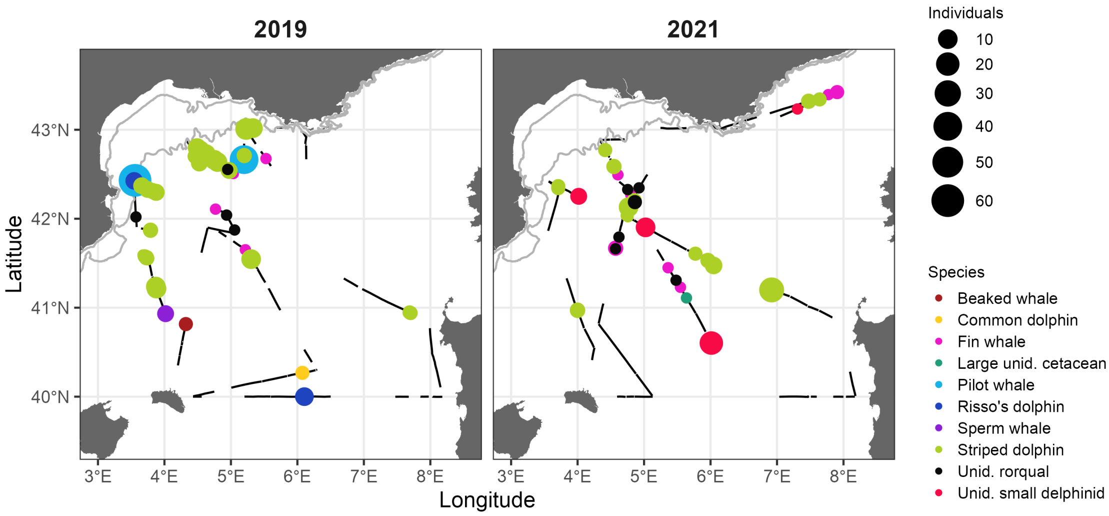

Figure 6. Cetacean observations made during the MOOSE surveys in 2019 and 2021, along the sampled transects (in black). The colour of points indicates sighted species, and their size is proportional to the number of sighted individuals.

as well as sperm, beaked and fin whales. In 2021, 1313 km were sampled, with five taxa sighted: striped-dolphins and small delphinids (either common or striped), fin whales and other non-identified rorquals.

2.4. Requirements for successful visual cetacean census on multi-disciplinary surveys

Most of the conditions required for successful visual observation of cetaceans on oceanographic surveys are linked to the distance sampling methodology. This methodology assumes a decreasing detection probability with an increasing distance to the observation platform. For this detection to be optimal, the observation must be carried out from the highest point achievable with best observation conditions possible. In addition, the single platform line transect protocol is required to be carried out along transects, with a sufficient and steady vessel speed along the effort track. Ideally, the observation protocol should be implemented with two or three observers for both sides of the transects to be surveyed at the same time. Equally important, the observers must be dedicated full-time to the observation task, and not be required for helping in trawl haul sorting or any other task carried out on-board the research vessel.

Those conditions come with specific requirements for the vessels to operate cetacean observations protocol on. The first of all is the place on-board for observers. The room that can be made for observers depends on vessel characteristics (its capacity after accounting for the crew members) and on the scientific teams already involved in the survey. From this parameter depends the protocol that will actually be implemented (one, two or three observers; see section 2.2.3.).

The second crucial element is the structure of the vessel and the accessibility to its highest observation points: does the vessel has a bridge, an upper deck, a crow's nest or monkey island from which the observations can be carried out, and what are the heights of these structures? The higher observation point with the wider unobstructed view is to be prioritised for best detectability of cetaceans, but the actual choice of observation platform must take account of the communication infrastructures on the ship (in particular the position of the radar relative to the potential observation platform). For example, the monkey's island is often the most suitable place for observation, but can be discarded due to the proximity of the radar and its associated health hazards to the observers. The observation platform must also be sufficiently safeguarded for the observers to work in safety (for example, the floor must not be slippery when wet and a guardrail must be present). Good conditions for at-sea observation also depend on the accessibility to the bridge in case of bad weather and on the possibility to carry on observation from this bridge in that case. Alternatively, the protocol can be operated from the top observation platform whatever the weather if this platform is protected. Ideally, the bridge should be accessible and usable with computer connection to permit the systematic recording of observations directly on-board.

The characteristics of the survey itself are also of importance for a survey to be used as a cetacean observation platform. Indeed, the observations are carried along transects, during daytime and with a steady speed. This combination is directly dependent on the survey scheme (transect- or station-based?), on the breakdown of effort between day and night, and between transects, stations or routes. These parameters greatly vary according to the survey type. For example, acoustic fisheries surveys are carried along transects during daytime with a steady and reduced speed. In this case, observation can be carried out synchronously with acoustic sampling. Bottom trawl surveys, however, are based on stations with potentially extensive route between stations. In this case, observation is carried out during the route phases (if the vessel speed can be maintained steady and reduced), and halted during sampling stations. A similar pattern can occur for oceanographic surveys operating stations and mooring or fixed buoys maintenance. Finally, the vessel track and speed must be publishable, which might be an issue with surveys conducted by or vessels operated by military services. Similarly, the vessel must be operated with a GPS, and that GPS be accessible to retrieve effort tracks for subsequent analysis of observations.

3. Inventory of existing surveys in the ACCOBAMS area

3.1. Fisheries surveys

3.1.1. EU - MEDIAS

The Pan European Mediterranean acoustic surveys (MEDIAS) has been launched in 2009 to answer the objectives of the EU Data Collection Framework (DCF), and, more recently, of the MSFD (Figure 7). The international survey is carried out annually within Mediterranean European waters during the summer season, most of the sampling scheme being covered from June to September. The aim is to assess small pelagic fish stocks, in particular of anchovies and sardines, following standardised transect-based acoustic sampling. The protocols follow the ICES recommendations (see above section 2.2.1.; MEDIAS Handbook, 2021), with day-time acoustic sampling backed up with pelagic trawling for confirmation of relative species composition and inform biological properties of schools (size, weight, age, maturity). Occurrence and abundance of other taxa (jellyfishes, elasmobranchs, etc) and of marine litter in hauls are also recorded. Oceanographic parameters are measured at predefined hydrological stations with CTD, and planktonic communities are characterised through sampling with plankton nets or CUFES.

