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Research

Can a "doughnut" economic framework be useful to monitor the blue economy success? A fisheries example

Miquel Ortega [1], Marta Coll [1,2] and Francisco Ramírez [1]

ABSTRACT. In this paper, we employ a "doughnut" economic approach to comprehensively assess the state of the purse-seiners fisheries sector in the northwestern Mediterranean Sea. The analysis identifies several instances of ecological overshooting and shortages in basic social needs, indicating that the current situation is, in many respects, far from being in a secure, ecologically safe, and socially just space. It demonstrates that the necessary transition to achieve a sustainable sector is not solely a technical or financial issue; it also requires sufficient social capabilities to lead and manage the process, taking into consideration the social context in which it would occur. Our assessment indicates the need for urgent action and an overarching transition plan that includes an ecosystem-based fishery management plan, including commercial and social plans. The study showcases that this approach is useful in providing valuable information to support the transition of fisheries toward sustainability. Moreover, utilizing this non-fisheries-specific framework can facilitate the participation of fisheries expertise in broader discussions about the socioeconomic and ecological changes needed to achieve a post-growth-oriented blue economy.

Key Words: *blue economy; doughnut economy; ecosystem-based fisheries management; Mediterranean Sea; post-growth*

INTRODUCTION

The 2012 "Rio +20" United Nations Conference on Sustainable Development (UNCSD) marked a turning point in the popularization of the emerging blue economy concept (Pauly 2010). Coastal countries successfully integrated "blue economy" as part of the growing global international "green economy" agenda. Since then, the blue economy has been widely adopted by major international institutions as a conceptual framework for their ocean-related activities (World Bank and United Nations Department of Economic and Social Affairs 2017).

Although there are competing and sometimes conflicting definitions (Voyer et al. 2018), the European Union Blue Economy Observatory includes a diverse range of industries and sectors under the umbrella of the blue economy, such as blue technology, coastal tourism, desalination, marine infrastructure and robotics, marine living resources, marine non-living resources, marine renewable energy, marine defense, maritime transport, ocean energy, port activities, blue research and innovation, and shipbuilding and repair (European Commission 2023a).

However, the blue economy is not merely a collection of industries or sector activities. Since its international political popularization, it has emphasized the need to move beyond business as usual and adopt more sustainable practices (Potgieter 2018, European Commission 2021, Youssef 2023). This, in turn, requires evaluating these multiple transitions in a complex and integrated manner, from a sustainability development perspective.

Evaluating the success of the blue economy

Over the past 50 years, a global multifactorial ecological crisis has emerged, in addition to the ongoing societal duty of meeting the basic needs of millions of people worldwide. The increasing use of materials by the social metabolism (Fischer-Kowalski 1998, Fischer-Kowalski and Hüttler 1998, United Nations Environment Programme et al. 2019) and the resulting pollution has led to global environmental change. The marine ecosystems are not an exception, and the old concept of the ocean as an endless wealth of marine resources has evolved to the perception that there is no place in the ocean where human impacts cannot be noticed (Halpern et al. 2008, 2019, Díaz et al. 2019).

Among other social actors, economists and relevant political organizations are rethinking what the best possible economic indicators and goals are, in order to move toward sustainability while ensuring that all relevant stakeholders have appropriate information to support their decision-making processes in coherence with the societal challenges of the 21st century (European Commission 2009, OECD 2011). However, measuring the success of a sectorial transition is challenging, and requires suitable and accessible indicators.

In the context of the European blue economy, the challenge of finding new indicators beyond the growth paradigm (D'Alisa et al. 2015, Jackson 2017, Hadjimichael 2018, Stiglitz et al. 2018, Ertör and Hadjimichael 2020, Bennett et al. 2021) is explicit in the new EU sustainable blue economy strategy "Transforming the EU's Blue Economy for a Sustainable Future" (European Commission 2021), which states, "We need to shift the focus from "blue growth" to a sustainable blue economy." If this is the case, what are then the new indicators to be used? The current overall indicators used in the blue economy observatory and the blue economy report (European Commission et al. 2022, European Commission 2023b) are focused in monetary indicators (GVA, Turnover, Gross Operative surplus, net investment) and employment indicators (persons employed, average remuneration per employee). In some areas, but not all, they also include some production indicators, such as fished tons, energy production, or the volume of transported containers. In contrast, the use of ecological indicators in the European blue economy evaluation system (European Commission et al. 2022) adopts an approach based in the marine accounting system, trying to measure the

