SET OF GUIDELINES BY P1 AND P2 FOR THE MOST EFFECTIVE PROCEDURES TO SAFEGUARD THE SUSTAINABILITY OF FISHERY IN THE FRAMEWORK OF MARINE PROTECTED AREA

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Report	*Set of guidelines by P1 and P2 for the most effective procedures to safeguard the sustainability of fishery in the framework of Marine Protected Areas*
Description	This report presents guidelines proposed by P1 and P2 for safeguarding the sustainability of fishery within the marine SCI areas IT3270025 and IT4060018. The guidelines emphasize data collection and monitoring to support ecosystem-based management. Two pilot actions were conducted in the two areas, utilizing acoustic monitoring and fishing effort estimation, providing groundbreaking insights into fish biomass and spatial patterns. The guidelines highlight the importance of a dedicated monitoring body, catch data reporting, hydroacoustic surveys, revised fishery management plans, and coordination with neighboring SCI areas. These guidelines ensure informed decision-making and sustainable fishing practices.
Version	1.0
Author	GreenSea Soc. Coop.
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1. Introduction

The Adriatic Sea, with its marine and coastal ecosystems, serves a crucial role in facilitating various human activities, such as coastal tourism, fisheries, and aquaculture. As a result, the Adriatic coasts have become highly populated regions within the Mediterranean. However, these human activities pose a threat to marine and coastal ecosystems on which they strongly depend, often compromising their functionality and available resources.

To acknowledge the sea's significance in supporting socio-economic well-being and the pressing need to preserve the structure and functions of ecosystems, the European Union has urged its Member States to establish Marine Protected Areas (MPAs). These designated areas aim to safeguard the natural environment by monitoring the interactions between humans and their surroundings and mitigating the adverse impacts of human activities on marine life. This initiative aligns with the sustainability objectives outlined in Agenda 2030 and SDG14, specifically focused on "Life below Water" (UN, 2015).

The establishment of MPAs can be a key tool to prevent negative feedback loops on several levels of social-ecological systems. Indeed, the overexploitation of natural resources and excessive impacts could lead to an eventual collapse of fish stocks or severe damage to ecosystems, and this in turn can have cascade far-reaching consequences in the social and economic sectors. Therefore, it is among the European priorities to control the exploitation of resources and fish stock, while protecting the biodiversity and the ecological processes.

The Marine Strategy Framework Directive (2008/56/EC) identifies MPAs as the primary tool for protecting marine ecosystems from the pressures and impacts of human activities. They are considered essential areas for achieving the restoration of a healthy biodiversity status.

Despite the significant designation of approximately 625,000 km2 of European Seas as MPAs, many of these areas are currently more similar to legally defined zones, where the effectiveness of regulations to limit the impacts of fishing and maritime activities remains untested.

Fishing activities have been identified as one of the major anthropogenic pressure on biodiversity and on marine ecosystem structure. Certain common fishing practices in Europe not only directly impact biomass through harvesting, but also have negative consequences for productivity, population dynamics of non-target species, and key habitats. These habitats may require many years to recover and regain a healthy status once altered.

Among the various fishing techniques, trawling is particularly problematic as it significantly affects benthic habitats and results in substantial by-catch of non-target species (Jennings & Kaiser, 1998). By-catch can include not only non-commercial fish species but also waterbirds, turtles, and marine mammals. Despite its impacts, bottom trawling continues to be a prevalent activity within European MPAs.

At present, only a mere 0.5% of MPAs in European seas are designated as no-take zones, where all fishing activities are prohibited. This figure falls short of the objective to designate at least 30% of European seas as MPAs by 2030. The limited spread of these fully protected areas, where rigorous conservation measures are applied to preserve marine ecosystems and their biodiversity, may stem from concerns that restricting or banning human activities could lead to short-term social and economic setbacks.

This concern is particularly relevant in Italy, where fishing and aquaculture contribute approximately 2.4% to the total production of the primary sector at the national level, based on 2020 data from the Stati Generali della Pesca e dell'Acquacoltura (Lega Coop Agroalimentare, 2020).

The northern Adriatic region is known for its high productivity and serves as a crucial basin for both aquaculture and fisheries. This area attracts a significant portion of the Italian maritime fishing fleet and lagoon fleets. The current Italian fishing fleet comprises 12,227 units, as per the EU Fleet Register in 2023. Many of these units operate in the northern Adriatic GSA 17, which encompasses areas with sandy shallows and depths of approximately 30-35 meters.

Various fishing gear types are utilized in this region, including hydraulic dredges, bottom trawls, longlines, gillnets, midwater pair trawls, and seines. Despite the high fishing activity in these areas, there are two important Sites of Community Importance (SCI) that are recognized. One is situated off the Emilia-Romagna region, while the other is located off the coast of the Veneto region. Currently, fishing is permitted within these SCI areas as long as the recommendations for protecting species of Community importance, such as turtles and dolphins, are followed.

However, the situation presents a complex interplay between ecological and economic considerations. Reports of dolphins and turtles have been increasing, possibly influenced by Community policies that encourage reporting systems and reduce fishing effort. Concurrently, the maritime fleet in the Northern Adriatic has significantly declined over the past two decades, both in terms of the number of boats and in terms of tonnage and power. This trend is particularly notable in Emilia-Romagna and Veneto, resulting in a loss of fishing vessels in these regions (GreenSea Soc. Coop., 2023).

Given these circumstances, it becomes crucial to establish common guidelines based on scientific knowledge for the sustainable management of fishing activities within the SCI areas off the Po Delta. These guidelines would serve multiple purposes: safeguarding protected species and the ecological role played by these areas, as well as avoiding unforeseen and potentially undesirable socio-economic outcomes.

The evaluation of MPAs' impacts on coastal communities and fishermen requires a comprehensive understanding of socio-economic factors and the implementation of systemic approaches to identify relationships and interactions between natural and social ecosystems. Additionally,

assessing the impacts of human activities on marine ecosystems is challenging due to the uncertainty surrounding the evolution of dynamics resulting from climate, environmental, and social threats, whether real or perceived.
This report is conducted as part of the Interreg Italy-Croatia ARGOS project (Shared Governance of Sustainable Fisheries and Aquaculture Activities as Leverage to Protect Marine Resources in the Adriatic Sea). It focuses on the pilot action carried out by Partner 1 (Veneto Region) and Partner 2 (Emilia-Romagna Region) within their jurisdiction, specifically within the marine SCI area SCI IT3270025 and IT4060018. The pilot action aimed to gather scientifically reliable information on the abundance and spatiotemporal distribution of fish stocks in the area. Based on the outcomes of this pilot action, along with surveys and studies conducted in other InterReg projects related to northern Adriatic fisheries management and analysis of relevant scientific literature, a set of guidelines is proposed to ensure the sustainability of fisheries within the marine SCI areas.

2. Fishery management in marine protected areas: a review of the state of the art with a focus on the project area

Marine protected areas (MPAs) are generally established to protect habitats, species, and processes essential for healthy, functioning marine ecosystems. In the EU context, The Natura 2000 network is the cornerstone of MPAs, and in this perspective, the concept of MPA overlaps with that of marine SCI (European Environment Agency, 2023). MPAs can provide social and economic benefits for local communities, such as supporting fisheries, tourism, and recreation. However, managing fishing activities in MPAs can be challenging, as different stakeholders may have different and sometimes conflicting interests and objectives.
One of the key issues in fishery management in MPAs is assessing the impacts of fishing on the conservation features of the MPAs, such as rare, threatened or important habitats and species. Fishing can cause direct and indirect effects on the marine environment, such as reducing biomass, diversity and size of target and non-target species, altering food webs and ecosystem functions, damaging benthic habitats and increasing bycatch and discards (Coppa et al., 2021). Therefore, it is essential to monitor and evaluate the ecological status of the MPAs and the fishing pressure exerted by different gears and methods. This can be done by using various indicators (Gascuel et al., 2016)
In the Mediterranean Sea, which is one of the most overexploited seas in the world (Colloca et al., 2017), assessing the impacts of fishing on MPAs is particularly challenging due to several factors. First, there is a lack of reliable and comprehensive data on fisheries catches, efforts and socio- economic aspects, especially for small-scale fisheries, which represent

more than 80% of the fleet in terms of vessels (GFCM, 2022). Second, there is a high diversity and complexity of marine habitats and species, many of which are endemic or vulnerable to fishing pressure (Coppa et al., 2021). Third, there is a high heterogeneity and variability of environmental conditions and human pressures across different subregions, such as the western Mediterranean, the central Mediterranean, the eastern Mediterranean and the Adriatic Sea (Colloca et al., 2017).

The Adriatic Sea is a semi-enclosed basin that hosts a rich biodiversity and a variety of fishing activities, ranging from small-scale coastal fisheries to large-scale industrial fisheries (Coppa et al., 2021). It is also one of the most productive areas in the Mediterranean, due to its hydrological and geomorphological characteristics (Grati et al., 2018). However, the Adriatic Sea is also facing serious threats from overfishing, habitat degradation, pollution, climate change and invasive species (Bastardie et al., 2017; Libralato et al., 2015). Therefore, assessing the impacts of fishing on MPAs in the Adriatic Sea requires a multidimensional and integrated approach that considers the spatial and temporal dynamics of both the ecological and socio-economic systems (Coppa et al., 2021).

Another issue in fishery management in MPAs is designing and implementing effective measures to regulate fishing activities and ensure compliance with the conservation objectives of the MPAs. Depending on the type and level of protection of the MPAs, different measures can be applied, such as spatial or temporal closures, gear restrictions or bans, catch quotas or limits, size limits, or selectivity improvements (FAO, 2011).

These measures should be based on scientific evidence and take into account the biological characteristics of the target species and habitats, such as their life cycle, mobility, resilience, and connectivity (Coppa et al., 2021). Moreover, these measures should be consistent with the broader fisheries management framework and aligned with national and international policies and regulations.

In the Mediterranean Sea, which is shared by more than 20 countries with different political, economic, and social systems, there is a need for regional and subregional cooperation and coordination among the countries and stakeholders involved in fishery management in MPAs. The General Fisheries Commission for the Mediterranean (GFCM) is the main regional fisheries management organization that aims to ensure the conservation and the sustainable use of living marine resources as well as the sustainable development of aquaculture in the Mediterranean and in the Black Sea (GFCM, 2022). The GFCM has adopted a 2030 Strategy for sustainable fisheries and aquaculture in the Mediterranean and the Black Sea, which defines five targets: productive fisheries in healthy seas; effective compliance and enforcement; sustainable aquaculture development; thriving communities and better livelihoods; and capacity building and technical support (GFCM, 2022).

In the Adriatic Sea, which, besides Italy and Croatia, is also shared by five other countries (Slovenia, Bosnia and Herzegovina, Montenegro, Albania, and Greece), there is also a need for subregional cooperation and coordination among the countries and stakeholders involved in fishery management in MPAs. The Adriatic Sea is one of the subregions where the GFCM has established a subregional management unit (SRMU) to facilitate the implementation of its 2030 Strategy. The SRMU aims to promote a common approach to fisheries management based on ecosystem-based principles, taking into account the specificities of each subregion (GFCM, 2022). The SRMU also aims to foster dialogue and collaboration among the countries and stakeholders through subregional committees, working groups, and projects.

A third issue in fishery management in MPAs is engaging and involving stakeholders in the decision-making process and ensuring their participation and cooperation in the implementation and enforcement of the measures. Stakeholders include fishers, managers, scientists, conservationists, consumers, tourists, and other users of marine resources and space (Coppa et al., 2021). Stakeholder engagement can help to improve the legitimacy, transparency, and accountability of the management process, as well as to increase the awareness, acceptance and compliance of the stakeholders with the measures (Di Franco et al., 2016).

In the Mediterranean Sea, which is characterized by a high diversity and complexity of socio-cultural contexts and values, stakeholder engagement is particularly important and challenging for fishery management in MPAs. One of the main challenges is to balance the different interests and expectations of the stakeholders, who may have different perceptions and preferences about the benefits and costs of MPAs. Another challenge is to overcome the barriers and conflicts that may arise from historical, political, economic, or institutional factors, such as lack of trust, communication, or cooperation among stakeholders (Coppa et al., 2021).

In the Adriatic Sea, which is a hotspot of small-scale fisheries (SSF), stakeholder engagement is also crucial and difficult for fishery management in MPAs. SSF are characterized by a high diversity of fishing gears, methods, species, and socio-economic contexts, as well as by a strong connection with local communities and traditions. SSF are often marginalized or excluded from decision-making processes due to their low political representation, lack of organization, or limited access to information or resources. Therefore, it is essential to recognize and empower SSF stakeholders, by enhancing their participation, representation, and capacity building in fishery management in MPAs (Coppa et al., 2021).