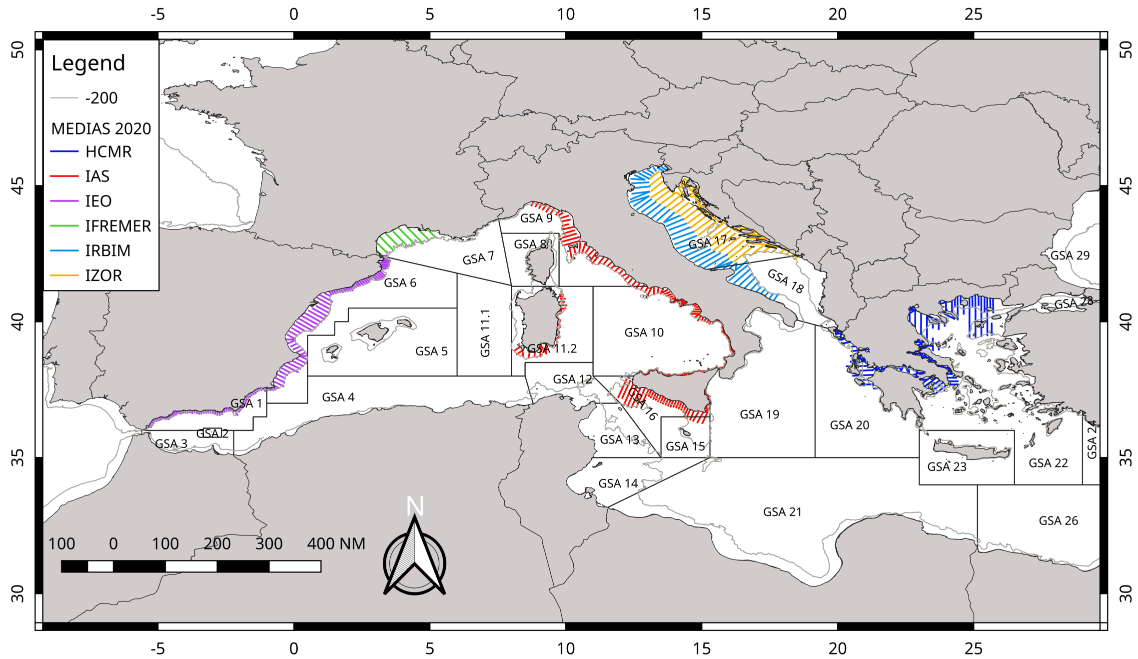

Figure 7. MEDIAS sampling design for the year 2020. Transects are shown for each participating countries, coloured according to the leading institute. The GFCM areas are displayed in black.

Similarly to other acoustic surveys, MEDIAS is restricted to the shelves, and is subdivided according to the GFCM areas (Figure 7). The Spanish coast is sampled by the IEO on-board the R/V Miguel Oliver in June-July. This Spanish section of MEDIAS is built on the ECOMAR surveys carried out in the area since the 90's. The French part is surveyed by the Ifremer on-board the R/V L'Europe in June-July as well. These two fisheries surveys are complemented with marine megafauna observers following the Megascope protocol described earlier. In Italy, the CNR-IRBIM survey the Italian and Slovenian sections of the Northern Adriatic Sea in June-July, while the CNR-IAS survey the Ligurian, Tyrrhenian, Sardinian and Sicilian shelves from July to September. All Italian surveys are carried out on-board the R/V Dallaporta. The eastern Adriatic Sea is monitored by Croatia (IOF-IZOR) on-board the R/V Bios DVA in August-September. Finally, Eastern Ionian Sea and Northern Aegean Seas are monitored by the Hellenic Center for Marine Research (HCMR) in October and June-July (respectively) on-board the R/V Philia. The MEDIAS is also implemented within the Black Sea, in Bulgaria (November-December) and Romania (R/V Steaua de Mare-1, in June and October-November).

Non-EU sections are also monitored under specific projects. The southern Adriatic Sea (Albania and Montenegro), for example, have been monitored from 2008 to 2016 thanks to funding by FAO AdriaMed project and the CNR, as well as in 2019 and 2021 in the framework of the MarE project (funded by "Cooperazione Italiana allo sviluppo"/AICS Tirana and executed by CIHEAM of Bari). Malta waters (Sicily Channel) were sampled in August 2018 during the ANCHOVA survey, as part of the MEDIAS and CALYPSO South projects. The GFCM BlackSea4Fish project allowed the Turkish and Georgian waters to be monitored in 2018 following the MEDIAS protocols, on-board the Turkish R/V BILIM-2 and R/V SURAT-1.

3.1.2. EU - MEDITS

The MEDITS survey (Figure 8; Table 1) is a bottom trawl survey born in 1994 as European Commission Project involving France, Greece, Italy and Spain before being extended to Slovenia, Croatia, Malta, Montenegro, Cyprus, Albania and Morocco (occasional), thanks to the involvement of the GFCM to promote collaboration with non-EU countries (AdriaMed and CopeMed projects in particular). The Black Sea waters of Bulgaria and Romania are also monitored. As for MEDIAS, MEDITS aims at answering the objectives of the DCF and MFSD. The protocol follows the ICES requirements (see above 2.2.1), with a station-based sampling design (MEDITS Handbook, 2017, Spedicato *et al.*, 2019). All encountered species larger than 1 cm are recorded, alongside the total weight, the number of individuals and the individual length. Complementary biological parameters (sex, maturity, age, individual weight) are also recorded for some particular species. Marine litter data is also collected. Hydrological samples are also retrieved at stations in most countries (CTD, plankton nets and FerryBox). MEDITS is carried out on-board hired fishing vessels (Cyprus, Greece, Malta) or research vessels (Croatia, France, Italy, Spain) during the summer season (from April to early September, depending on countries).