[1]Institute of Marine Science (ICM-CSIC), [2]Ecopath International Initiative

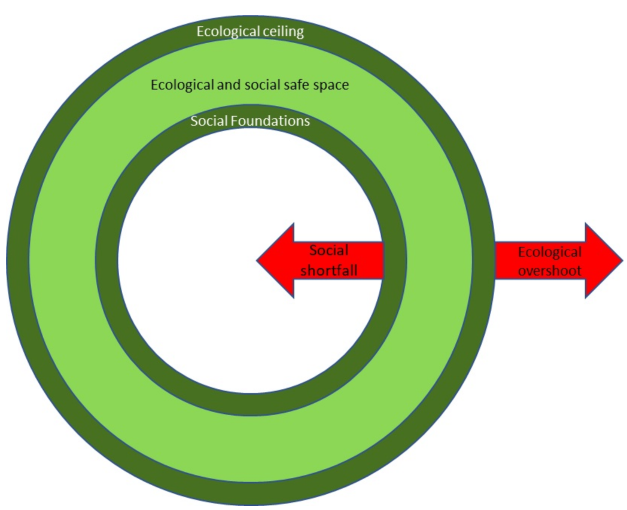
environmental status of marine ecosystems and the ecosystem services, in line with the idea of having a triple bottom line perspective of blue activities (Slaper and Hall 2011). However, currently, there is no comprehensive, acknowledged sectorial indicator framework that aligns with the shift from "blue growth" to a sustainable blue economy. This framework should be useful for the different blue economic sectors and easily recognizable by non-marine experts, while also aiding decision makers in aligning the economy with societal objectives (United Nations 2015, United Nations Environment Programme 2021). To make progress toward this goal, exploring innovative approaches beyond existing marine indicator frameworks can be a valuable strategy.

An alternative to evaluate the success of the economy: the "doughnut economy" framework

Since 2012, with the publication of Kate Raworth's groundbreaking work *A Safe and Just Space for Humanity: Can we Live within the Doughnut?* (Raworth 2012), and particularly in the last five years since the release of her book *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist* (Raworth 2017), the doughnut approach to the economy has gained momentum in economic and sustainability analyses. Because of its simplicity and holistic vision, it is now used at a broad range of scales, from the international to the local levels (DEAL 2022, Fang 2022, Fanning et al. 2022).

The core of the doughnut framework consists of two concentric rings (Fig. 1): the inner ring represents the basic needs social foundation, derived from the social priorities agreed upon in the Sustainable Development Goals (United Nations 2015), ensuring that no one falls short on life's essentials, while the outer ring represents the ecological ceiling, based in the planetary boundaries framework (Steffen et al. 2015). The doughnut-shaped space between these two boundaries represents an ecologically safe and socially just space where societies should aim to be (Raworth 2017), serving as an alternative to the GDP growth-oriented economic goal.

Fig. 1. The global doughnut economy representation of social and planetary boundaries (Raworth et al. 2020).



The doughnut analysis has been developed in very few sectorial perspectives such as tourism, city water management, or mobility (Valencia Lenero 2021, Dillman et al. 2023, Hartman and Heslinga 2023). In the marine context, the planetary boundaries analysis has been explored (Nash et al. 2017), and the first attempts to link the doughnut economy framework with marine ecosystem services have been published (Cook et al. 2023), but the doughnut approach has not been applied yet from a sectorial perspective.

A natural starting point for the development of the doughnut approach within the blue economy is the fisheries sector. Its economic significance and long history of ecosystem-based fisheries management studies (Costanza et al. 1998, Pauly et al. 2002, Pikitch et al. 2004, Link 2010, Christensen and Maclean 2011) have delved not only into the dynamics of individual species but also the entire ecosystem, trophic relationships, energy flows, environmental factors, and human impacts (Botsford et al. 1997, Duda and Sherman 2002, Cury et al. 2003, 2008). Additionally, it is an area where there remains a need to develop further human-related indicators (Hornborg et al. 2019), and integrate these indicators into a comprehensive framework that can be easily understood by a diverse range of stakeholders, including those who are not specialists in fisheries.