In conclusion, fishery management in MPAs is a complex and dynamic process that requires a multidisciplinary and participatory approach. By addressing the issues of impact assessment, regulation design and implementation, and stakeholder engagement, fishery management in MPAs can contribute to achieving both conservation and socio-economic goals, and to enhancing the resilience and sustainability of marine ecosystems and fisheries. The Mediterranean Sea and the Adriatic Sea present some specific features and challenges for fishery management in MPAs that require regional cooperation and coordination. Some of the best practices for fishery management in MPAs include: using an ecosystem-based approach that considers the interactions and trade-offs among ecological, social and economic objectives; applying the precautionary and adaptive principles to cope with uncertainty and change; using a combination of spatial and temporal measures that are tailored to the specific context and objectives of each MPA; involving stakeholders in all stages of the planning, implementation and evaluation of MPAs; ensuring effective compliance and enforcement mechanisms that are based on incentives, education and participation; and monitoring and evaluating the ecological and socio-economic impacts and outcomes of MPAs using appropriate indicators and methods (Di Franco et al., 2016; Rice et al., 2012).

3. Marine SCI areas in the Northern Adriatic

The establishment of Sites of Community Interest (SCI) in the maritime waters of Emilia-Romagna and Veneto was acknowledged by the Italian Ministry for the Environment and for the Protection of Land and Sea (MATTM) following the outcomes of the Marine Biogeographical Seminar with the European Commission (Malta, 27-29 September 2016) and the Conference on fisheries management measures in Natura 2000 sites (Zadar, 6-12 October 2017), as well as in response to EU Pilot 8348/16/ENV. The targeted species for protection are the bottlenose dolphin (Tursiops truncatus) and sea turtle (Caretta caretta), both listed in Annexes II and IV of the Habitat Directive. Furthermore, Caretta caretta holds priority status with designated nesting and feeding sites within the Mediterranean region (Casale & Margaritoulis, 2010). As transboundary species, the safeguarding of bottlenose dolphins and sea turtles necessitates considering the entire maritime space, accounting for migration barriers and disturbances such as platforms, maritime traffic, pollution from estuarine areas and river deltas, as well as noise pollution.
In response to the Ministry's guidance, the regions of Emilia-Romagna and Veneto have undertaken collaborative efforts in engaging and consulting with stakeholders in the fisheries sector to define the boundaries of the SCI areas and establish appropriate conservation measures. Simultaneously, they have conducted data collection on the target species as part of the ministerial Monitoring Programs outlined in Article 11 of Legislative Decree no. 190/2010. Additionally, their contribution to the study titled "Interaction between fishing and protected species Tursiops truncatus and Caretta caretta. Assessment of the state of incidence and survey among professional fishing operators - TARTATUR" funded under the EMFF 2014-2020 and published in January 2019 has furthered their efforts.

Through this process, the marine SCIs IT4060018 and IT3270025 have been defined, situated in the waters off to the Po River delta within the jurisdiction of the two regions (Fig. 1).

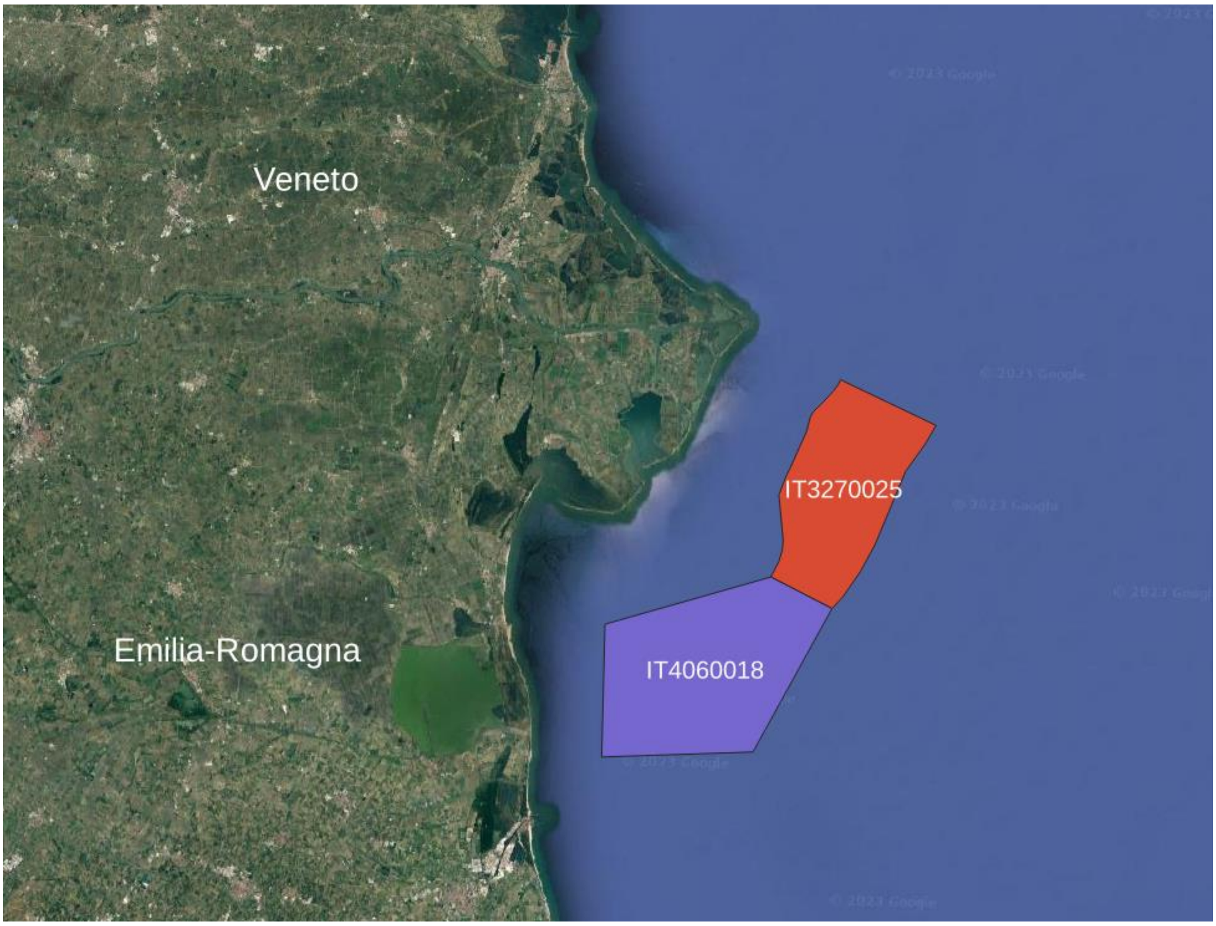

Figure 1: Location of the SCI areas established by Veneto and Emilia-Romagna

The conservation measures implemented in the two sites, respectively through Resolution of the Regional Council of Veneto No. 1135 of August 6, 2020, Annex C, and through Resolution of theRegional Council of Emilia-Romagna No. 710 of May 17, 2021, are completely similar.
Below is an extract of the list of these measures found in the Deliberation of Veneto Region and by the Regional Council Resolution of Emilia-Romagna:

3.1. Veneto Region

Obligations

A. Avoid voluntarily approaching specimens belonging to the protected species, unless they approach the humans first;

B. report the finding of dead and/or beached specimens to the territorially competent Port Authorities;

C. maintain a straight course when trawls are in operation;

D. mark gillnets and other fixed gear with tags;

E. apply turtle bycatch reduction devices to fishing gear currently in use when deemed effective as mitigation measures as part of the application of the study and monitoring activities indicated in the active interventions.

Prohibitions

A. Prohibition to use longlines and lines with single and multiple hooks, both for professional and recreational fishermen;

B. Prohibition to build new offshore wind farms;

C. Prohibition of windsurfing, kitesurfing, water skiing, jet skiing, motor towing of flying equipment (kites, ascending parachutes, and similar devices), and organizing nautical and motor boating events;

D. Prohibition of any close interaction with the protected animals, including voluntary approaching, capturing, feeding the animals, and swimming close to them;

Best practices

A. Involve representatives of the professional fishing community in the management body of the SCI area and in the possible modification and redefinition of mitigation measures.

B. Carry out studies for the application of selection and mitigation tools.

C. Hand over non-releasable animals and/or carcasses to the appropriate bodies after agreement with the Harbour Offices in order to ascertain the causes of injuries or deaths. In the case of live animals, ensure adequate welfare conditions for the animals by providing for their release and/or their transfer to a recovery centre, reporting both events to the competent bodies.

D. Provide facilities for the safe storage of turtles captured alive and for their transfer to recovery centers, without compromising, slowing down, or hindering the activities of fishermen. Define and implement a protocol for turtle recovery.

E. Financially support fishing enterprises that use selection tools and possible deterrents.

F. Continue and implement training through theoretical-practical information and refresher courses for fishermen and other stakeholders on the monitoring of animals at sea, interaction with other institutional and non-institutional actors, animal management and the use of mitigation tools to reduce possible mortality. These activities should be extended to other actors such as boaters, sport fishermen, and transport operators. The training activities will also include a return of data compiled by research and monitoring bodies that will enable informed participation in the critical review of conservation and management measures for these species. These will be manifested through public meetings with direct stakeholders and the various fishing sectors.Implement training and public information activities by integrating fishing tourism activities with dolphin-watching activities through adequate training and compliance with the international rules governing these activities.

G. Maintain and support scientific research, monitoring activities on land (beachings) and at sea (free-ranging and incidental catches) with the direct participation of fishing enterprises. These activities should be made continuous and systematic in order to identify the density, abundance, and distribution of animal populations. In addition, the Monitoring Programmes referred to in Article 11 of Legislative Decree 190/2010, as defined by Italy in the Ministerial Decree of 11 February 2015 (Framework Agreement between the MATTM and the 15 Italian Coastal Regions) must be ensured. The coordination and definition of monitoring and research activities will be carried out by the Veneto Region, directly involving fishing enterprises. Fishermen will actively participate by providing information using rapid and effective tools (dedicated Apps, websites, etc.) and being an active part of this activity. The Interregional Beaching Network, Veneto and Emilia-Romagna, must be supported, making it coordinated at the institutional level so that it can be made able to intervene with unique and harmonized protocols and procedures for providing the necessary information supporting management and ensuring adequate monitoring for all the causes (anthropic and otherwise) that determine animal stranding.

H. Define incidental catch indices through constant monitoring at land and at sea, analyzing individual gear and mortality data.

I. Promote and involve all stakeholders in demonstration activities and research projects concerning the different factors that threaten the conservation status of bottlenose dolphins and turtles. In particular, continue with good practices concerning the collection of marine litter and ghost nets that represent an imminent and impactful danger. These actions should concern all stakeholders, not only fishermen who already actively participate in “fishing for litter” campaigns and have been involved in plastic reduction projects. In this sense, it is important that the waste collected at sea is classified as generic and not special and that its management does not entail additional burdens for fishermen who, instead, provide an irreplaceable service for the benefit of the entire marine ecosystem.

J. Support and promote sustainable fishing, including through objective sustainability certifications, according to accredited standards such as MSC or 'Friends of the Sea'. It is possible to further implement this effort by trying to extend it also to other gears and expanding it with certification systems with specific references to respect and protection of bottlenose dolphins and sea turtles. This is also thanks to EMFF funding, which allows for an adequate economic return thanks to direct contact with the consumer and adequate product valorization.

3.2. Emilia Romagna Region

Prohibitions

A. Prohibition on using longlines and single and multiple hook lines, both for professional fishermen and recreational anglers.

B. Prohibition on constructing new offshore wind farms.

C. Prohibition on conducting prospecting, exploration, and hydrocarbon cultivation activities throughout the SCI territory.

D. Prohibition on practicing windsurfing, kitesurfing, water skiing, jet skiing, towing motorized flight equipment (kites, parasails, and similar devices), and organizing nautical and powerboat events.

E. Prohibition on voluntarily approaching marine turtles and bottlenose dolphins unless the same individuals approach the boats or people.

F. Prohibition on capturing and feeding marine turtles and bottlenose dolphins.

G. With the exception of motorized vehicles dedicated to professional fishing, all motorized and non-motorized watercraft are prohibited from traveling at a speed exceeding 8 knots. This speed may be exceeded in the case of adverse weather and sea conditions or in situations where safety and health issues on board require an immediate return to port.

H. Prohibition on engaging in any fishing activity in the current SCI area coinciding with the "Foce Reno" military shooting range (echo 346).

Obligations

A. Report the finding of dead, injured, or distressed marine turtles and bottlenose dolphins to the competent Harbour Masters or authorized recovery centres.

B. Maintain a straight course when trawling and towed nets are in operation.

C. Mark fishing nets and other fishing gear with tags.

D. Apply turtle bycatch reduction measures to the currently used fishing gear, if considered effective as mitigation measures within the framework of the implementation of study and monitoring activities specified in the active interventions.