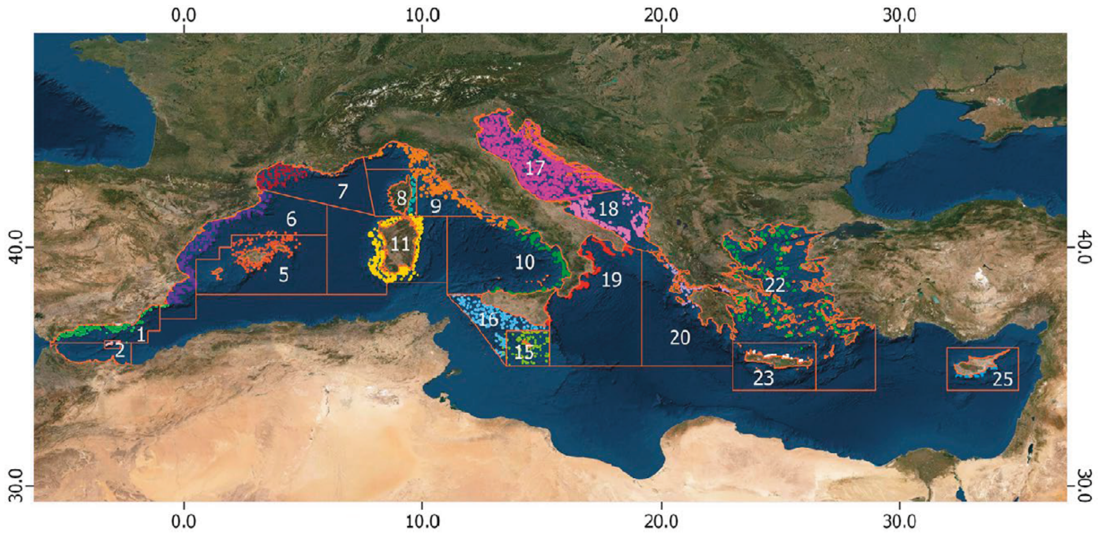

Figure 8. MEDITS sampling design, displaying haul stations for each GFCM areas, with varying colours for varying leading institute. From Spedicato *et al.*, 2019.

Table 1. Contact list for the MEDITS survey (national leaders).

Country	Contact
Croatia	Igor Isailovic (igor@izor.hr)
Cyprus	Ioannis Thasitis (ithasitis@dfmr.moa.gov.cy)
France	Grégoire Certain (gregoire.certain@ifremer.fr)
Greece	Panagiota Peristeraki (notap@hcmr.gr)
Italy	Maria Teresa Spedicato (spedicato@coispa.it)
Malta	Julian Laspina (julian.laspina@gov.mt)
Slovenia	Bojan Marceta (bojan.marceta@zzrs.si)
Spain	Enric Massuti (enric.massuti@ieo.es)

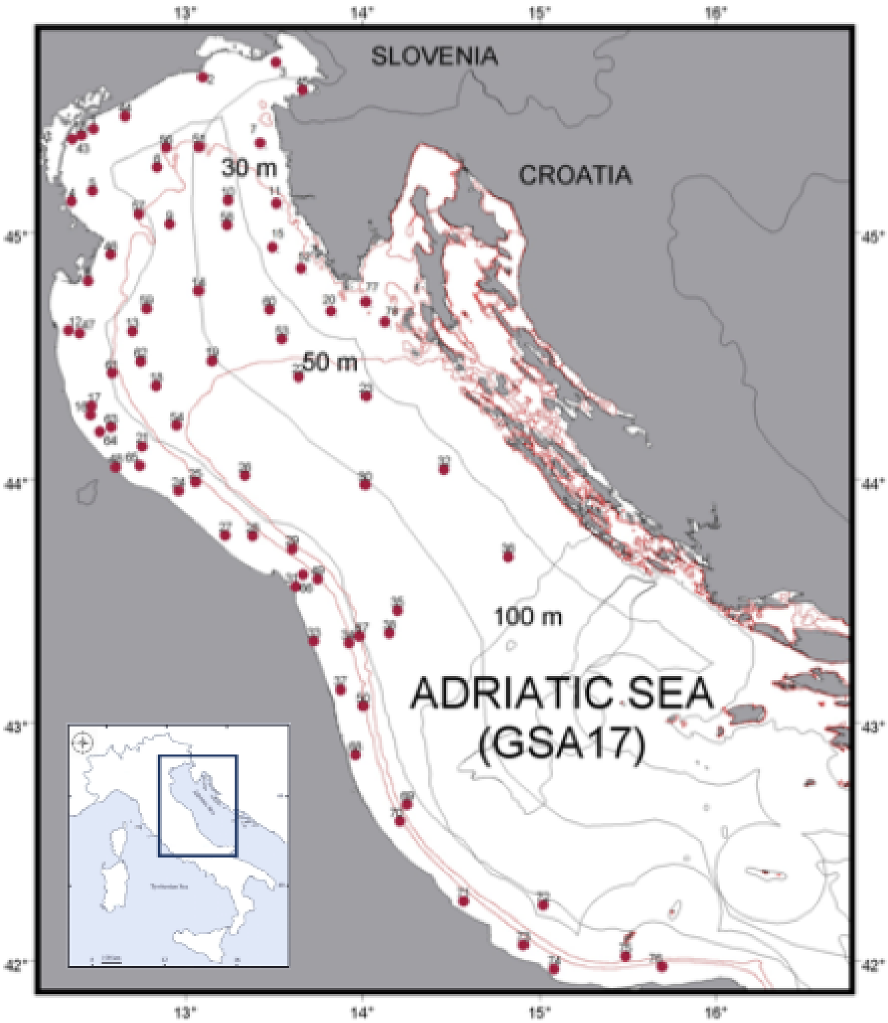

Figure 9. Haul stations sampled during the SoleMon survey (in red). The 30m, 50m and 100m isobaths are shown in orange, red and grey, respectively. The countries EEZ are displayed in grey. From ICES WGBEAM (2019).

3.1.3. EU - SoleMon

The common sole is one of the most commercially important species in the GFCM area, since the Mediterranean provides about 15% of the world catches. 22% of those catches are made within the Adriatic Sea, which motivated the implementation of a sole-targeted fisheries survey in the area. This survey is thus optimised towards the common sole and uses a beam trawl (unlike MEDITS) which is more reliable for this particular species (ICES WGBEAM, 2019). This international effort has been conducted in its current form annually since 2017 over the whole northern and central Adriatic Sea (Figure 9), involving Italy, Slovenia, Croatia, Montenegro and Albania and is part of the DCF and MSFD. The trawl survey follows a fixed station-based design, and CTD are continuously collected during the tow to record oceanographic parameters. Although the common sole is the main target (measured, counted, weighted with information about age and maturity), all encountered species are recorded, counted and measured. The survey is led by the CNR-ISMAR and operated on-board the R/V Dallaporta in November-December.

3.1.4. Morocco

The Mediterranean continental shelf (20–500m deep) of Morocco is monitored with acoustic surveys targeting small pelagic fish twice a year in spring (April—May) and autumn (September—October), on-board the R/V Amir Moulay Abdallah. Regularly spaced transects are sampled during daytime, with pelagic trawls realized on consistent echotraces to help identify fish schools and collect biological parameters (Figure 10; Table 2). Oceanographic data is collected along transects on 50 predefined hydrological stations with CTDs and plankton net tows (characterisation and quantification of plankton community and fish eggs).