In this context, we explore the potential of applying the doughnut economy perspective in the fishing industry through a specific case study: the purse-seiners economic sector in the Northwestern Mediterranean Sea. Finally, we reflect on the advantages and limitations of using this perspective in relation to the goals of the blue economy while also discussing its potential application in other sectors within the blue economy.

METHODS

Study area and fisheries characteristics

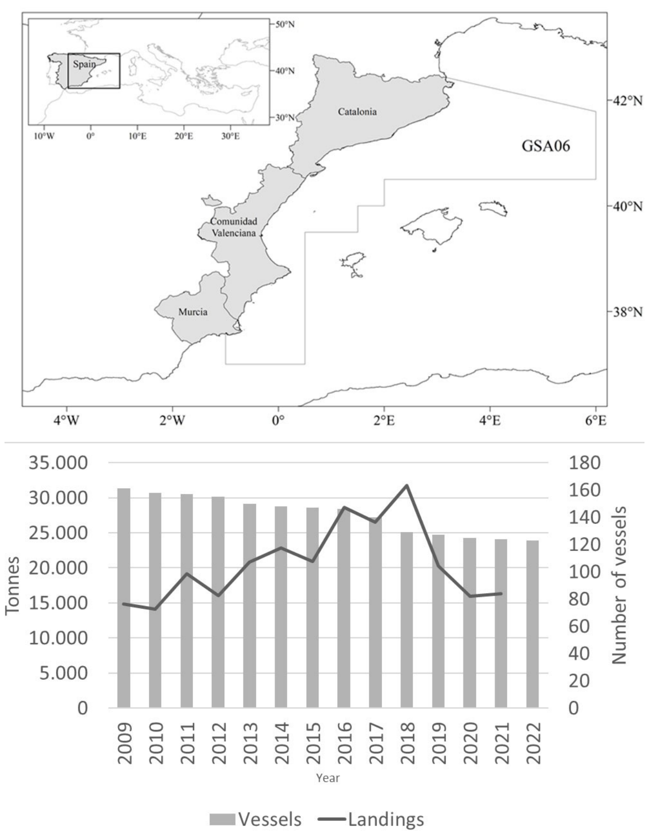
The Mediterranean basin is especially complex in terms of marine uses and ecological situation. It is one of most densely populated areas in the world, with high biological diversity and a long history of human activity (Coll et al. 2010, Lotze et al. 2011). It includes 21 modern countries with very different (and sometimes conflicting) socioeconomic and cultural traits, as well as some of the most renowned marine tourist destinations in the world. Moreover, it is an area of significant political interest for the development of the blue economy. As part of the European Commission's blue economy initiatives, a specific "Initiative for the sustainable development of the blue economy in the western Mediterranean" has been launched in partnership with the Union for the Mediterranean since 2017 (European Commission 2017).

According to the General Fisheries Commission for the Mediterranean Sea (GFCM), 90% of fish stocks in the Mediterranean are outside biologically sustainable limits (FAO 2022). Fisheries are putting a severe burden on Mediterranean marine ecosystems, and are making inhabiting communities more sensitive to the current climate crisis (Berkeley et al. 2004, Ottersen et al. 2006, Ramírez et al. 2021). However, fisheries also constitute an important socioeconomic sector: they are a major food source and provide employment and economic benefits to those engaged in the activity. Fisheries in the region deserve, therefore, an urgent transition toward sustainability.

Within the Mediterranean Spanish fishing sector, purse seiners represent a significant economic activity. As of 2021, the purse-seiners fleet accounted for only 8.7% of the Spanish Mediterranean vessels, and has significantly decreased in the last decade (Fig. 2). However, they contributed 21% of the gross value added, 29% of full-time equivalent jobs (MAPA 2021), and provided 53% of the total Spanish Mediterranean landings in weight. This fleet targets small pelagic fish, mainly European anchovy (*Engraulis encrasicolus*) and European sardine (*Sardina pilchardus*). Besides their commercial value, these species play a relevant ecological role within marine communities, and have suffered severe population declines over the last decades, mostly attributed to the combined effects of climate impacts and fishing pressure (Coll et al. 2019, Pennino et al. 2019, Saraux et al. 2019, Ramírez et al. 2021).