Active interventions and best practices

A. Involve representatives from the professional fishing and aquaculture sectors by the SCI marine management body in the modification and redefinition of mitigation measures, according to the provisions set out in a specific memorandum of understanding to be drawn up by the Emilia-Romagna Region.

B. Conduct studies for the application of selection tools and mitigation measures for marine turtles and bottlenose dolphins.

C. Transfer non-releasable animals and/or carcasses to the relevant authorities after reaching an agreement with the Harbour Masters to determine the causes of injuries or deaths. For live animals, ensure their well-being by releasing them or transferring them to recovery centres, reporting both events to the competent authorities.

D. Provide secure storage facilities for live captured turtles before their transfer to recovery centres, without compromising, slowing down, or obstructing fishermen's activities.

E. Provide economic support to fishing enterprises that use selection tools and any deterrents or bycatch reduction measures.

F. Provide economic support and promote sustainable fishing, including through certifications of sustainability, following accredited standards such as MSC or "Friends of the Sea." This effort can be further expanded by extending it to other tools and incorporating voluntary certification systems, facilitated by funding (e.g., EMFF) that allows for appropriate economic feedback and facilitates direct contact with consumers to enhance the economic value of fishery products.

G. Provide economic support to fishing and aquaculture enterprises in case of proven damages resulting from the presence of turtles and bottlenose dolphins in the marine SCI area.

H. Promote active participation through public meetings with stakeholders, particularly various fishing sectors, during the revision of conservation and management measures for these species.

I. Facilitate the organization of theoretical-practical informative courses and updates for fishermen and other stakeholders on monitoring animals at sea, the management of rescued animals, and the use of mitigation tools, aiming to reduce possible mortality. These activities should also be extended to other parties, such as recreational boaters, sports fishermen, and transport enterprises. Training activities should provide information utilizing data processed by research and monitoring entities.

J. Enhance training, dissemination, and public information activities by integrating fishing tourism with dolphin-watching activities through proper training and adherence to international rules governing such activities.

K. Provide financial support to scientific research and monitoring activities both on land (strandings) and at sea (free-ranging and accidental captures), including the participation of fishing enterprises. These activities should be continuous and systematic to identify the density, abundance, and distribution of animal populations. Define indices of accidental capture through ongoing monitoring on land and at sea, analyzing data for individual fishing gear and mortality records. Additionally, ensure the implementation of Monitoring Programs as defined in Article 11 of Legislative Decree 190/10, as specified by Italy in the Ministerial Decree of February 11, 2015 (Framework Agreement between the Ministry of the Environment, Land, and Sea and the 15 coastal Italian regions). The coordination and definition of monitoring and research activities will be carried out by the Region, directly involving fishing enterprises. Fishermen will actively participate in these initiatives, providing information and utilizing efficient and rapid tools (dedicated apps, websites, etc.).

L. Promote and engage all stakeholders in demonstration activities and research projects concerning the various impacts threatening the conservation status of bottlenose dolphins and turtles. In particular, continue with good practices regarding the collection of marine litter and ghost nets, which pose imminent and tangible dangers. These actions should involve all stakeholders, not just professional fishermen who already actively participate in "fishing for litter" campaigns and have been involved in projects to reduce plastic presence at sea. It is important that the waste collected at sea is classified as general waste rather than hazardous waste and that its management does not impose additional burdens on fishermen, who instead provide an invaluable service for the benefit of the entire marine ecosystem and the community.

M. Define and implement a protocol for the recovery of distressed turtles.

N. Support the Interregional Stranding Network between Veneto and Emilia-Romagna so that it is capable of intervening with unified and harmonized protocols and procedures to provide necessary management information and ensure adequate monitoring of all anthropogenic and non-anthropogenic causes of strandings.

4. MATERIALS AND METHODS

4.1. BIO-ACOUSTIC SURVEYS

To assess the fish community within the Marine SCI, a field activity was conducted using a Simrad EK-80 portable split-beam scientific echosounder system. The monitoring program involved periodic surveys aimed at gathering data on the abundance, distribution, and composition of the fish population in the designated area. The Simrad EK-80 echosounder utilized advanced wideband acoustic technology to generate highly detailed echograms, providing precise information on fish and school numbers, dimensions, and biomasses.
The surveys were conducted at regular intervals throughout the year 2022 and 2023 to capture seasonal variations in fish distribution and behavior. The collected data were then analyzed to assess the status and dynamics of the fish community, providing valuable insights into the ecological health and functioning of the Marine SCI.

The field surveys were 5 for Veneto Region and 15 for Emilia Romagna Region, as reported in the scheme below:

Veneto
11th March 2022 3rd May 2022 12th July 2022 6th October 2022 20th December 2022

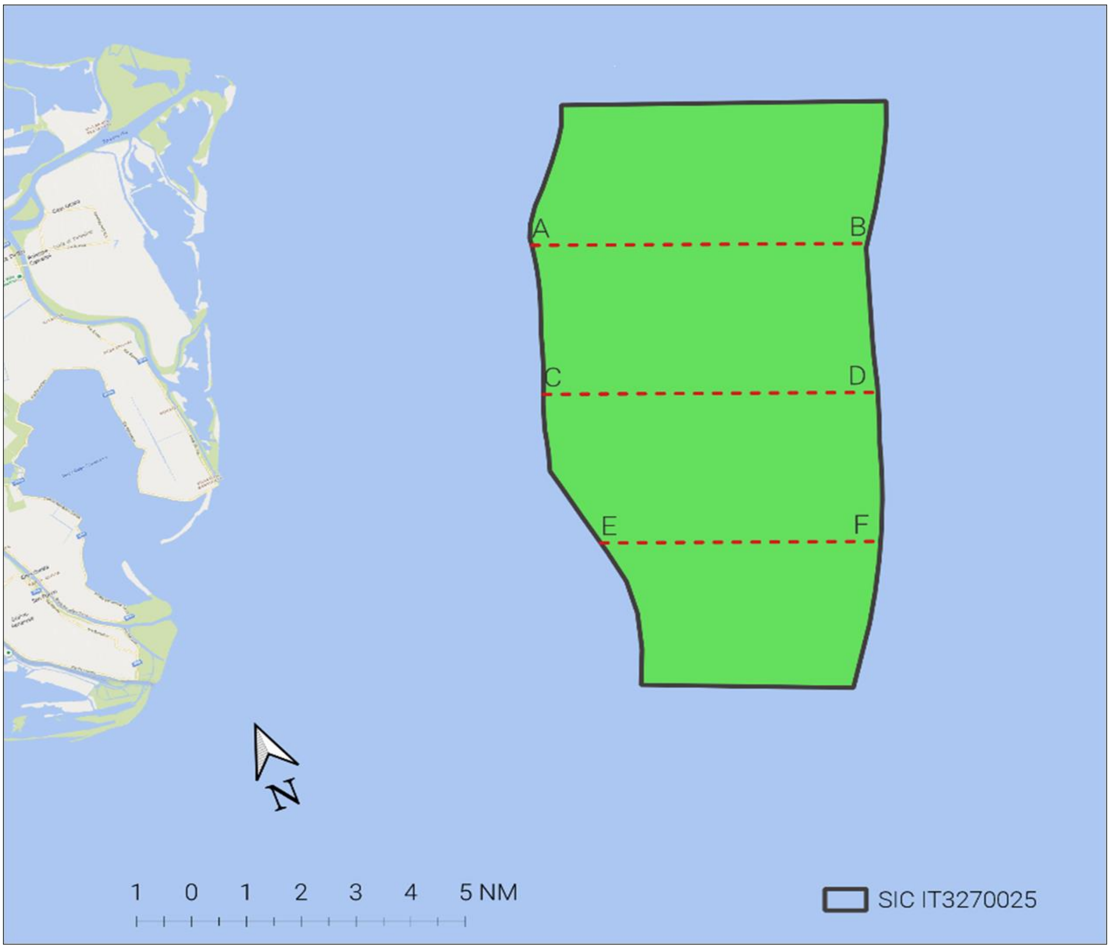

Figure 2: General layout of the survey transects. The actual routes followed varied slightly each time, depending on the weather conditions and other contingent factors.

Emilia Romagna
20 December 2022 morning
20 December 2022 afternoon
21 December 2022 morning
21 December 2022 afternoon
30 January 2023
31 January 2023
01 February 2023
20 March 2023
21 March 2023
22 March 2023
18 April 2023
19 April 2023
20 April 2023
26 April 2023
27 April 2023

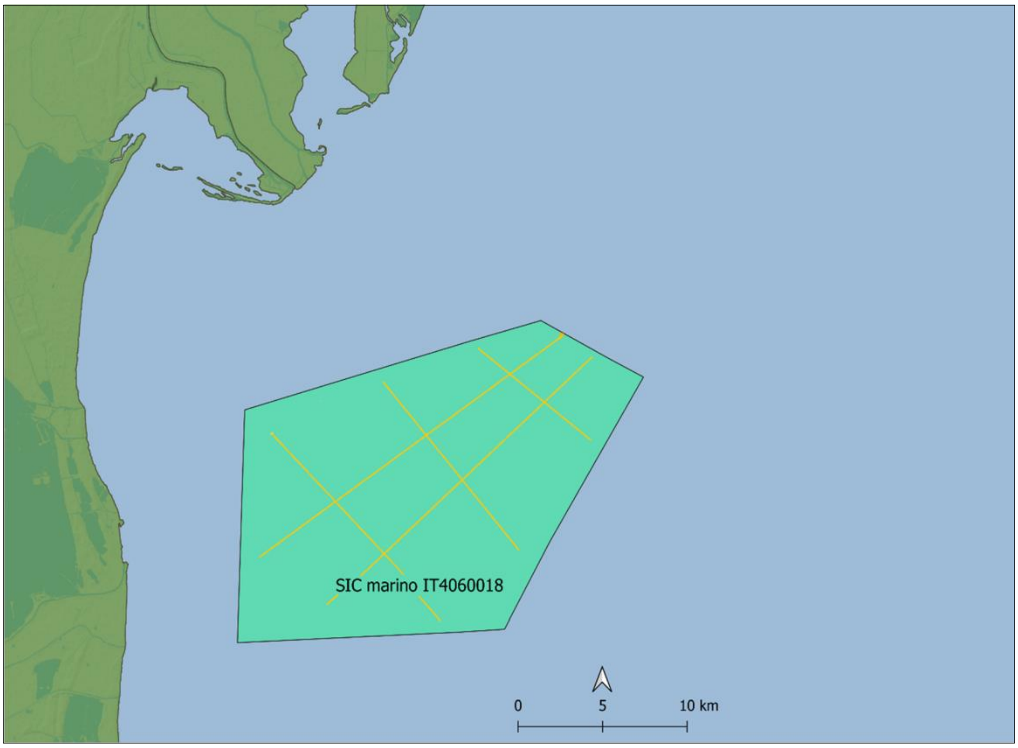

Figure 3: General layout of the survey transects. The actual routes followed varied slightly each time, depending on the weather conditions and other contingent factors.

4.2. Acoustic Method

The general operating principle of the Scientific Echosounder is analogous to that of a conventional fishfinder, which is frequently used by professional and recreational fishermen, but it offers the advantage of obtaining robust scientific data that can be recorded, stored long-term, spatially referenced, and analyzed using advanced statistical techniques.
The transducer (Fig. 4a) emits a pulse at a specific frequency when immersed in water; the resulting pressure wave propagates along the water column until it encounters a reflecting obstacle. A portion or all of the reflected echo is captured by the hydrophone within the transducer (Fig. 4b). The response is then recorded through the transceiver (Fig. 4c) and represented as an echogram (Fig. 4d). The frequency of the pressure pulses ("pings") and the beam width of the transducer determine the resolution of the obtainable data. All collected data are recorded on dedicated computer media for subsequent processing and analysis.
Acoustic reflectivity, also known as Target Strength (TS), is the fraction of echo reflected by the target and captured by the transducer. It is proportional to the size of the target and is measured in decibels (dB) (Simmonds, E.J., MacLennan, 2005). TS values can be used to determine the length of organisms present within the emission beam and, consequently, to estimate biomass (Frouzova et al., 2005). When individual targets are relatively small and dense within the sampled water volume, their echoes combine, and it is no longer possible to determine individual contributions in terms of reflected energy (Foote et al., 1986). In this case, the measured quantity is the backscatter volume (Sv or MVBS). To estimate fish densities the Echo Integration (also known as Sv/TS scaling) method was applied; this very robust technique is based on the ratio between the average reflection from all fish (the volume backscattering coefficient, Sv) and the average echo intensity from individual fish (the backscattering coefficient, σbs) in the linear domain according to the equation:

$$\rho \left[\mathrm{ind} \times \mathrm{m}^{-3} \right] = 10^{0.1(Sv - TS)}$$

Depending on the application, scientific echosounders can operate at different frequencies, typically ranging from 1 kHz to 5 MHz. The choice of frequency is always a compromise because low frequencies allow for exploring larger portions of the water column compared to high- frequency sound waves but at the expense of data resolution. High frequencies, above 200 kHz, enable the identification of very small targets, smaller than a millimeter, but in turbid waters like those in the upper Adriatic Sea, it is only possible to explore a few meters below the transducer due to signal attenuation. The most commonly used transducers for fish detection usually operate between 30 kHz and 200 kHz. The various factors that need to be considered when selecting the appropriate frequency for monitoring tasks are shown in Figure 5.