Morocco also conducts demersal surveys within its waters (following the MEDITS protocol). However, all oceanographic and fisheries surveys are currently being re-organized following the launching of a new research vessel, the

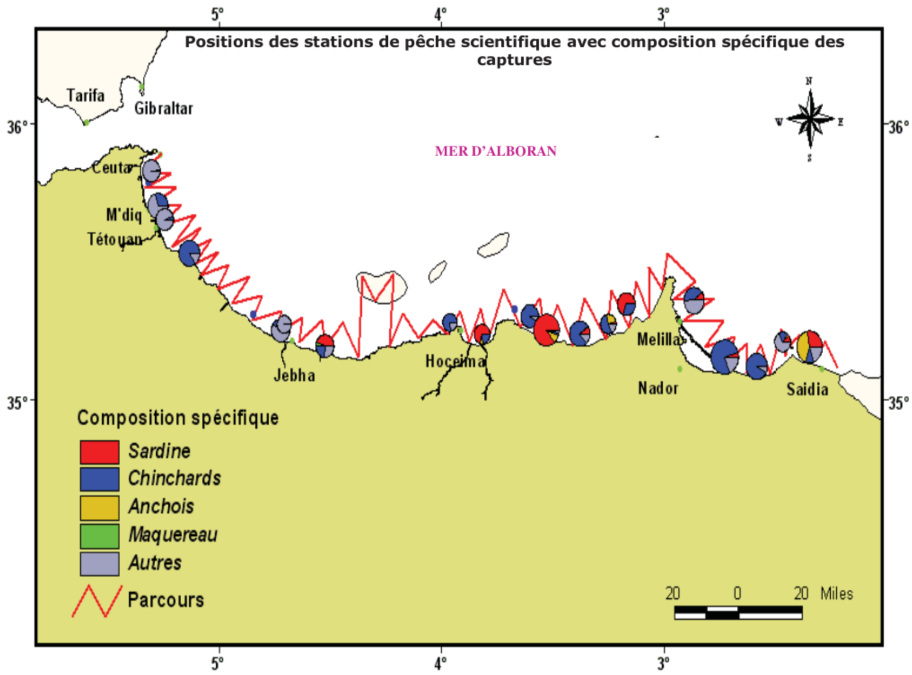

Figure 10. The sampling scheme for the acoustic survey conducted by Morocco in its Mediterranean waters. The acoustic transects are displayed in red, examples of species composition of hauls are shown with pie charts: sardines in red, horse mackerels in blue, anchovies in yellow, mackerels in green and other species in purple. Kindly provided by Najib Charouki.

R/V Marrakchi, and it is not clear, at the date of this report, what will be the ventilation of fisheries surveys in the Moroccan waters.

Table 2. Contact list for the Morocco fisheries surveys.

Survey	Contact
Pelagic acousticn	Najib Charouki (INRH; charouki@inrh.ma)

3.1.5. Tunisia

Tunisia conducts biennial pelagic and demersal surveys with the R/V Hannibal, a 32m research vessel owned by the Institut National des Sciences et Technologies de la Mer (INSTM; Table 3). The pelagic survey follows a transect-based sampling design covering the entire Tunisian shelf (Figure 11), coupling echo-integrated method with big vertical opening bottom trawling. This survey is conducted every two years in autumn and winter and targets the sardine, gilt sardine, anchovy and Atlantic horse mackerel.

The demersal survey follows a station-based design in the northern Tunisian EEZ using mostly big vertical opening trawl, in spring and summer, and targets Mullidae, Carangidae and Sparidae species (Figure 12). Egg samples are also surveyed during both surveys using bongo plankton nets.

Table 3. Contact list for the Tunisan fisheries surveys.

Survey	Contact
Demersal bottom trawl	Samia Fezzani (INSTM; samia.fezzani@instm.rnrt.tn)
Pelagic acoustic	Lofti Ben Adballah (INSTM; lotfi.benabdallah@instm.rnrt.tn)
Egg	Rafik Zarrad (INSTM; rafik.zarrad@instm.rnrt.tn)

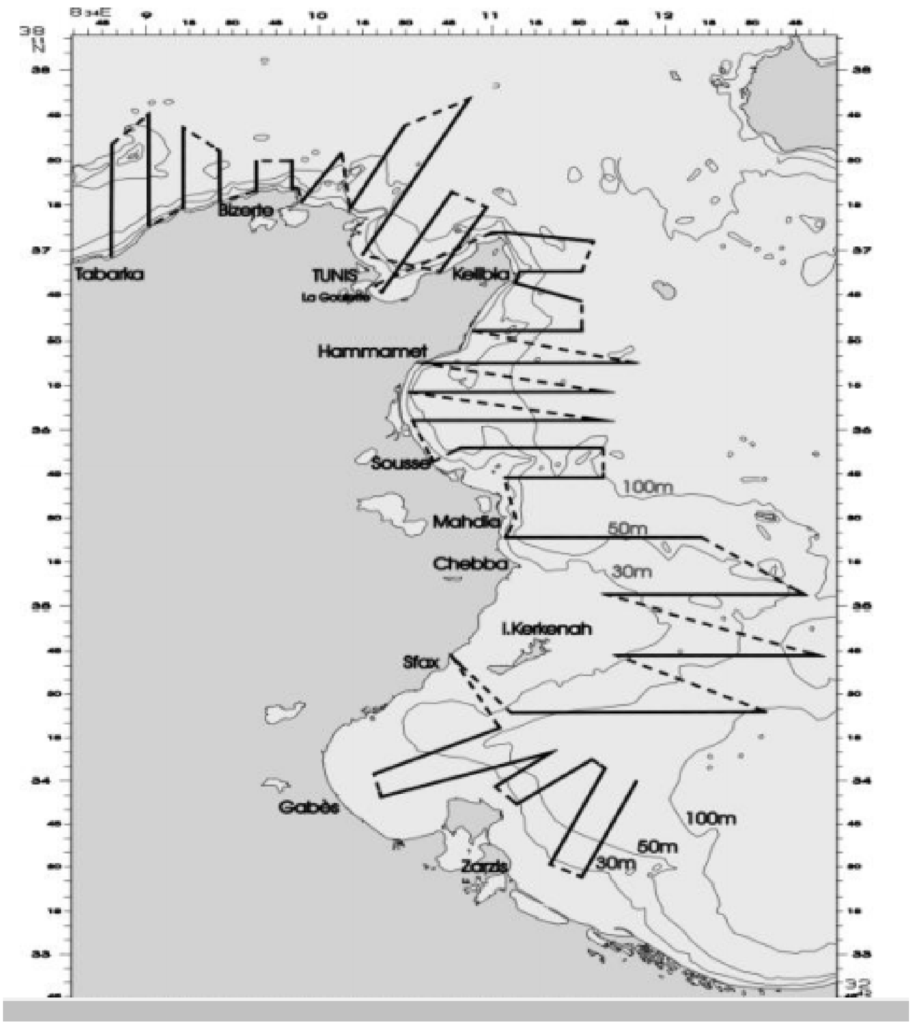

Figure 11. The sampling scheme for the acoustic survey conducted by Tunisia. The acoustic transects are displayed plain black, transit routes in dotted black lines. The 30m, 50m and 100m isobaths are shown in grey. Kindly provided by Mourad Cherif.