In 2022, the purse seiner fishing sector in the Spanish Mediterranean consisted of 121 vessels distributed in three coastal regions (from "North to South"): 61 in Catalonia, 38 in Valencia, and 21 in Murcia. Each vessel usually has a crew of 10 fishers, who return daily to harbor to sell the landings in fresh form, mainly to wholesalers and retail chains that sell the product mostly in the national fresh market (Ortega Cerdà and Coll 2022).

Fig. 2. Study area, Spanish Mediterranean purse-seiners fleet evolution (in number of vessels), and total landings in GSA6 for European anchovy (*Engraulis encrasicolus*) and European sardine (*Sardina pilchardus*). Source: Spanish Ministry of Agriculture, Fisheries and Food (MAPA) official data.



Doughnut adaptation

Planetary boundaries in the doughnut framework were initially established from a global systems analysis (Steffen 2022). Downsizing the doughnut perspective to a lower scale is not straightforward because the translation of limits is not linear (Turner and Wills 2022). Therefore, specific ecological analysis should be applied to target a regional, local, or sectorial perspective. The same logic applies to the social perspective.

According to the existing doughnut literature, downscaling exercises should adhere to the social and environmental rings with a safe space in between, and the dimensions and indicators used should be contextual (Raworth et al. 2020, Fang 2022, Fanning et al. 2022, Warnecke 2023). There is no standard method for their selection, but since it is a nested approach in all cases, indicators should always encompass both local and global scale perspectives (Raworth et al. 2020).

In our case we defined eight dimensions (Fig. 3) and 26 indicators that are relevant in the studied area (Table 1). In the ecological ceiling ring, we structured the information in four dimensions: the state and pressures of both key species, and the state and pressures on the ecosystems. In the social foundation ring we defined four dimensions: business viability, resilience, social livelihood, and governance and market relations (Fig. 3). Details of the indicators calculations and their justification can be found in the Appendix 1 Tables S1 and S2. In all dimensions, we combined a sectorial and regional/global perspective (Appendix 1 Table S3).

Our indicators selection was based on four main criteria: relevance, alignment with the doughnut economy framework, robustness, and availability. We used the most recent data available for each indicator.

Relevance for stakeholders and alignment with the doughnut framework are ensured by incorporating local knowledge into the indicator selection process, as well as including both ecological

Fig. 3. Structure of the purse-seiners sector doughnut analysis.

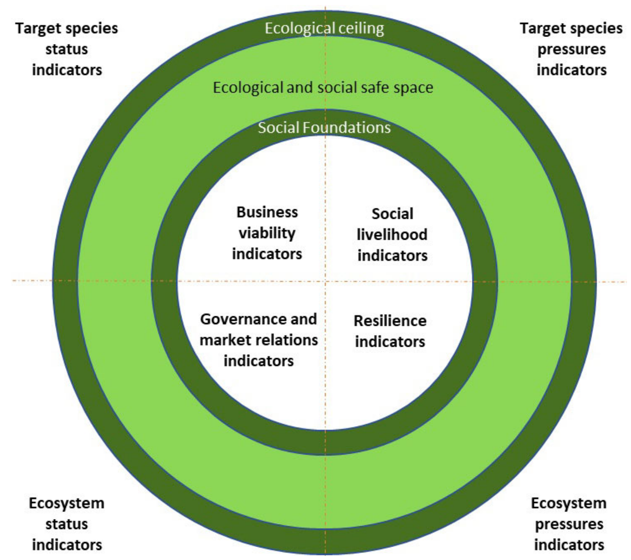


Table 1. Indicators used for the doughnut economy approach to northwestern Mediterranean purse-seiners fishery.