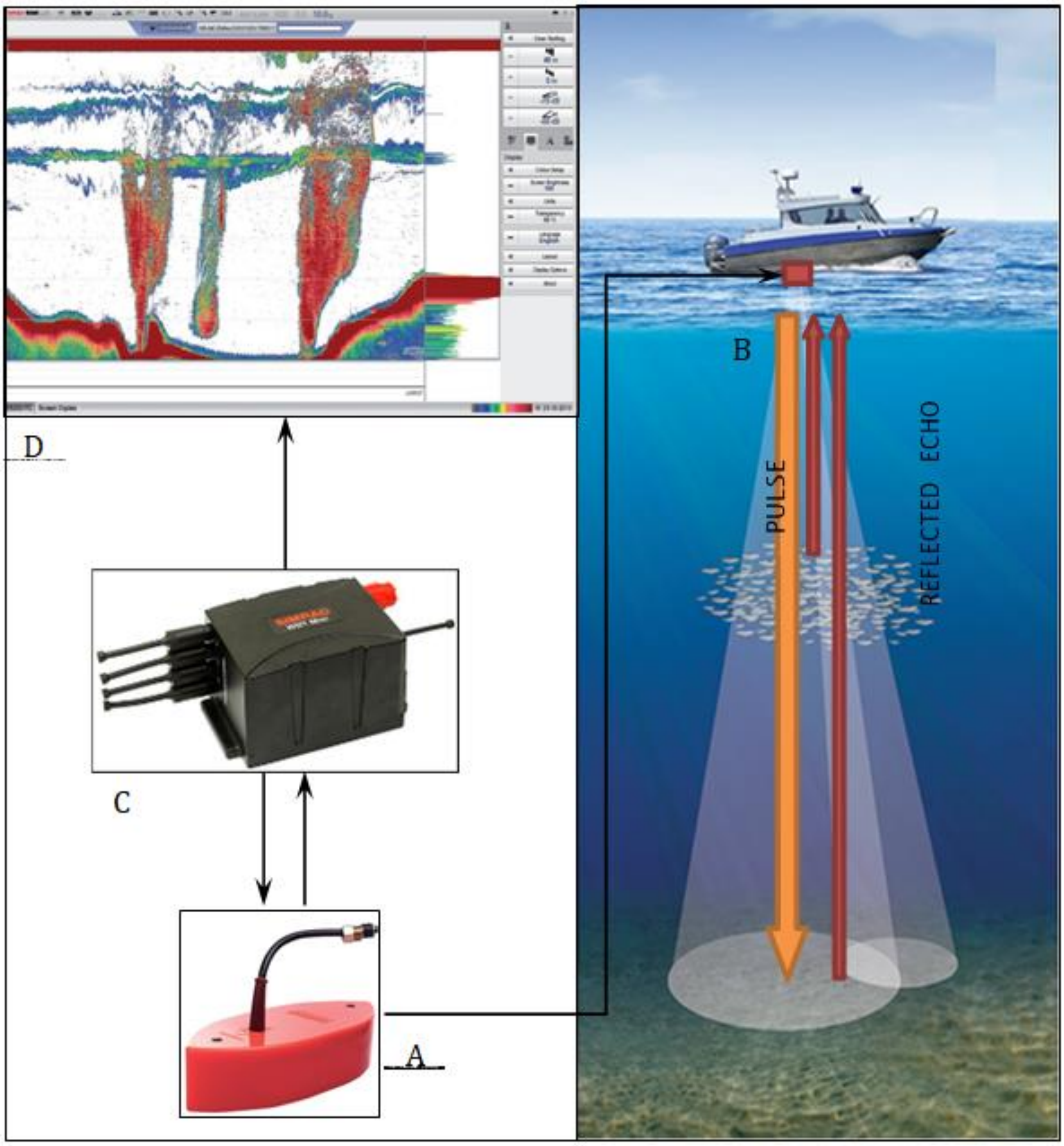

Figure 4: General diagram of a scientific echosounder system operation. The transducer (A) emits sound pulses and records the return echoes (B); the transceiver (C) controls the pulse emission, receives the echoes from the transducer, and generates an echogram (D).

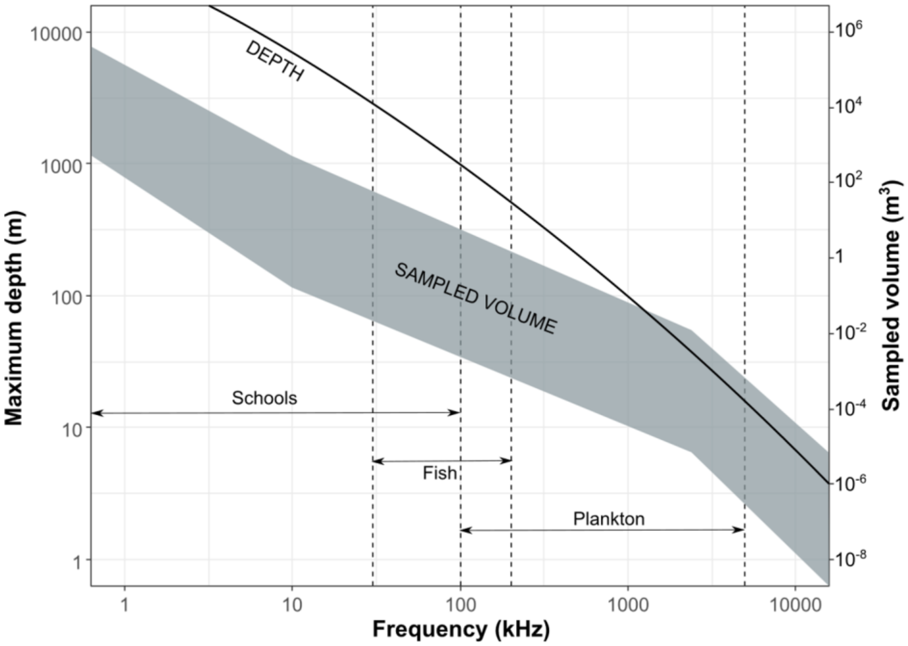

Figure 5: The ability of sonars to detect targets depends on the frequency of the emitted sound waves. The vertical range indicates the maximum distance at which targets can be identified and isolated from background noise. The horizontal axis shows the frequencies typically used for sampling schools, individual targets, and plankton (adapted from Simmonds, E.J., MacLennan, 2005).

The instrumentation used in this activity is characterized by high precision and accuracy of measurements, as the components have been assembled with the aim of minimizing electrical noise, which can in turn cause background noise (high signal-to-noise ratio). Additionally, the conical beam of sound waves is designed to minimize undesired effects such as the presence of side lobes (secondary emission regions that can interfere with the central region and lead to inaccurate measurements). Furthermore, a tungsten calibration sphere has been used to calibrate the echosounder, ensuring a specific response intensity for the water medium being explored, as sound wave transmission in water also depends on water salinity and temperature.

The split-beam technology, used at 38 kHz, allows for defining the target directionality. This is made possible by ideally dividing the transducer into 4 quadrants (channels - Figure 6a), each of which records the echo response intensity differentially. By integrating the four intensities for each ping, it is possible to estimate the target position within the emission cone. By summing the positions belonging to a single fish over multiple consecutive pings, it is possible to identify the direction of the target movement (Figure 6b).

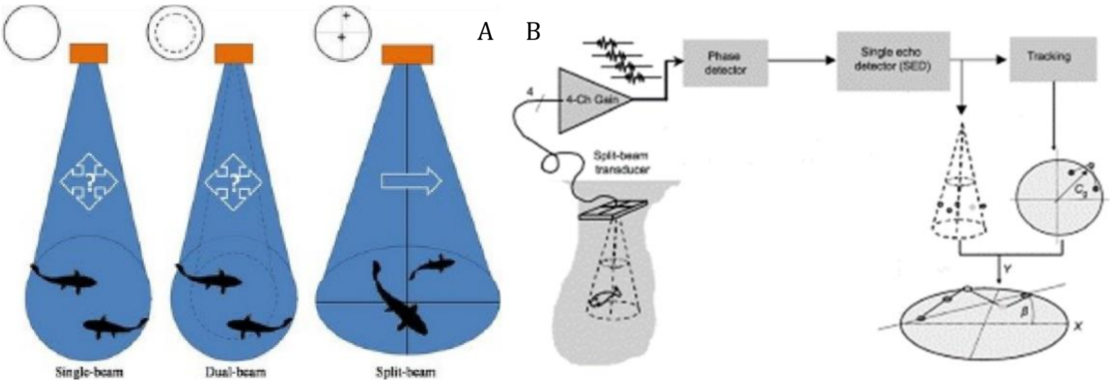

Figure 6: A - Single-beam technology can only discriminate targets along the vertical axis. Dual-beam technology utilizes a narrow central emission cone and a wider adjacent cone to enhance target identification. With the introduction of split-beam technology, it is possible to record the direction and speed of movement of individual fish. B - By integrating multiple successive detections of the same target (fish), it is possible to reconstruct its movements.

4.2.1. Setup

The Scientific Echosounder system, Simrad EK 80, employed for this project is equipped with split- beam technology and frequency modulation. It consists of a WBT-mini transceiver and a dual- frequency transducer operating at 38-200 kHz, with an aperture angle of 18 degrees. The data was acquired using frequencies of 38 kHz and 200 kHz.

The configuration adopted during all sampling campaigns is schematically shown in Figure 6. It involves a PC equipped with Simrad EK80 software and a GPS receiver capable of detecting and recording the vessel's movement speed, as well as the latitude and longitude positions of the pings. The WBT-Mini transceiver, which is powered by a 12V power supply, is connected to the personal computer via a LAN connection. Additionally, it is connected to the transducer, which is immersed in the water using an external pole support and fixed to one side of the vessel.

4.2.2. Acoustic data analysis

In this study, data collected at a frequency of 38 kHz were used. The echograms obtained during the acoustic survey were analyzed with the aim of isolating the biological targets present in the water column. Most fish have a Target Strength (TS) ranging from -65 to -20 dB, but this varies significantly with fish anatomy and orientation (Simmonds, E.J., MacLennan, 2005). Therefore, a conservative minimum threshold of -70 dB was adopted. The target intensity can be defined as the ratio between the reflected intensity value of the target and the logarithmic function of the sound intensity that hit the target, and it can be correlated to the length of the target and, consequently, to biomass (Johannesson & Mitson, 1983).

Within these considerations, the analysis procedure involved the following steps:

A. Visual examination of raw data.
B. Exclusion of portions containing erroneous data, if present.
C. Exclusion of the "near field" zone located at the upper part of the water column.
D. Detection of the seafloor line.
E. Implementation of the single-target detection algorithm to isolate the pings corresponding to living organisms.
F. Implementation of the fish tracking algorithm to aggregate and locate the fish.
G. Visual examination of the tracks to exclude poorly implemented data.
H. Exporting the data in tabular form.
I. Analysis of the exported data using R and GIS environments.