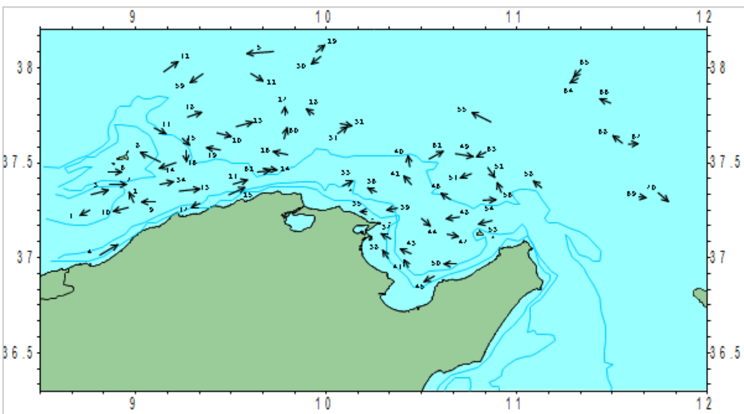

Figure 12. Sampling stations of the Tunisian demersal survey in the northern Tunisian EEZ. The 30m, 50m and 100m isobaths are shown in blue. Kindly provided by Mourad Cherif.

3.1.6. Romania

Romania is involved in the MEDIAS survey, but the NGO Mare Nostrum also conducts annually demersal surveys targeting veined rapa whelk (Rapana venosa; bottom trawl) and turbot (Scophthalmus maeoticus; bottomset gillnets) in spring and summer (Figure 13; Table 4). Those surveys are conducted on-board hired private fishing vessels.

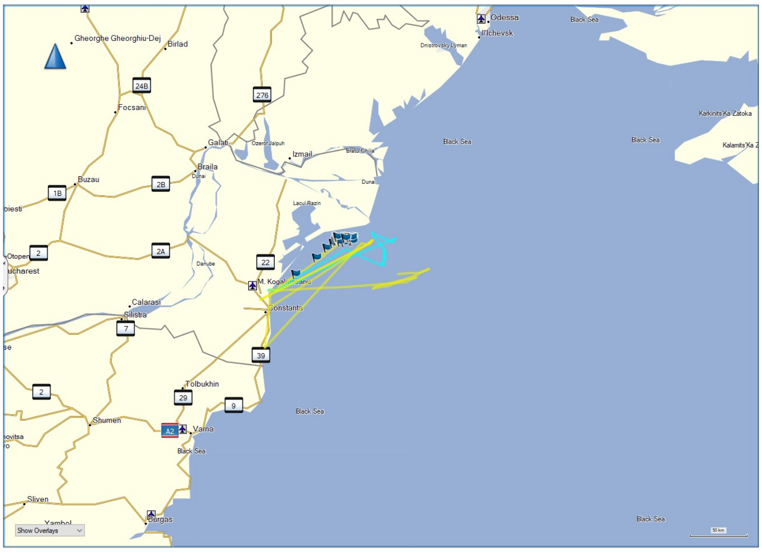

Figure 13. Sampling route for the annual demersal survey conducted by Mare Nostrum in Romania, targeting the veined rapa whelk. Kindly provided by Marian Paiu.

Table 4. Contact list for the Romanian fisheries surveys.

Survey	Contact
Demersal bottom trawl	Marian Paiu (Mare Nostrum; marianpaiu@marenostrum.ro)
Bottomset gillnets	idem

3.2. Oceanographic surveys

The Mediterranean Sea scientific community is strong of 30 years of EU and national-funded programs dedicated to the observation of oceanographic conditions and processes. All those programs benefit from the on-going effort of international standardisation and coordination and most are grouped under the Mediterranean Operational Network for the Global Ocean Observing System (MONGOOS). This System, a child system of the Global Ocean Observing System (GOOS), has been established to foster collaboration and standardisation of operational oceanography in the Mediterranean.

A wide array of surveys is included under the MONGOOS in-situ observation services, which operates open ocean fixed moorings, buoys, radars or gliders (Tintoré *et al.*, 2019). We already detailed one of them: the MOOSE survey (see Section 2.3.2), but similar observation systems are maintained throughout the Mediterranean.

Around the Balearic Islands, the SOCIB (Balearic Islands Coastal Ocean Observing and Forecasting System) operates a network of observing infrastructures including gliders (between Balearic and Sardinian and between Balearic and north Africa), drifters, stations and moorings. In addition, the Spanish observation and prediction system PORTUS is based upon a network of deep water and coastal buoys, radars and tide gauges. The Spanish Institute of Oceanography (IEO) also operates the long-term RADMED program, collecting seasonally hydrographic stations from Barcelona to the Alboran Sea on-board the R/V Francisco de Paula Navarro (Figure 14). During those cruises, the teams have traditionally kept records of encountered cetaceans.

Two regular cruises are conducted along the marine EEZ of Greece on-board the R/V Aegaeo, one under the MSFD context, the other under the WFD (Water Framework Directive). The MFSD cruises is conducted twice a year, in March and November, alternatively in the south Aegean/Levantine and the Ionian Sea every other year (Figure 15). The WFD cruises follow the same pattern, with the coastal waters of the Ionian and Aegean Seas being covered alternatively every year, and both twice a year in March and November. Both cruises are conducted on-board the R/V Aegaeo.