Dimension		Indicators
Social foundation		
Business viability		Return on equity
		Return on assets
		Profit margin
Social livelihood		Number of purse-seiners fishers
		Fishers wage
		Gender disparity
Resilience		Education
		Fishers' age structure
		Age of vessels
Governance and market relations		Buyers concentration
		Representation of purse-seiners members in regional fishers' sectoral representative bodies
		Representation of non-EU fishers in sectoral "executive committees"
Ecological ceiling		
Target species status	Biomass	Sardine biomass
		Anchovy biomass
	Health	Sardine mean size at first maturity
		Anchovy mean size at fist maturity
Target species pressures	Fishing	Sardine fishing mortality
		Anchovy fishing mortality
	Other anthropogenic	Microplastic presence in sardine
		Microplastic presence in anchovy
Ecosystem status		Overexploited commercial stocks
		Top predators at risk
Ecosystem pressures	Local	Out of optimal spawning sea surface temperatures for sardine
		Out of optimal spawning sea surface temperatures for anchovy
	Global	Fuel intensity
		Fish consumption

ceilings and social foundations indicators from both local and global perspectives, in line with the recommendations of Raworth et al. (2020). The dimensions and indicators have been chosen to address the primary concerns of fisheries, scientists, NGOs, and regional public administration. These selections were made through a comprehensive review of existing literature and active participation in numerous research projects in the area. These projects involved multiple field research activities and stakeholder engagement processes (Coll and Bellido 2020, Coll et al. 2020).

Robustness and availability are ensured by choosing indicators that have already been used and regularly reported by the Spanish Government and international institutions, such as the GFCM and the Scientific, Technical and Economic Committee for Fisheries (STECF), in the context of specific fisheries evaluation frameworks; have been previously used in peer-review literature; or are regularly provided by well-known international institutions (IUCN, EUMOFA, SABI). Appendix 1 Tables S1 and S2 provide details on the sources of each indicator.

Regarding the calculation of indicators, we followed similar studies (O'Neill et al. 2018, Fanning et al. 2022), and whenever possible, we present ecological and social indicators using the latest data available relative to their respective reference values (i.e., social boundaries that ensure the fulfillment of the basics social needs or ecological thresholds that should not be overshot). Reference values (Appendix 1 Tables S1 and S2) were defined using a conservative, risk-averse approach, considering the vulnerable situation of the fleet and ecosystem, following the same approach as the original planetary boundaries framework (Rockström et al. 2009). For indicators without clear absolute reference values (6 out of 26), we used trend analysis, presenting the indicator relative to the average of the longest available serial data. Regarding the ecological indicators, when the reference value was 0 (four indicators), we shifted the baseline to 1 to facilitate comparison with the remaining ecological indicators. The data sources, detailed calculation methodology, reference values, and the used temporal serial data can be found in Appendix 1 Tables S1 and S2.

Results presentation

Regarding results presentation, the sustainability border for ecological indicators is set on the outer dark green ring (Fig. 4). Ecological overshoots are represented by red columns that start from the outer green ring and extend to the outer boundary of the figure. An outer dotted ring corresponds to a value of 2 for the indicator, which indicates a doubling of the reference value. Indicators with values below the reference value, which are in the sustainable space, are shown as white columns that start from the outer dark green ring and pass through the green ring of the sustainable space.

On the other hand, the social indicators have their reference value within the internal green ring. Social deficits are depicted by red columns originating from the inner side of the internal dark green ring, where all the indicators attain a value of 1, and these columns extend toward the center of the figure. If any indicator lacks a red column, it is considered to be meeting its minimum social foundation level. The central dot-point ring displays a value of 0 for the indicator. Grey columns represent the lack of sufficient historical records to establish either an absolute reference value or a trend analysis, and yellow dots shows that the value varies by region in the studied area.