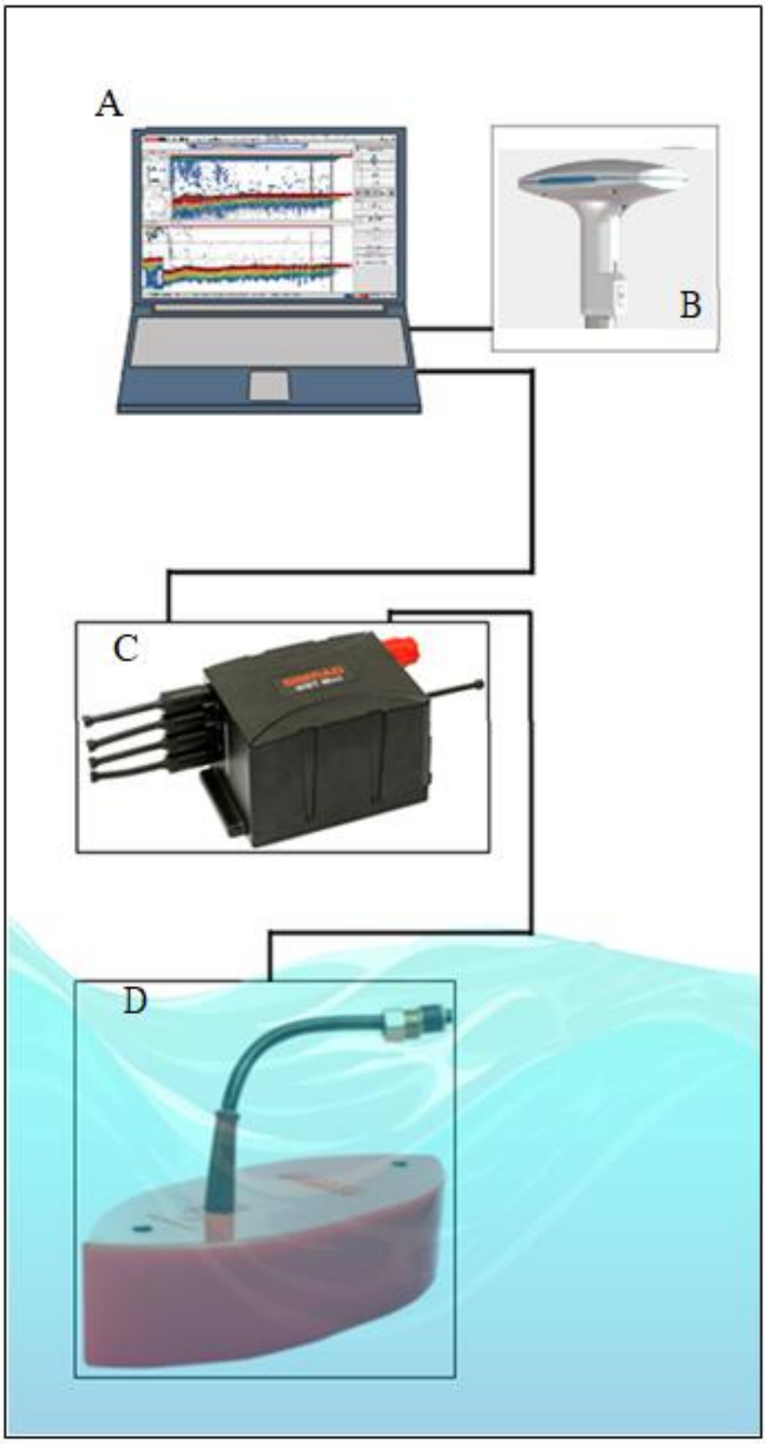

Figure 7: Instrumentation setup diagram - Laptop with acquisition software (A); MRU with compass, motion sensor, and GPS receiver (B); Simrad WBT-MINI transceiver (C); 38-200 kHz split-beam transducer (D).

4.2.3. Spatial pattern of fishing effort in the study area

In order to evaluate the spatial distribution of fishing effort within the area affected by the Marine SCI, we utilized the fishing effort maps generated by the FAIRSEA project, another InterReg Italy- Croatia project. The FAIRSEA partners successfully produced detailed maps of fishing effort throughout the entire Adriatic Sea.

The availability of these comprehensive fishing effort maps proved instrumental in our assessment of the fishing activities within the Marine SCI area. By analyzing the spatial patterns of fishing effort over time and across different fishing metiers, we gained valuable insights into the intensity and distribution of fishing activities within the designated area. This information is crucial for understanding the potential impact of fishing on the marine ecosystem and for developing effective management guidelines.

The FAIRSEA project employed a comprehensive approach to map and assess fishing effort in the Adriatic and Ionian seas. The estimation of fishing effort was conducted within the framework of the project, utilizing a reference grid with a cell size of 5 x 5 km that covered the designated area of interest (Russo et al., 2021).

For fleets equipped with VMS/AIS (Vessel Monitoring System/Automatic Identification System), the VMSbase platform was utilized to process the VMS and AIS datasets. The integration of VMS and AIS data followed a standardized procedure (Russo et al., 2014) and underwent further processing through the VMSbase platform (Russo et al., 2014, 2016). The workflow included data cleaning to identify and flag duplicates and erroneous pings (a "ping", in the context of vessel tracking, is discrete data transmission from a VMS or AIS device that contains information about a vessel position and other relevant parameters), track cutting to sort pings temporally and identify in-harbour positions and tracks representing vessel trips, track interpolation to standardize pings frequency and synchronize temporal coordinates, and assignment of bathymetry to each ping (Russo et al., 2021).

The identification of fishing points involved classifying interpolated pings as "Fishing" or "not fishing" based on case study-specific filters for speed and depth. Fishing set positions were determined within each track (fishing trip). Fishing gear assignment was carried out using an Artificial Neural Network and vessel-specific information, such as gear authorizations and expert judgment. The output of the analysis included maps representing the monthly distribution of fishing effort within the reference grid (Russo et al., 2021).

The FAIRSEA project focused on the Italian fleet operating in the study area, utilizing VMS/AIS data from January 2007 to December 2018. Vessels were classified by gear type and further categorized based on Length Overall (LOA) classes. Fishing trips were associated with specific gear types, and fishing set positions were identified using depth and speed filters. The fishing effort data were aggregated spatially and expressed in Fishing Hours (Russo et al., 2021).

For the purposes of the pilot action in ARGOS, relevant data for the Marine SCI area were extracted from the FAIRSEA maps. Specifically, we retrieved the most recent available data pertaining to fishing metiers that directly affected the SCI area (OTB - Bottom Otter Trawls, PTM- Midwater Pair Trawls, and TBB - Beam Trawls). This targeted selection allowed for a focused analysis of the fishing effort in the SCI area, facilitating the evaluation of its impact and informing conservation measures (Russo et al., 2021).

5. RESULTS

Below are the results of the investigations for the Veneto and Emilia-Romagna marine SCIs.

5.1. Veneto Region

The sampling campaigns were carried out throughout 2022, namely in March, May, July, October, and December. The sampling design allowed for highlighting the time pattern and for estimating the spatial distribution of fish in the SCI area under study.
The density of fish per hectare was increasing from March to October, then started to decrease at the beginning of the winter, in December. Moreover, the heterogeneity of the data was lower in July and October than in the other months (Fig. 8a).
As regards biomass density (Fig. 8b), the increasing trend from March to July was still present, but with a higher variability. While the lower biomass density was registered in March, October was again the month with the maximum value and with lower heterogeneity than other months. December followed with a pretty high median value that, on the other hand, was characterized by high variability of biomass density due to the fish being numerous but often presenting also smaller sizes.

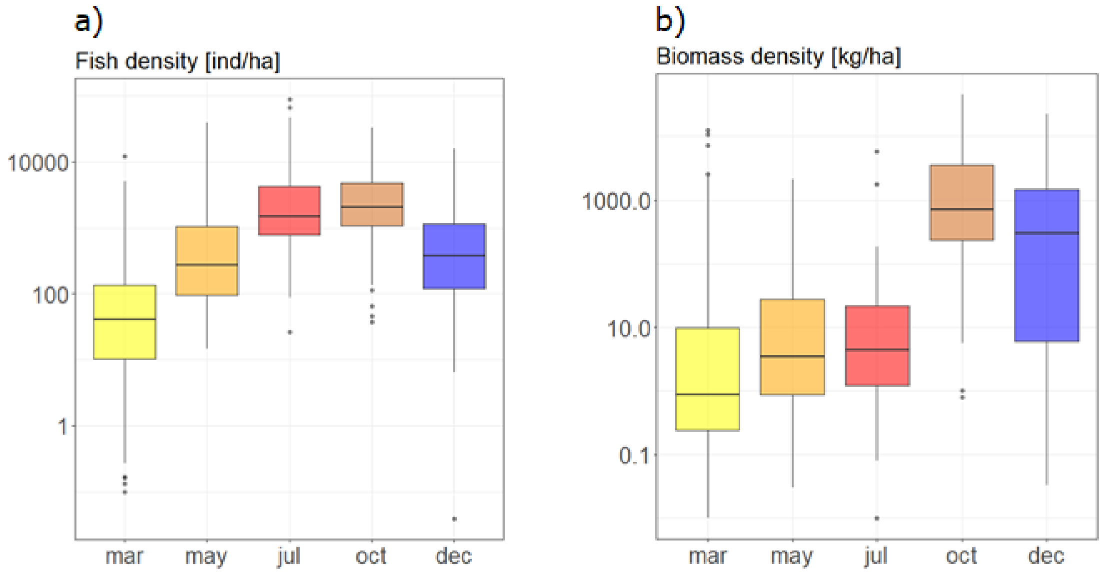

Figure 8: Results of the analyses on fish density in the five echosounding campaigns within the SCI area.

Fish presence was recorded in the whole water column with a higher frequency in the bottom layer. The highest biomass density was occurring in areas where the depth is between -25 to -27 meters below mean sea level (Fig. 9).

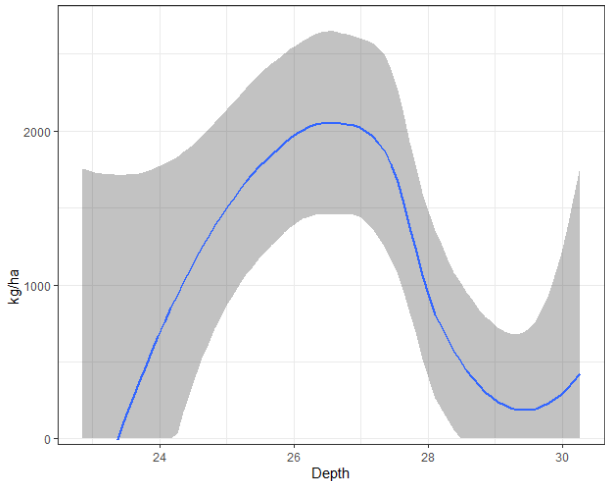

Figure 9: Density of fish biomass (kg/ha) retrieved in the study area, related to the bottom depth.

Figure 10 shows the spatial distribution of the biomass density, estimated through ordinary kriging method used for interpolation. Two spots emerged as density hotspots, located in the middle of the SCI area and in the Southern left quadrant. However, a slight heterogeneity spreads on the site, with a higher aggregation southward.

To compare the likely fish distribution to the fishing exploitation pattern, we calculated the fishing effort in terms of fishing hours, based on the aggregation of 2018 data made available through the Fairsea project database (available at https://www.italy-croatia.eu/web/fairsea/docs-and-tools).

Overall, fishing activities seem to be focused primarily on the westernmost northern part of the SCI area, facing the Po River delta, while appearing to be evenly distributed in the remaining part (Fig. 11). Such a fishing pattern resulted in an average of 1257 hours per year (±644) with bottom trawling gears, and an average of 357 (±233) hours per year with midwater pair trawl.

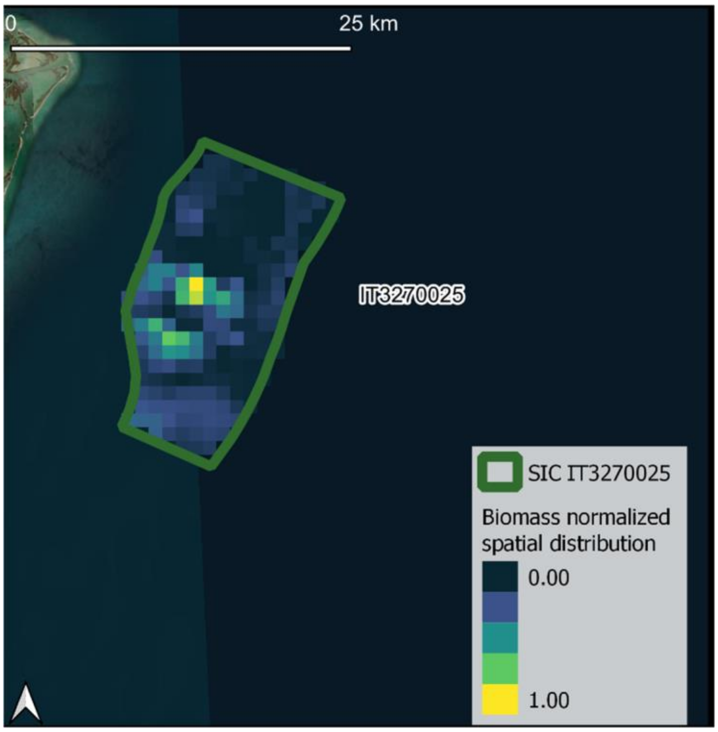

Figure 10: Map of the spatial distribution of biomass, showing the points of major aggregations.