In Turkey, the Center for Marine Ecosystems and Climate Research (DEKOSIM) operates an expedition-based time series (an array of fixed stations monitored monthly for physical, chemical and biological properties), a monthly

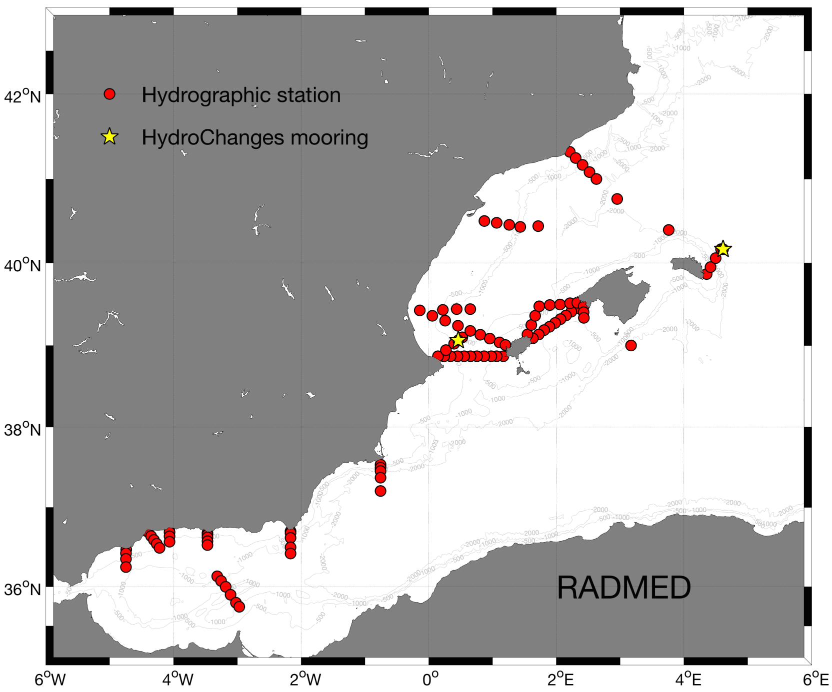

Figure 14. RADMED hydrographic sampling stations in the western Mediterranean. Kindly provided by Rosa Balbin.

demersal trawl survey and a mooring system.

In the Levantine basin, Israel conducts since 2002 transect-based bi-annual monitoring cruises from 20 to 1700 m water depths (on-board the R/V Shikmona and R/V Bat Galim). The bio-geochemical properties of the water column (from temperature and nutrients to plankton) are monitored at eight permanent stations during those monitoring. Israel also operates the only deep-moored station of the Levantine Basin (1500m deep, monitoring physical, chemical and biological properties of the water column), and gliders monitoring bi-annual transects.

In Bulgaria, the Nikola Vaptsarov Naval Academy conduct an oceanographic cruise along the shelf between 30 and 50 m depths on-board the R/V Kiril I Method II (Figure 16).

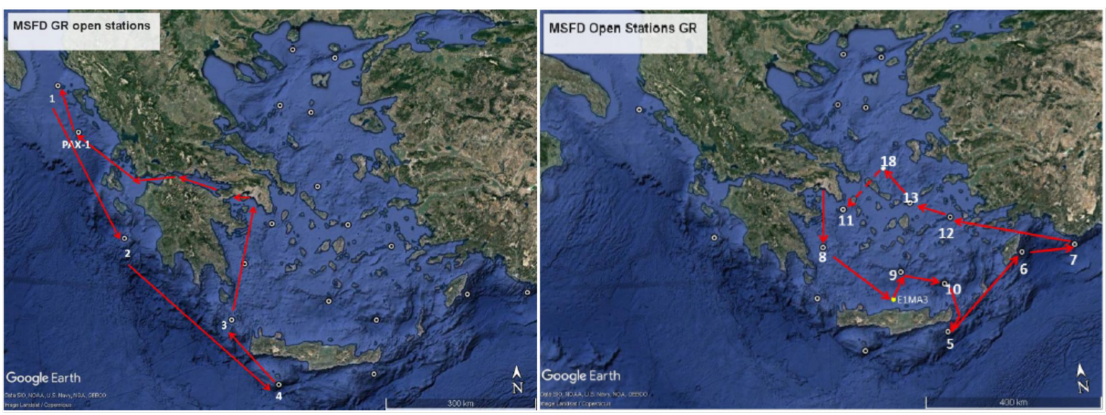

Figure 15. Cruise routes (in red) and sampling stations (white numbers) for the Greek MSFD cruises in the Ionian (left) and Aegean Seas (right). Kindly provided by Christina Zeri.

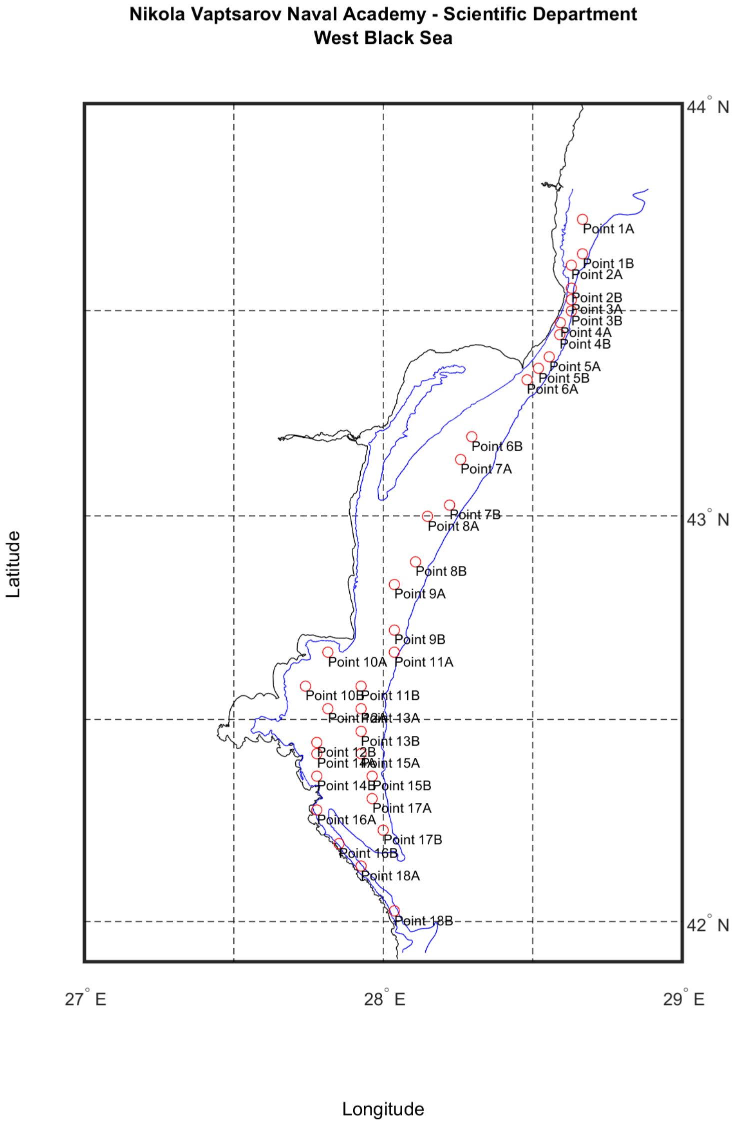

Figure 16. Stations sampled (in red) during the oceanographic cruise conducted by the Nikola Vaptsarov Naval Academy in Bulgarian EEZ. The black line displays the coast, the blue lines, the isobaths. Kindly provided by Miroslav Tsvetkov.