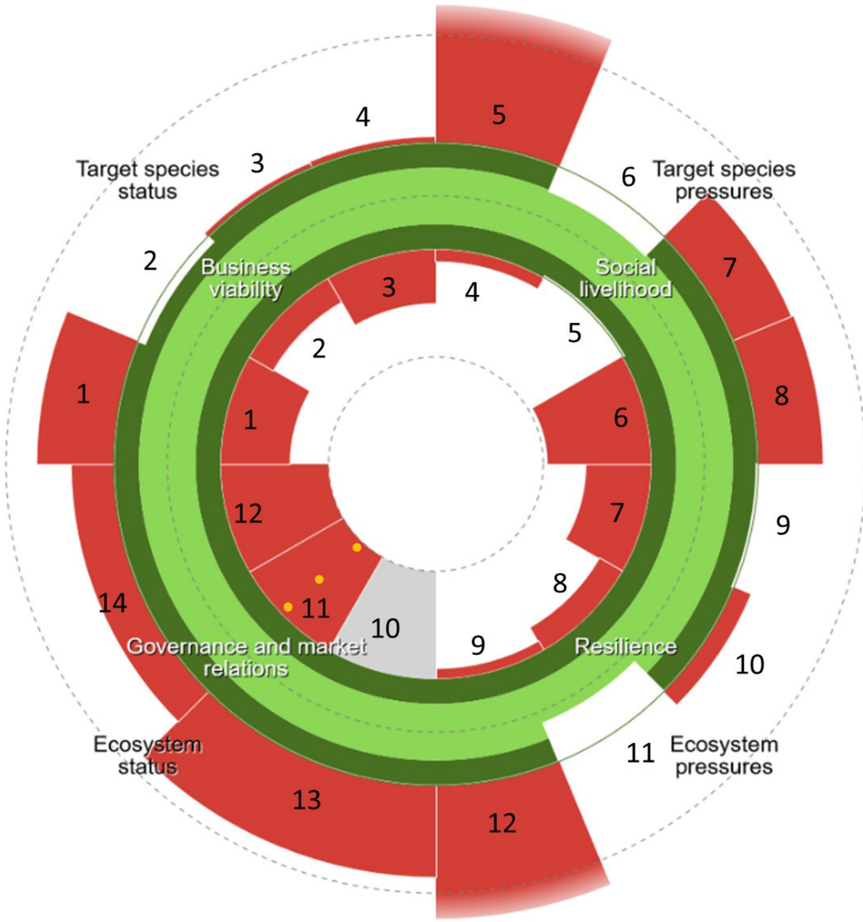
RESULTS AND DISCUSSION

The doughnut assessment presents a comprehensive view of the activity of Spanish purse-seiners in the northwestern Mediterranean Sea (see Fig. 4 and Appendix 1 Tables S1 and S2 for detailed data). Our results suggest that the current situation is in many aspects far from being in a secure space, ecologically safe, or socially just (Fig. 4). The resulting doughnut portrait can help explain the evolution on the number of purse-seine vessels in the area, with a decrease of 20% in the last 10 years (Fig. 2). It is coherent with the justification of the recently approved "Spanish Mediterranean purse seiners sustainability management plan" (MAPA 2023a) that considers that urgent action needs to be deployed in this fishing sector.

From the business perspective, most of the purse-seiner activity is working with smaller profitability than other small and medium business in the region (Indicator S1: 64%), so external investment is not easy to gather. Moreover, 25% (Indicator S2) of the analyzed fleet did work in 2021 with negative profitability, which may lead to viability problems at midterm if the situation does not change. This information points to the idea that the sector is not stabilized, and some subsegments may be in important difficulties in the years to come if changes do not occur.

The targeted species and ecosystem indicators are coherent with previous studies that have shown in general negative trends in both the main commercial species of the fishing sector, European anchovy and European sardine, as well as the ecosystem where they live (Indicators E 1–11,13,14). Significant changes in

Fig. 4. Application of the doughnut framework to the northwestern Mediterranean Sea purse-seiners fishery. In red: those indicators that overshoot the ecological reference values and shortfall the social reference values; in grey: those indicators without data.



Social Foundation

BUSINESS VIABILITY
1. Return on Equity -ROE: 0.36
2. Return on Assets - ROA: 0.75
3. Profit margin: 0.50

SOCIAL LIVELIHOOD
4. Number of purse-seiners fishers: 0.89
5. Fishers wage: 1.04
6. Gender disparity: 0.04

RESILIENCE
7. Education: 0.40
8. Fishers age structure: 0.76
9. Age of vessels: 0.91

TRANSITION
10. Buyers concentration: Not available
11. Representation of purse-seiners members in regional fishers sectoral representative bodies: regional dependent
12. Representation of non-EU fishers in sectoral executive committees: 0

Ecological ceilings

TARGET SPECIES STATUS
1. Sardine biomass: 1.71
2. Anchovy biomass: 0.73
3. Sardine mean size at first maturity: 1.04
4. Anchovy mean size at first maturity: 1.05

TARGET SPECIES PRESSURES
5. Sardine fishing mortality: 2.28
6. Anchovy fishing mortality: 0.51
7. Microplastic presence in sardine: 1.58
8. Microplastic presence in anchovy: 1.60