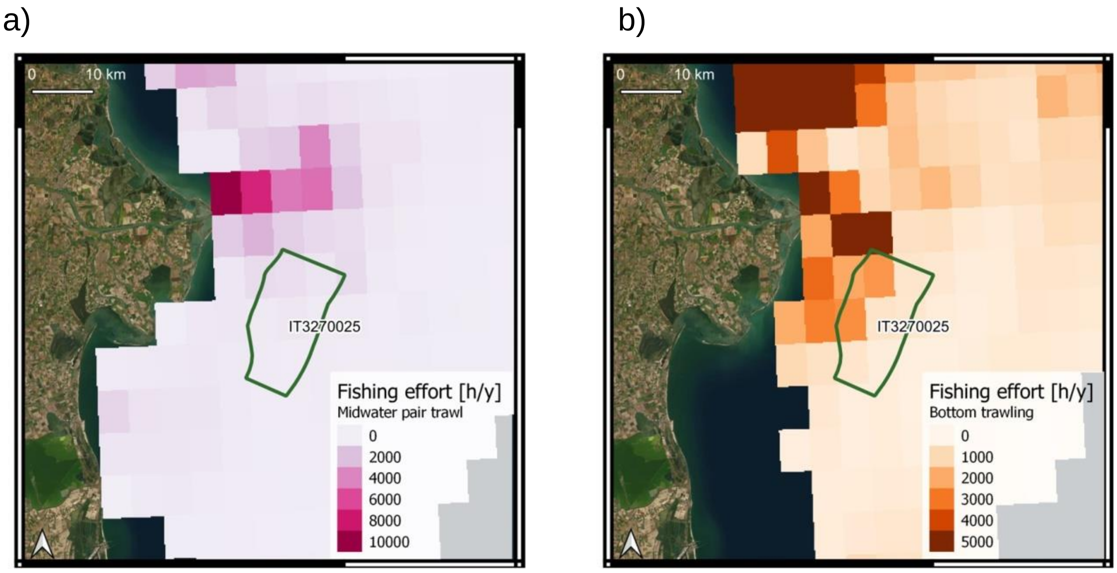

Figure 11: Maps of the fishing effort according to the available data, retrieved from Fairsea project data & tools (source: https://www.italy-croatia.eu/web/fairsea/docs-and-tools). a) Effort from midwater pair trawl fishing, referred to 2018 data. b) Effort from bottom trawling fishing, including otter trawl and beam trawl, referred to 2018 data.

5.2. Emilia Romagna Region

The results of the echosounding field campaings allow for effectively estimating the density of the fish within the SCI area under study and for detecting time and space distributional patterns. The biomass density per hectare was pretty high in December, and almost similar between March and April. In the campaigns of January and February, a slightly lower value than the other months was observed. The heterogeneity was similar in all the campaigns, suggesting the presence of areas with noticeable differences in terms of biomass per hectares (Fig. 12a).
As regards the fish density (Fig. 12b), an increasing trend can be noticed shifting from winter to spring. The maximum median value was indeed recorded in April, as opposite to what is was observed in December and the very first campaigns of the 2023. While the lower biomass density was registered in March, October was again the month with the maximum value and with lower heterogeneity than other months. Considering both the results, in December the lower number of fish per hectare with an occurring higher biomass account for the presence of individuals with a greater size. On the other hand, the increased number of

individuals per hectare in April flanked with a similar biomass density suggests the presence of fish with a smaller size.

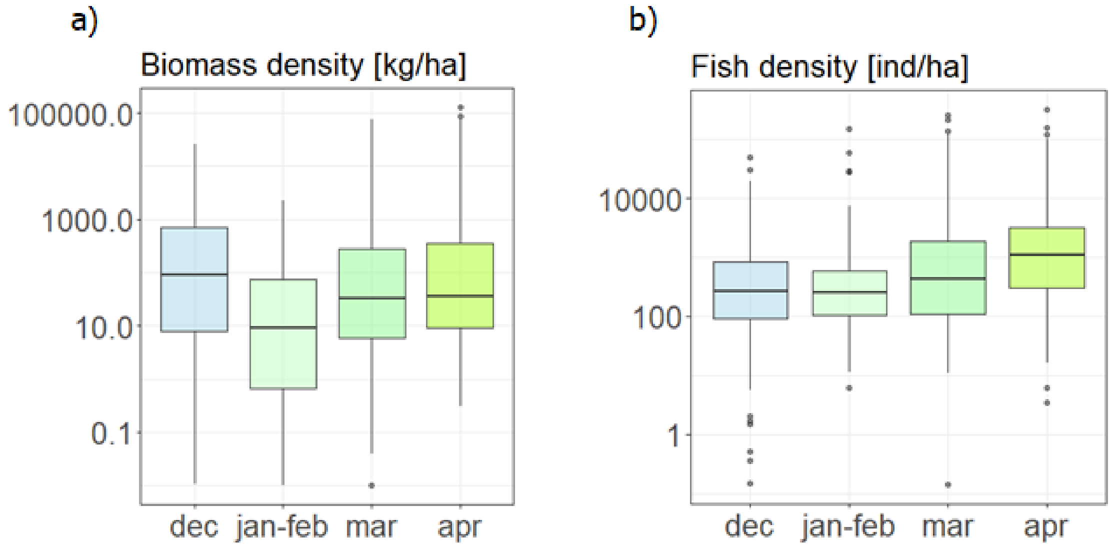

Figure 12: Results of the analyses on fish density in the five echosounding campaigns within the SCI area. a) Density as kg of biomass per hectare; b) density as number of individuals per hectare.

The presence of fish schools and fish of different sizes was consistently recorded in the whole water column. However, the aggregated data suggest that there was a high likeliness to find higher biomass density in areas where the depth fell in the range between -16 and -19 meters, and in areas with a depth from -25 to -31 below mean sea level (Fig. 13).

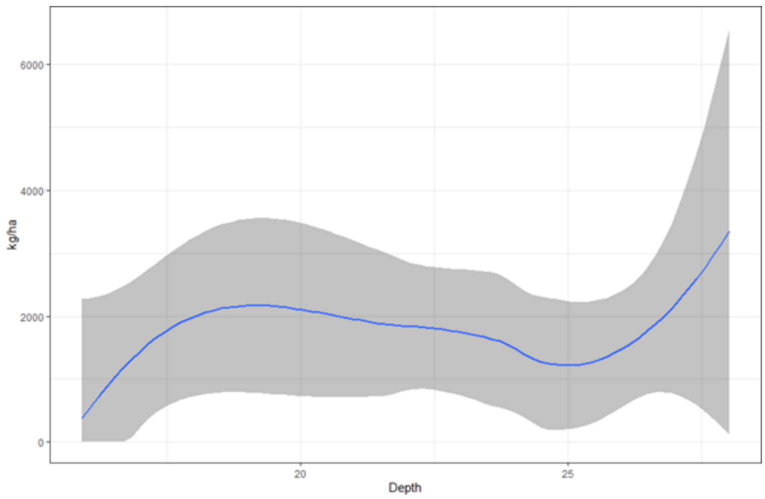

Figure 13: Density of fish biomass (kg/ha) retrieved in the study area, related to the bottom depth.

Figure 14 shows the spatial distribution of the biomass density, estimated through ordinary kriging method for interpolation. Two spots emerged as density hotspots, located in the middle of the SCI area and in the Southern left quadrant. However, a slight heterogeneity spreads on the site, with a higher aggregation southward.
To compare the likely fish distribution to the fishing exploitation pattern, we calculated the fishing effort in terms of fishing hours, based on the aggregation of 2018 data made available through the Fairsea project database (available at https://www.italy-croatia.eu/web/fairsea/docs-and-tools).
Overall, fishing activities seem to be focused primarily on the Northern part of the SCI area, while appearing less frequent in the occidental and southern part (Fig. 15). Such a spotted fishing pattern resulted in an average of 398 hours per year (±112) with bottom trawling gears, and an average of 311 (±122) hours per year with midwater pair trawl. However, these are considered conservative estimations worth further investigation.

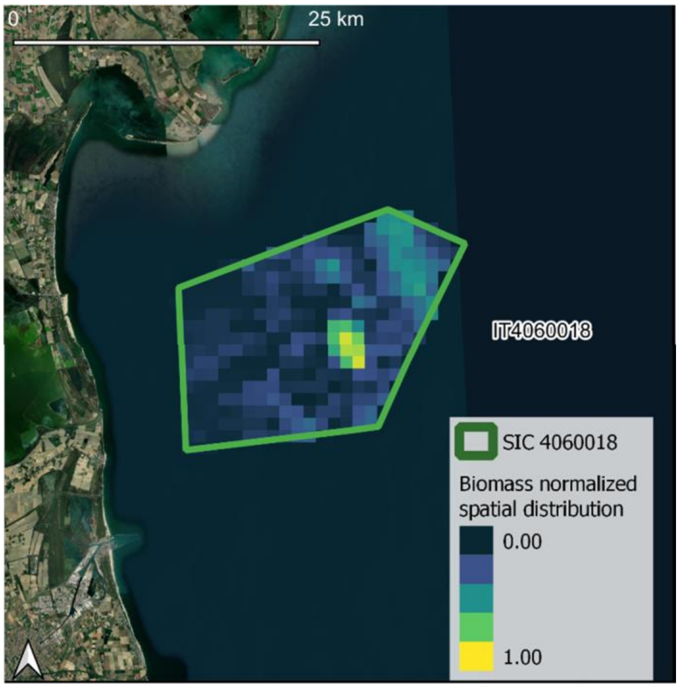

Figure 14: Map of the spatial distribution of biomass, showing the points of major aggregations within the Emilia-Romagna SCI area IT4060018.

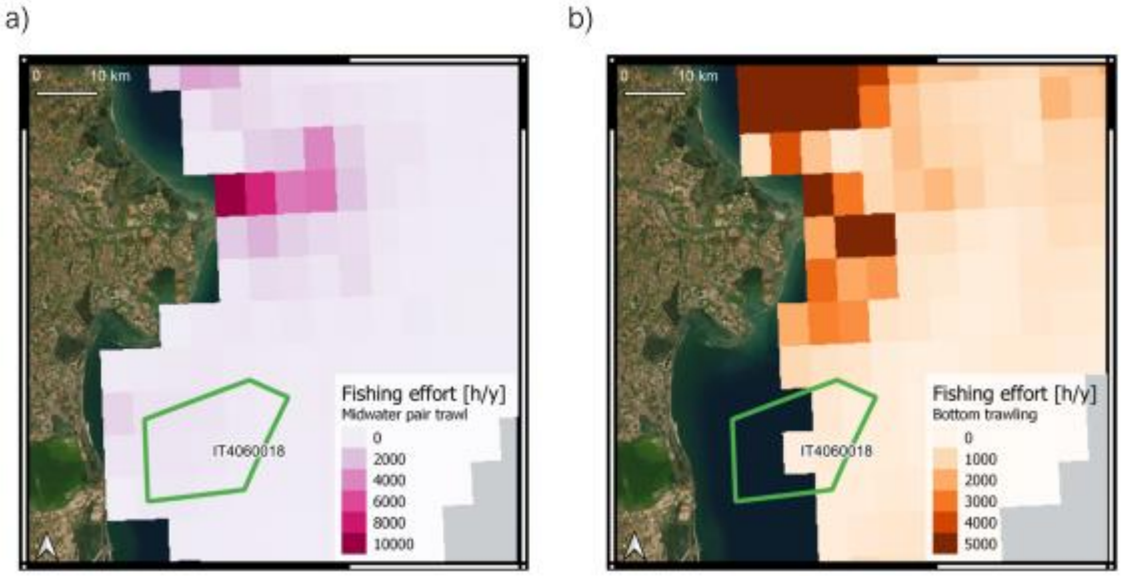

Figure 15: Maps of the fishing effort according to the available data, retrieved from Fairsea project data & tools (source: https://www.italy-croatia.eu/web/fairsea/docs-and-tools). a) Effort from midwater pair trawl fishing, referred to 2018 data. b) Effort from bottom trawling fishing, including otter trawl and beam trawl, referred to 2018 data.

6. DISCUSSION

6.1. Biodiversity and conservation needs in the marine SCI area

The northern Adriatic, characterized by its gradual deepening towards the Ionian Sea, features rocky shores and seabeds on the eastern side, while the western coast of northern Italy is dominated by sandy bottoms influenced by sediment and freshwater influx from the Po River. This unique configuration gives rise to diverse seabed habitats, where muddy and sandy substrates predominate, with limited occurrences of Posidonia meadows and rocky outcrops.

The region's biodiversity is strongly influenced by the fluvial inputs from the Po River and the bathymetric characteristics, resulting in high primary and secondary productivity. These conditions support not only abundant fish stocks but also attract reptiles and marine mammals. Among the charismatic species found in the area, the loggerhead turtle (*Caretta caretta*) and the bottlenose dolphin (*Tursiops truncatus*) hold significant importance, garnering attention for conservation efforts over several decades.

The established Site of Community Interest (SCI) in the Northern Adriatic aim to protect these species, implementing measures that, while not outright prohibiting fishing or boating, contribute to their conservation. Recent studies have revealed that the Adriatic population of bottlenose dolphins is not a homogeneous unit from a genetic perspective but rather consists of locally differentiated populations, loyal to specific sub-basins (Gaspari et al., 2015). Current data estimates approximately 100-150 individuals in the Gulf of Trieste area, over 200 individuals in the Kvarner area, and at least 300 individuals in northern Dalmatia.