Table 5. Contact list for the oceanographic surveys.

Country	Survey	Contact
Bulgaria		Miroslav Tsvetkov (Nikola Vaptsarov Naval Academy; m.tsvetkov@nvna.eu)
France	MOOSE	Anthony Bosse (MIO; anthony.bosse@mio.osupytheas.fr), Laurent Mortier (LOCEAN; mortier@locean-ipsl.upmc.fr), Pierre Testor (LOCEAN; laurent.mortier@locean.ipsl.fr)
Greece	MFSD WFD	Christina Zeri (HCMR; chris@hcmr.gr) Alexandra Pavlidou (HCMR; aleka@hcmr.gr)
Italy		Katrin Schroeder (CNR; katrin.schroeder@ismar.cnr.it)
Spain	RADMED	Carmen Garcia Martinez (IEO; mcarmen.garcia@ieo.es), Rosa Balbin (IEO; rosa.balbin@ieo.es)

4. Pilot study

Several of the above-mentioned surveys present strong potential to be used as observation platforms to set-up cetacean monitoring and make a step towards ecosystemic survey. The main criteria to be considered in identifying candidates for pilot study are:

1. The type of platform (research vessels or fishing vessels): surveys conducted on-board hired fishing vessels are generally avoided, due to lack of place and sub-optimal observation conditions.
2. The sampled area: megafauna monitoring is already routinely implemented within the north-western basin during French and Spanish MEDIAS surveys; while there is persistent lack of surveys within the southern and south-eastern basin despite the existence of good potential. We therefore advise to prioritize surveys occurring in these areas.
3. The study design and the recurrence of the survey: the study design must be compatible with the distance sampling requirements, and, more importantly, the survey must be routinely conducted at regular intervals to be relevant for setting up monitoring.
4. The characteristics of the vessel: an observation platform must be possible to implement within the vessel, with good observation conditions and respecting security requirements.
5. The type of survey (fishery or oceanographic): both have potential for ecosystemic studies, but fisheries surveys are more integrated with the monitoring of all ecosystem compartments (fish [that is, prey] in particular, that are not monitored by oceanographic surveys).

Given those criteria, we propose in Table 6 a classification of the above-mentioned surveys suitable for adding-on megafauna observers.

Table 6. Suggestion of prioritisation of existing surveys regarding the opportunity to add-on cetacean observers, based on above-mentioned criteria.

	Country	Survey	Advantages	Drawbacks
1	Morocco	Acoustic survey	Recurring surveys (annually and seasonally) with a study design compatible with distance sampling	The R/V Amir Moulay Abdallah is a small vessel, negotiation and prioritisation might be necessary
		Demersal		Contact must be updated to know the reorganisation of surveys with the R/V Marrakchi
2	Tunisia	Acoustic, demersal	Same as above	Same as above
3	Bulgaria	Oceanographic survey	Sampling the shelf of an under-studied area (regarding cetaceans and harbour porpoise)	Oceanographic survey within shallow waters (information on physical and biological conditions but not about prey)
4	Greece	Oceanographic (MSFD, both)	Survey the hellenic trench, a region of recognized importance to sperm whales	Large vessel
5	MEDIAS - All countries not already monitoring cetaceans		Fisheries, standardised protocol across borders, EU scale (but miss southern basin), very strong potential for ecosystemic studies (already the case in France and Spain)	Research vessels, but places might be scarce for many (small vessels)
6	MEDITS - All countries		Fisheries, standardised protocol across borders, EU scale (but miss southern basin)	Fishing vessels for most countries, except Croatia, France, Italy, Spain. Vessels currently at full capacities, so might necessitate priorisation and negociation

5. Recommendations to the Scientific Committee

Given the recommendation made by the workshop held on 11-14th October 2021 to the Parties to commit to and facilitate the implementation of the ACCOBAMS Long-Term Monitoring Programme (R1), to develop and implement coherent synergies for ASI, subregional, national programmes [R4 and R5],

[1] We recommend to foster international collaborations and ecosystemic monitoring in the Mediterranean and Black Seas by basing the designation of pilot studies on the following criteria:

1. give priority to studies conducted on research vessels;
2. give priority to studies conducted within under-studied parts of the ACCOBAMS area, namely the southern and south-eastern basins;
3. give priority to recurring studies with stable protocols and sampling scheme;
4. give priority to surveys conducted on research vessels with suitable observation platforms to reliably monitor megafauna;
5. give priority to fisheries surveys where possible
6. to use a relevant and consistent multi-taxa observation protocol (marine megafauna, human activities and marine litter).

[2] Based on these criteria, we recommend to consider for pilot study (in this order) Moroccan and Tunisian acoustic and demersal surveys, Bulgarian oceanographic survey (conducted by the Naval Academy), the Greek MFSD and WFD surveys, the MEDIAS survey (national component not already implementing megafauna monitoring within) and the MEDITS survey.

[3] We recommend to connect with the existing national surveys using ecosystemic approaches (French and Spanish MEDIAS; French Moose survey, Spanish RADMED survey) to include these national initiatives within the LTMP held by the ACCOBAMS, to strengthen collaborations with the GCFM as to foster standardisation of scientific protocols throughout the basin.

References

Astarloa, A., Louzao, M., Boyra, G., Martinez, U., Rubio, A., Irigoien, X., ... & Chust, G. (2019). Identifying main interactions in marine predator–prey networks of the Bay of Biscay. ICES Journal of Marine Science, 76(7), 2247-2259.

Astarloa, A., Glennie, R., Chust, G., García-Baron, I., Boyra, G., Martínez, U., ... & Louzao, M. (2021). Niche segregation mechanisms in marine apex predators inhabiting dynamic environments. Diversity and Distributions, 27(5), 799-815.

Carpentieri, P., Bonanno, A. and Scarcella, G. (2020). Technical guidelines for scientific surveys in the Mediterranean and the Black Sea. FAO Fisheries and Aquaculture Technical Papers No. 641. Rome, FAO. https://doi.org/10.4060/ca8870en

Cocquempot, L., Delacourt, C., Paillet, J., Riou, P., Aucan, J., Castelle, B., ... & Vuillemin, R. (2019). Coastal ocean and nearshore observation: A French case study. Frontiers in Marine Science, 6, 324.