ECOSYSTEM PRESSURES
9. Out of optimal spawning sea surface temperature for sardine: 0.97
10. Out of optimal sea surface temperatures for anchovy: 1.17
11. Fuel intensity: 0.23
12. Fish consumption: 2.24

ECOSYSTEM STATUS
13. Overexploited commercial stocks: 1.85
14. Top predators at risk: 1.39

biomass, abundance, growth patterns, age structure, and body condition have been recorded, mostly showing declining trends due to the isolated or combined effects of different drivers such as fishing pressure, environmental changes, and lower quality or quantity of food availability (Coll et al. 2019, Lloret-Lloret et al. 2022).

It is also worth noting that anchovy stocks are in a better state than sardine stocks. According to the latest evaluation by the Working Group on Stock Assessment of Small Pelagic Species (WGSASP), anchovy is considered to be sustainably exploited (Indicator S6). On the other hand, sardine reports record a low biomass compared to historical information (Coll and Bellido 2020), and high overfishing levels (2.28 F/Fmsy). However, projections show that anchovy distributions may decline at the end of the 21 century because of climate change (Pennino et al. 2020a).

Some of the ecosystem pressures that are affecting the health status are also showing negative trends, including some long-term anthropologically driven processes such as changes in sea surface temperature (Fernández-Corredor et al. 2021) and reductions in the number of days with optimal spawning conditions for anchovies (Ramírez et al. 2021, Ouled-Cheikh et al. 2022; Indicator E 9,10), as well as the presence of plastics in the guts of small pelagic fish (Compa et al. 2018, Pennino et al. 2020b; Indicator E7, E8).

When considering the implications on a global scale, it is worth mentioning that Spanish per capita fish consumption remains much higher than the world average (Indicator E12) while its self-sufficiency rate in 2020 was 49% (EUMOFA 2023), so it relies significantly on imports. However, it is important to highlight that the fuel efficiency of Mediterranean pure-seiners is much better than the average Spanish Mediterranean fleets, especially when compared to bottom trawling (Muñoz et al. 2023; Indicator E11).

In relation to the social dimension, although the grey column in the "buyer's concentration" indicator (Fig. 4) represents the lack of sufficient historical records to establish either an absolute reference value or a tendency analysis, it is remarkable that the concentration of buyers is high, with five buyers in Catalonia and Valencia accounting for more than 50% of all purse seiner captures in 2021 (Ortega Cerdà and Coll 2022). Data collection only began in 2021, and in the near future, a tendency approach can be applied to analyze the trend of this indicator. The red column with yellow dots in the "representation of purse-seiners in regional fishermen sectorial representative bodies" indicator shows that the value varies by region, with proportional representation in Catalonia and no representation in Valencia and Murcia.

Fisheries transition

The doughnut approach is a flexible non-sectorial specific framework that can be used in the different blue economy activities supporting multi-sectorial discussion processes. It provides a holistic view of the analyzed sector and the ecosystem where it interacts, and adds to other already existing specific sectorial holistic indicator approaches, such as, for example, in the fisheries case Anderson et al. (2015) or Carpenter et al. (2021), and those linked with ecosystem fisheries assessments (Bundy et al. 2012, Shin et al. 2012, Kleisner et al. 2013, Fu et al. 2019, Lockerbie et al. 2020), or the information provided regularly in specific reports by institutions such as the STECF.

Our case study shows that the doughnut approach can be a useful information framework to discuss fisheries transition in line with the blue economy objectives. Although the purse-seiner fishing pressure indicators show that total fishing pressure should decrease, it is important to note that in coherence with an Ecosystem-Based Fisheries Approach, the ecosystem status indicators of the doughnut suggest that improvement should not only focus on the stock itself but also on improving the whole ecosystem, where key ecological processes supporting the targeted species take place. Some measures could lead to win-win situations if they embrace multiple objectives, such as establishing areas where fisheries and climate change strategies go hand in hand (Pennino et al. 2019, Ramírez et al. 2021) or protecting nursery areas and addressing interactions with other fisheries that damage the key anchovy and sardine essential fish habitats (Tugores et al. 2011, Giannoulaki et al. 2013).