Regarding turtles, the Northern Adriatic is recognized as one of the crucial foraging grounds for adult individuals. Notably, in recent years, there has been an increase in observations of turtles laying eggs along the Northern Adriatic coast, although this area is not considered ideal for breeding. Sightings of adult turtles offshore have also risen, often involving distressed individuals floating on the surface or displaying signs of fatigue. Additionally, there appears to be a slight increase in the discovery of dead turtles floating or stranded (VEGAL, 2019). However, it is important to note that assessing whether the cases have genuinely increased or if it is a result of enhanced awareness campaigns and dedicated data collection projects is challenging.

Furthermore, recent scientific literature reports indicate the potential presence of the monk seal (*Monachus monachus*) in the northern Adriatic based on environmental DNA signals collected in a comprehensive Mediterranean-wide study (Valsecchi et al., 2023). Although this species is not currently protected, it is intriguing to note this occurrence, highlighting the significance of the habitats in the Northern Adriatic.

The presence of these species reaffirms the environmental significance of the Adriatic basin and underscores the importance of adhering to biodiversity protection systems. However, the potential risks associated with interactions between these animals and individuals involved in fishing activities have yet to be thoroughly analyzed in the Northern Adriatic region.

In the past, the fishing industry believed that the presence of dolphins near nets was due to their abundance. However, it has since been discovered that the issue of predation on aquaculture facilities and nets is actually caused by the overexploitation of fish stocks, which forces cetaceans to seek alternative food sources as their ability to successfully hunt wild fish diminishes (Bearzi et al., 2011).

Currently, various data and testimonies indicate that interactions between bottlenose dolphins, turtles, and fishing fleets are relatively limited. An interesting study conducted by the Dolphin Biology and Conservation association assessed the extent to which bottlenose dolphins followed fishing vessels in the waters of Emilia-Romagna. The results showed that out of 189 observed vessels, bottlenose dolphins followed 72.7% of pairs of vessels engaged in pelagic trawling and 24.6% of units engaged in bottom trawling. In contrast, none of the observed "rapido" trawlers were followed by bottlenose dolphins (Bearzi & Bonizzoni, 2018).

Furthermore, discussions held during ARGOS project meetings with local fishermen revealed that bottlenose dolphins are not regularly observed and tend to anticipate fishing boats rather than actively follow them. As a result, their entanglement in trawls, at least in the northern Adriatic, is rare. Therefore, interactions between dolphins and fishing activities are generally limited and do not typically have negative impacts on either party.

However, the use of gillnets and trammel nets in SCI zones remains a concern for dolphin-fishing interactions. In this regard, many fishermen are now equipped with electronic devices known as "acoustic harassment devices" that deter bottlenose dolphins from approaching, thus reducing the risk of entanglement and damage to the nets. Scientific studies have demonstrated the effectiveness of these acoustic deterrents in protecting both nets and fish, although optimal results are achieved when combined with other good practices that involve the operator's experience and the use of suitably modified nets (Buscaino et al., 2021).

While it is not possible to completely exclude the potential damage to nets caused by bottlenose dolphins, their presence also brings benefits by helping to maintain a balanced trophic network. In this sense, they provide a regulatory service that can compensate for occasional economic losses that may occur (Pace et al., 2022).

Regarding turtles, there is currently limited data available on their interactions with professional fishing. Periodic reports of turtle catches in midwater and bottom trawls are provided by fishermen's testimonies and monitoring activities, such as those conducted within the TartaTur project. However, a comprehensive and exhaustive database on this matter is still lacking.

In cases of accidental capture, the impact is usually more detrimental to the turtle than to the fishing gear or catch. Consequently, efforts are being made to develop turtle catch avoidance systems to be deployed at the mouth of trawl nets (Tudela, 2004).
A promising approach to enhance the protection and management of bottlenose dolphins and turtles in the northern Adriatic is the development of guidelines specifically tailored to each fishing system. These guidelines would incorporate existing devices such as acoustic deterrents and turtle exclusion barriers (as suggested by VEGAL, 2019 and reported in Lucchetti et al., 2019), as well as new experimental approaches.
Overall, the conservation of bottlenose dolphins and turtles in the Northern Adriatic Sea does not conflict with fishery management that considers social and socio-economic aspects. Instead, it provides an opportunity for experimentation, training, and collaboration between operators and stakeholders.

6.2. Field survey evidence and spatial pattern of fishing effort

The presented data are an expression of one of the first studies related to the distribution of marine biomass in Italy within an SCI area and are relatively close to being a true stock assessment, given their recursiveness and frequency in time and space. They, therefore, represent a kind of benchmark against which temporal trends or spatial patterns could be compared in the future, with the undeniable advantage that the sampling campaigns do not harm nor disturbs the fish and other marine creatures.

Veneto Region
The hydroacoustic monitoring allowed us to identify a clear seasonal pattern in fish biomass density (kg per hectare), with higher values observed from March to October and a decline in December, with the highest variability in biomass density from March to July. Fish presence was recorded in the whole water column, with the highest biomass density occurring in areas where the depth is between -25 to -27 meters below mean sea level. These patterns can be attributed to the life cycles and behavior of fish in the northern Adriatic Sea, which are influenced by seasonality, climate factors, and meteorological trends.
Furthermore, the echosounding results enabled us to detect areas with the highest aggregation of fish within the Veneto region SCI area. These areas can be related to the nutrient-rich waters coming from the mainland, which can add support to the observed seasonal patterns of fish biomass density that are typically related also to ecological processes such as organic matter availability and riverine water discharge. The highest values of biomass density were detected on the Southernmost left quadrants, right in the direction of the contiguous SCI area under the Emilia-Romagna region, which raises the

question of whether it will be possible to keep monitoring both areas and starting to consider joint management of the two Adriatic SCI areas.
Overall, the results of the pilot action highlight the importance of continuous monitoring of fish biomass density in the SCI area, as well as the need for collaboration and joint management between different regions to achieve long-term sustainability of fish resources. This information will be critical for the development of effective management strategies and policies that balance conservation with sustainable use, ensuring the health and resilience of the marine ecosystem in the area.

Emilia Romagna Region

Hydroacoustic highlighted that the fish density (individuals per hectare) answers to a seasonal shift from winter to spring, increasing from December to April; however, the biomass density suggested that in December the fish within the SCI area were more dispersed but presented a greater size. In general, fish presence was recorded in the whole water column, with the highest biomass density occurring in areas where the depth is between -25 to -27 meters below mean sea level.
These trends can be attributed to the life cycles and behavior of fish in the northern Adriatic Sea, which are influenced by seasonality, climate factors, and meteorological trends. Considering this time pattern and the spatial distribution together, it can be hypothesized that other ecological key processes, such as primary productivity in nutrient-rich waters coming from the inland, may explain the observed patterns of fish biomass density.
In addition, echosounding results allowed for detecting spots with the highest aggregation of fish within the Emilia-Romagna region SCI area.
Since the highest values of biomass density were detected in the center of the SCI area and on the Northern side, it can be concluded that the location of the area is quite suitable to protect biodiversity and fish populations' life cycles.
Moreover, the presence of the contiguous SCI area under the Veneto region just northward suggests that it could be advisable to monitor both areas and consider joint management of the two Adriatic SCI areas.

6.3. Management of fishing in protected areas: balancing conservation and socio-economic factors

The success of marine protected areas hinges on their conservation effectiveness and their ability to deliver desired outcomes for both the ecosystems and the surrounding communities. Achieving a balance between conservation objectives and the socio-economic sustainability of fisheries management systems remains a complex and contentious issue. It necessitates the collection of rigorous scientific evidence to understand the potential benefits of marine protected areas on adjacent populations in both the short and long term.

The positive impacts of marine protected areas on biodiversity conservation and ecosystem health have been unequivocally demonstrated in numerous studies (FAO, 2017). These benefits extend beyond conservation by also enhancing commercially important fish stocks. Notably, the effectiveness of marine protected areas in protecting fish populations can also benefit fishermen and their long-term economic activities. One significant mechanism through which this occurs is the "spill-over" effect, whereby protected areas serve as sources of repopulation, replenishing fish stocks in adjacent areas where fishing, aquaculture, and other activities are permitted (Medoff et al., 2022).

However, the specific effects of protected areas on the fisheries sector in the northern Adriatic are yet to be fully determined. Assessing these effects requires consideration of multiple ecological, social, and economic factors, as well as external pressures such as climate change and unpredictable social dynamics. A comprehensive understanding of the threats and impacts arising from external pressures is crucial for evaluating the performance of protected areas and informing effective management strategies.

The successful implementation of marine protected areas heavily relies on managing social, demographic, cultural, and market factors. It is essential that these protected areas deliver tangible benefits to the communities involved, particularly in terms of livelihoods, food security, and social resilience. Challenges arise when multiple stakeholders, some overlapping with fisheries and others competing with them, are involved in the interactions between marine protected areas and human activities. Furthermore, compliance with regulations often depends on effective monitoring and enforcement mechanisms, as well as the availability of financial compensation where necessary. In this context, participatory approaches and the ecosystem- based approach to fisheries management can play crucial roles in protecting, monitoring, and managing fisheries and marine protected areas while ensuring the resilience of both.

Taking into account the considerations discussed in this report, along with current data and trends in socio-economic indicators relating to the fisheries sector in Veneto (see also GreenSea Soc. Coop., 2023), it can be concluded that the establishment of the two SCI areas off the Po Delta has not resulted in significant changes to the northern Adriatic Sea's fishing sector. Moreover, the current SCI management system is not expected to have negative economic and employment impacts.

However, it should be acknowledged that the existing management system may not lead to substantial improvements in marine biodiversity conservation and habitat preservation, except for the increased protection of dolphins and turtles. To enhance the management of protected areas in the Northern Adriatic, there is a need for concerted research efforts and data collection to obtain interdisciplinary knowledge that can inform sustainable management plans. Given the Adriatic Sea's ecological significance and the economic importance of human activities, engaging all stakeholders in decision-making processes becomes crucial. Collaborative management strategies that strike a balance between potentially detrimental human activities and beneficial measures within the SCIs and surrounding areas can be achieved through participatory approaches involving local, national, and cross-border administrations, as well as scientific research actors.

By deepening interdisciplinary studies, employing modelling tools, and fostering participatory approaches, effective long-term management strategies rooted in the principles of ecosystem- based fishery management can be developed. These strategies aim to ensure the preservation and sustainable use of the marine environment in the Northern Adriatic. Interdisciplinary approaches that integrate ecological, social, and economic perspectives will provide a comprehensive understanding of the complex dynamics between marine protected areas, fisheries, and the surrounding communities.

Through the use of modelling tools, researchers can simulate various scenarios and evaluate the potential impacts of different management strategies on both biodiversity conservation and socio-economic factors. These models can help identify optimal approaches that balance the protection of marine resources with the needs of local communities, ensuring that the benefits of marine protected areas extend beyond ecological outcomes.

In addition to modelling, participatory approaches play a crucial role in effective management. Engaging local communities, fishermen, and other stakeholders in decision-making processes fosters a sense of ownership and encourages the adoption of conservation measures. Collaborative platforms, such as stakeholder dialogues and participatory workshops, provide opportunities for knowledge exchange, shared learning, and the co-creation of management strategies.

Finally, the pilot action demonstrated that a combination of echosounding and remote vessel tracking helps to provide a helpful understanding of the distribution of fish, their aggregating patterns, and the fishing pressure exerted on them. Further studies are therefore needed to assess, on the one hand, the fishing effort with higher accuracy and on a continuous time basis, and on the other hand, the fish stock status and its sensitivity to environmental and anthropogenic-related parameters.

This knowledge is fundamental for adaptive fisheries management, allowing for timely adjustments to fishing regulations, such as area-based management approaches. Continuous monitoring ensures that fisheries management measures are evidence-based, responsive to changing conditions, and promote the long-term sustainability of fish populations and marine ecosystems in the Northern Adriatic.

Incorporating these monitoring techniques into the broader management framework strengthens the foundation for effective decision-making and conservation efforts. By integrating scientific data from echosounding and remote vessel tracking with socio-economic information, stakeholder engagement, and modelling, a more comprehensive and accurate picture of the Northern Adriatic's fisheries can be obtained. This holistic approach supports the development and implementation of targeted management measures, contributing to the sustainable use and conservation of fish resources.

In conclusion, the management of fishing activities in the Northern Adriatic within the context of marine protected areas requires a holistic and interdisciplinary approach. By integrating ecological, social, and economic considerations, and hard evidence from continuous monitoring, it is possible to develop management strategies that effectively conserve marine biodiversity while ensuring the well-being and sustainable livelihoods of local communities.

6.4. Proposed management guidelines

A comprehensive set of guidelines has been developed to facilitate efficient and adaptable management of fishing activities within SCI areas. These guidelines are based on evidence derived from field acoustic monitoring, fishing effort estimation, and best practices for managing fisheries in protected areas. Fish stocks are dynamic resources influenced by various factors, including environmental conditions, fishing pressure, and migration patterns. Thus, regular monitoring is crucial to ensure sustainable fishing activities.