Darmon, G., Miaud, C., Claro, F., Doremus, G., & Galgani, F. (2017). Risk assessment reveals high exposure of sea turtles to marine debris in French Mediterranean and metropolitan Atlantic waters. Deep Sea Research Part II: Topical Studies in Oceanography, 141, 319-328.

Dessier, A., Bustamante, P., Chouvelon, T., Huret, M., Pagano, M., Marquis, E., ... & Dupuy, C. (2018). The spring mesozooplankton variability and its relationship with hydrobiological structure over year-to-year changes (2003–2013) in the southern Bay of Biscay (Northeast Atlantic). Progress in Oceanography, 166, 76-87.

Doray, M., Petitgas, P., Romagnan, J. B., Huret, M., Duhamel, E., Dupuy, C., ... & Massé, J. (2018a). The PELGAS survey: ship-based integrated monitoring of the Bay of Biscay pelagic ecosystem. Progress in Oceanography, 166, 15-29.

Doray, M., Hervy, C., Huret, M., & Petitgas, P. (2018b). Spring habitats of small pelagic fish communities in the Bay of Biscay. Progress in Oceanography, 166, 88-108.

de Boois, I. J. (Ed) (2019). Moving towards integrated ecosystem monitoring. ICES Cooperative Research Report No. 347. 44 pp. http://doi.org/10.17895/ices.pub.4703

Galgani, L., Beiras, R., Galgani, F., Panti, C., & Borja, A. (2019). Impacts of marine litter. Frontiers in Marine Science, 6, 208.

Hammond, P., Francis, T., Heinemann, D., Long, K., Moore, J., Punt, A., Reeves, R., Sepúlveda, M., Sigurðsson, G., Siple, M., Víkingsson, G., Wade, P., Williams, R., Zerbini, A. (2021). Estimating the Abundance of Marine Mammal Populations. Frontiers in Marine Science, 8, 1316.

ICES IBTSWG (2019). Manual for the International Bottom Trawl Surveys. Series of ICES Survey Protocols. SISP 10, Version 10. 86 pp. http://doi.org/10.17895/ices.pub.5713

ICES WGBEAM (2019). Manual for the Offshore Beam Trawl Surveys, Version 3.4, April 2019, Working Group on Beam Trawl Surveys. 54pp. http://doi.org/10.17895/ices.pub.5353

ICES WGMEGS (2019). Manual for mackerel and horse mackerel egg surveys, sampling at sea. Series of ICES Survey Protocols SISP 6. 82 pp. http://doi.org/10.17895/ices.pub.5140

Johansen, K.L., Boertmann, D., Mosbech, A. & Hansen, T.B. 2015. Manual for seabird and marine mammal survey on seismic vessels in Greenland. 4th revised edition, April 2015. Aarhus University, DCE – Danish Centre for Environment and Energy, 74 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 152 http://dce2.au.dk/pub/SR152.pdf

Lambert, C., Authier, M., Doray, M., Dorémus, G., Spitz, J., & Ridoux, V. (2018). Decadal stability in top predator habitat preferences in the Bay of Biscay. Progress in Oceanography, 166, 109-120.

Lambert, C., Authier, M., Doray, M., Dorémus, G., Spitz, J., & Ridoux, V. (2019). Hide and seek in the Bay of Biscay—a functional investigation of marine megafauna and small pelagic fish interactions. ICES Journal of Marine Science, 76(1), 113-123.

Lambert, C., Authier, M., Dorémus, G., Laran, S., Panigada, S., Spitz, J., ... & Ridoux, V. (2020). Setting the scene for Mediterranean litterscape management: The first basin-scale quantification and mapping of floating marine debris. Environmental Pollution, 263, 114430.

Louzao, M., Valeiras, J., García-Barcelona, S., González-Quirós, R., Nogueira, E., Iglesias, M., ... & Santos, M. B. (2019). Marine megafauna niche coexistence and hotspot areas in a temperate ecosystem. Continental Shelf Research, 186, 77-87.

Massé, J., Uriarte, A., Angélico, M. M., and Carrera, P. (Eds.) (2018). Pelagic survey series for sardine and anchovy in ICES subareas 8 and 9 – Towards an ecosystemapproach. ICES Cooperative Research Report No. 332. 268 pp.https://doi.org/10.17895/ices.pub.4599

MEDIAS Handbook (2021). Version n. 9, MEDIAS Working Group, 15 pp.

MEDITS Handbook (2017). Version n. 9, MEDITS Working Group,106 pp.

O'Donnell, D., Johnston, G., Mullins, E., Keogh, N. and Power, J. (2018). Blue Whiting Acoustic Survey cruise report, March 20- April 06, 2018. FSS Survey Series: 2018/01. Marine Institute

O'Donnell, C., O'Malley, M., Smith, T., O'Brien, S., Mullins, E., Connaughton, P., Perez Tadeo, M., & Barile, C. (2020a). Western European Shelf Pelagic Acoustic Survey (WESPAS), 03 June – 12 July, 2020. FEAS Survey Series: 2020/03. Marine Institute.

O'Donnell, C., Mullins, E., Lyons, K., Connaughton, P., & Perez Tadeo, M. (2020b). Celtic Sea Herring Acoustic Survey Cruise Report 2020, 04 - 24 October, 2020. Feas Survey Series; 2020/04. Marine Institute

Petitgas, P., Huret, M., Dupuy, C., Spitz, J., Authier, M., Romagnan, J. B., & Doray, M. (2018). Ecosystem spatial structure revealed by integrated survey data. Progress in Oceanography, 166, 189-198.

Spedicato M.T., Massutí E., Mérigot B., Tserpes G., Jadaud A., Relini G. (2019). The MEDITS trawl survey specifications in an ecosystem approach to fishery management. Sci. Mar. 83S1: 9-20

Tasker, M.L., Jones, P.H., Dixon, T. and Blake, B.F. (1984) Couting seabirds at sea from ships: a review of methods employed and suggestion for a standardized approach. The Auk, 101: 567-577,

Tintoré, J., Pinardi, N., Álvarez-Fanjul, E., Aguiar, E., Álvarez-Berastegui, D., Bajo, M., ... & Zodiatis, G. (2019). Challenges for sustained observing and forecasting systems in the Mediterranean Sea. Frontiers in Marine Science, 6, 568.