The guidelines proposed in this report outline specific protocols for data collection and monitoring, such as the establishment of a monitoring body, mandatory reporting of catch data from commercial vessels, and hydroacoustic surveys. These protocols aim to ensure continuous and up-to-date comprehension of fishing pressure and resource status in the area. By implementing these guidelines, decision-makers can make informed and timely decisions about fishing activities, enabling appropriate management actions when necessary.

The primary objective of these guidelines is to achieve sustainable fishing practices while protecting the marine ecosystem for future generations. The key elements of this protocol are further outlined below.

1. Identification of a Data Collection/Monitoring Body

First and foremost, it is crucial to establish a dedicated body responsible for data collection and monitoring. This body should consist of a multidisciplinary team comprising fisheries scientists, ecologists, and relevant stakeholders. Their role will be to coordinate and oversee the implementation of the data collection and monitoring protocols outlined in these guidelines.

2. Communication and Catch Data Reporting

In order to ensure comprehensive data coverage, all commercial vessels intending to exploit the protected areas for fishing purposes are required to communicate their intention and confirm it on a yearly basis. This communication process will enable the data collection body to maintain an accurate record of fishing activities in the area.

Furthermore, these vessels must provide catch data to the monitoring body. This includes detailed information on landed biomass per species per day. By collecting and analyzing this catch data, valuable insights can be gained into the composition and abundance of target species and non- target species in the area.

To enhance the spatial monitoring of fishing activities, vessels will be monitored through the use of Automatic Identification System (AIS) tracks or the installation of inexpensive tracking devices. This spatial monitoring will enable a better understanding of fishing effort distribution and allow for the assessment of potential overlaps with protected habitats or species' critical areas.

3. Hydroacoustic Surveys for Resource Monitoring

Regular hydroacoustic survey campaigns should be conducted within the protected areas on a seasonal basis. These surveys utilize echosounding techniques to assess the state of resources, including the abundance and distribution of fish populations. By systematically collecting data on the density and biomass of fish, these surveys provide valuable information on the health and dynamics of the fish communities within the protected areas.

4. Revision of Fishery Management Plans

After at least one year of comprehensive monitoring, based on the evidence collected from catch data reporting and hydroacoustic surveys, a proposal for the revision of the existing fishery management plans should be developed. This revised plan will be specific to the protected areas and will encompass both temporal and spatial limits on various fishing activities.

The revised fishery management plan should be equally or more restrictive than the general management plans already enacted, ensuring the conservation of vulnerable species and habitats within the protected areas. It will be subjected to periodic revisions based on the results of ongoing monitoring efforts. This adaptive approach will allow for the continual evaluation of management measures and their effectiveness, ensuring that the fisheries within the protected areas are sustainable and in line with conservation objectives.

5. Extension of the Protected Area and Monitoring Measures toward the Coast

Since the behavior and reproductive success of Adriatic fishes are strongly linked not only to the sea but also to the coastal zone, it is strongly suggested to start considering extending the protected SCI area and its related monitoring measures toward the coast. This would not go against the social and economic sustainability of the fishery, given that nor bottom trawling nor midwater pair trawling insist on the sandy zone of lower bathymetry, to which the southern areas of the Po delta are faced.

6. Coordination of Monitoring and Management Efforts with Contiguous SCI Area

Considering that a likely aggregating pattern for fish was revealed in the northernmost right quadrants, towards the contiguous SCI area of the Veneto region, it is strongly recommended to initiate discussions on coordinated monitoring and management.

7. REFERENCES

Bastardie, F., Angelini, S., Bolognini, L., Fuga, F., Manfredi, C., Martinelli, M., Nielsen, J. R., Santojanni, A., Scarcella, G., & Grati, F. (2017). Spatial planning for fisheries in the Northern Adriatic: Working toward viable and sustainable fishing. Ecosphere, 8(2). https://doi.org/10.1002/ecs2.1696

Bearzi, G., & Bonizzoni, S. (2018). Interazioni fra delfini e pesca in Adriatico settentrionale. Resoconto tecnico.

Bearzi, G., Bonizzoni, S., & Gonzalvo, J. (2011). Dolphins and coastal fisheries within a marine protected area: mismatch between dolphin occurrence and reported depredation. Aquatic Conservation: Marine and Freshwater Ecosystems, 21(3), 261–267. https://doi.org/10.1002/aqc.1179

Buscaino, G., Ceraulo, M., Alonge, G., Pace, D. S., Grammauta, R., Maccarrone, V., Bonanno, A., Mazzola, S., & Papale, E. (2021). Artisanal fishing, dolphins, and interactive pinger: A study from a passive acoustic perspective. Aquatic Conservation: Marine and Freshwater Ecosystems, 31(8), 2241–2256. https://doi.org/10.1002/aqc.3588

Casale, P., & Margaritoulis, D. (Eds.). (2010). Sea turtles in the Mediterranean: distribution, threats and conservation priorities. IUCN/SSC Marine Turtle Specialist Group.

Colloca, F., Scarcella, G., & Libralato, S. (2017). Recent trends and impacts of fisheries exploitation on Mediterranean stocks and ecosystems. Frontiers in Marine Science, 4(AUG), 244. https://doi.org/10.3389/FMARS.2017.00244/BIBTEX

Coppa, S., Pronti, A., Massaro, G., Brundu, R., Camedda, A., Palazzo, L., Nobile, G., Pagliarino, E., & de Lucia, G. A. (2021). Fishery management in a marine protected area with compliance gaps: Socio- economic and biological insights as a first step on the path of sustainability. Journal of Environmental Management, 280, 111754. https://doi.org/10.1016/J.JENVMAN.2020.111754

Di Franco, A., Thiriet, P., Di Carlo, G., Dimitriadis, C., Francour, P., Gutiérrez, N. L., Jeudy De Grissac, A., Koutsoubas, D., Milazzo, M., Otero, M. D. M., Piante, C., Plass-Johnson, J., Sainz-Trapaga, S., Santarossa, L., Tudela, S., & Guidetti, P. (2016). Five key attributes can increase marine protected areas performance for small-scale fisheries management. Scientific Reports, 6(1), 1–9. https://doi.org/10.1038/srep38135

Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union L164/19, (2008) (testimony of European Council).

European Environment Agency. (2023). Protecting marine life in Europe's seas. https://www.eea.europa.eu/highlights/protecting-marine-life-in-europe2019s-seas-1
FAO. (2017). Marine protected areas: Interactions with fishery livelihoods and food security (Issue 603). https://www.fao.org/3/i6742e/i6742e.pdf

Foote, K. G., Aglen, A., & Nakken, O. (1986). Measurement of fish target strength with a split beam echo sounder. Journal of the Acoustical Society of America, 80(2), 612–621. https://doi.org/10.1121/1.394056

Frouzova, J., Kubecka, J., Balk, H., & Frouz, J. (2005). Target strength of some European fish species and its dependence on fish body parameters. Fisheries Research, 75(1–3), 86–96. https://doi.org/10.1016/J.FISHRES.2005.04.011

Gascuel, D., Coll, M., Fox, C., Guénette, S., Guitton, J., Kenny, A., Knittweis, L., Rasmus Nielsen, J., Piet, G., Raid, T., Travers-Trolet, M., & Shephard, S. (2016). Fishing impact and environmental status in European seas: a diagnosis from stock assessments and ecosystem indicators. Fish and Fisheries, 17(1), 31–55. https://doi.org/10.1111/FAF.12090

Gaspari, S., Scheinin, A., Holcer, D., Fortuna, C., Natali, C., Genov, T., Frantzis, A., Chelazzi, G., & Moura, A. E. (2015). Drivers of Population Structure of the Bottlenose Dolphin (Tursiops truncatus) in the Eastern Mediterranean Sea. Evolutionary Biology, 42(2), 177–190. https://doi.org/10.1007/s11692- 015-9309-8

GFCM. (2022). The State of Mediterranean and Black Sea Fisheries. https://doi.org/10.4060/cc3370en

Grati, F., Aladžuz, A., Azzurro, E., Bolognini, L., Carbonara, P., Çobani, M., Domenichetti, F., Dragičević, B.,Dulčić, J., Durović, M., Ikica, Z., Joksimović, A., Kolitari, J., Marčeta, B., Matić-Skoko, S., Vrdoljak, D., Lembo, G., Santojanni, A., Spedicato, M. T., … Milone, N. (2018). Seasonal dynamics of small-scale fisheries in the Adriatic Sea. Mediterranean Marine Science, 19(1), 21–35. https://doi.org/10.12681/mms.2153

GreenSea Soc. Coop. (2023). Deliverable Number D3.2.4: Evaluation of the consequences on the vitality of north Adriatic fish-related chains and fisheries communities derived from the establishment of new protected marine areas (Issue D3.2.4). www.greenseainstitute.com

Jennings, S., & Kaiser, M. J. (1998). The Effects of Fishing on Marine Ecosystems. https://doi.org/10.1016/S0065-2881(08)60212-6

Johannesson, K. A., & Mitson, R. B. (1983). Acoustic properties of fish. Fisheries Acoustics - A Practical Manual for Aquatic Biomass Estimation. http://www.fao.org/docrep/x5818e/x5818e06.htm

Libralato, S., Caccin, A., & Pranovi, F. (2015). Modeling species invasions using thermal and trophic niche dynamics under climate change. Frontiers in Marine Science, 2(MAY). https://doi.org/10.3389/fmars.2015.00029

Lucchetti, A., Bargione, G., Petetta, A., Vasapollo, C., & Virgili, M. (2019). Reducing Sea Turtle Bycatch in the Mediterranean Mixed Demersal Fisheries. Frontiers in Marine Science, 6. https://doi.org/10.3389/fmars.2019.00387

Medoff, S., Lynham, J., & Raynor, J. (2022). Spillover benefits from the world's largest fully protected MPA.Science, 378(6617), 313–316. https://doi.org/10.1126/science.abn0098

Pace, D. S., Ferri, S., Giacomini, G., di Marco, C., Papale, E., Silvestri, M., Pedrazzi, G., Ventura, D., Casoli, E., & Ardizzone, G. (2022). Resources and population traits modulate the association patterns in the common bottlenose dolphin living nearby the Tiber River estuary (Mediterranean Sea). Frontiers in Marine Science, 9, 935235. https://doi.org/10.3389/fmars.2022.935235

Rice, J., Moksness, E., Attwood, C., Brown, S. K., Dahle, G., Gjerde, K. M., Grefsrud, E. S., Kenchington, R., Ring Kleiven, A., McConney, P., Ngoile, M. A. K., Næsje, T. F., Olsen, E., Olsen, E. M., Sanders, J., Sharma, C., Vestergaard, O., & Westlund, L. (2012). The role of MPAs in reconciling fisheries management with conservation of biological diversity. Ocean & Coastal Management, 69, 217–230. https://doi.org/10.1016/J.OCECOAMAN.2012.08.001

Russo, T., D'Andrea, L., Cipriano, G., Ricci, P., Carlucci, R., Vujević, A., Vrgoc, N., & Libralato, S. (2021).FAIRSEA Deliverable 4.5.1: Fishing effort map distribution.

Russo, T., Parisi, A., Cataudella, S., & Ciriaco, S. (2014). VMSbase: an R-package for VMS and logbook data management and analysis in fisheries ecology. Environmental Modelling & Software, 55, 283– 288.

Russo, T., Parisi, A., D'Andrea, L., & Cataudella, S. (2016). Towards the implementation of an ecosystem- based approach to fisheries management (EAFM): a practical software tool for the evaluation of measures and simulation of management scenarios. Ecological Modelling, 330, 82–94.

Simmonds, E.J., MacLennan, D. N. (2005). Fisheries Acoustics: Theory and Practice, 2nd ed. Fish and Aquatic Resources Series 10. https://doi.org/10.1002/9780470995303

Tudela, S. (2004). Ecosystem effects of fishing in the Mediterranean: an analysis of the major threats of fishing gear and practices to biodiversity and marine habitats.

Valsecchi, E., Tavecchia, G., Boldrocchi, G., Coppola, E., Ramella, D., Conte, L., Blasi, M., Bruno, A., & Galli, P. (2023). Playing "hide and seek" with the Mediterranean monk seal: a citizen science dataset reveals its distribution from molecular traces (eDNA). Scientific Reports, 13(1), 2610. https://doi.org/10.1038/s41598-023-27835-6

VEGAL. (2019). Interazione tra pesca e specie protette Tursiops truncatus e Caretta caretta. Valutazione dello stato d'incidenza e indagine tra gli operatori della pesca professionale. https://www.vegal.net/public/studi_e_pubblicazioni/FLAG_Tartatur1/Azione1_Valutazione%20dello%20stato%20di%20incidenza%20e%20indagine%20tra%20gli%20operatori%20della%20pesca.pdf