It is important to note that the profit margin indicator shows that the economic strategy of most businesses in the fishing sector is based on small margins (Indicator S3: 69% of the analyzed businesses have less than a 3% margin) and big catch volumes. This strategy makes the sector fragile in case of cost increases or volume fluctuations, whether they are natural or management-driven. Therefore, structured fish management processes that may reduce fishing catches would be more readily embraced if they are accompanied by strategies that increase profit margins, to prevent an increase in the number of businesses with negative economic profitability. Another potential strategy involves increasing public subsidies, similar to what has recently been approved by the Spanish Government, to promote the expansion of temporary cessation of activities aimed at supporting sardine recovery (MAPA 2023b).

Currently, significant catch volumes of sardine and anchovy are below the size of maturity and the minimum conservation reference size, therefore, these were immature and small-sized individuals that had not bred yet (Coll and Bellido 2020, ICATMAR 2021). Selective output fishing strategies, such as increasing the minimum size of fish allowed to be sold, in addition to a global catch decrease, may help to recover the ecosystem functioning while minimizing the impact on economic profitability, because the margin of selling bigger fish is higher because fish commercial categories are used in local auctions. An increase of the minimum conservation size has been recently approved in the new "Spanish Mediterranean purse seiners sustainability management plan" (MAPA 2023a).

Another strategy to increase profit margin could be to try to increase the seller's negotiation capacity. However, given the high concentration of buyers in the region (Ortega Cerdà and Coll 2022, Ortega Cerdà et al. 2023), and the fact that most buyers purchase from other national and international markets, increasing the bargaining power of sellers in the purse-seiner fishery is more challenging than in other fisheries where buyer concentration is lower. An alternative could be for sellers to negotiate collectively, through guilds or producer organizations, to create high-volume seller agreements in some of the biggest ports (such as the already existing example in Tarragona, which allows fishers to know how much they will be paid before going to fish), or by jointly negotiating through multi-harbor fishers' producer organizations.

A third option to increase the profit margin would be to process part of the catch. Although there are important fish processors in the area, they mostly use sardine and anchovy from the Atlantic because they consider the size of the Mediterranean fish as not sufficient and the volume fluctuations are too high, which is a common problem with other Mediterranean fish products that retailers also address (Ortega Cerdà and Coll 2022, Gómez et al. 2023). Nevertheless, some studies have been carried out to develop new products adapted to the local catch (Calle and Elsa 2021). A qualitative improvement in the status of the landed species may be key to successful transition processes.

The necessary transition to achieve a sustainable sector is not solely a technical or financial issue; it also requires sufficient social capabilities to lead and manage the process, taking into consideration the social context where it would occur. In this regard, there are several indicators that should be considered. First, as we can see in the doughnut indicators, the purse-seiner fishing community has a disproportionate number of male fishers over 40 years of age with low levels of basic education (Indicators S 6–8); it is not surprising then that the government promotes the incorporation of young fishers (MAPA 2023c).

Second, the difficult ecological and economic situation has resulted in low wages for workers who spend more than 8 hours at sea at night. Indicators show that a significant portion of purse-seiner fisher workers are paid less than the average wage in Spain, with some receiving only minimum wage (Indicator S5). Additionally, the traditional shared remuneration system does not include fixed salaries, as owners pay based on the economic results obtained in the period, usually on a weekly or biweekly basis (Guillen et al. 2015). Consequently, there is a high degree of weekly income uncertainty and fluctuations. Potential measures to reduce uncertainty for workers, such as introducing monthly assured fixed salaries with bonuses based on economic results, have not been implemented in this fishery. As a result, there are currently difficulties in finding fishers, and the fleet is increasingly attracting the most vulnerable sectors of society with fewer job opportunities, particularly non-EU citizens that are not present in the sectoral executive committees of the fisheries decision-making institutions (Indicator S12). Official data from 2019 shows that 20.2% of Mediterranean crew members were non-EU citizens (MAPA 2020), while the number of fishers in the community has decreased by 11% compared to the previous three-year average (Indicator S4). From a technical resilience perspective, indicators show that a significant portion of the Mediterranean fleet is aging (Indicator S9), resulting in decreased technical resilience. The demand for public funds to construct new purse seiners and/or modernize the existing fleet is a contentious issue among purse-seine fishers in the Spanish Mediterranean fleet (Ortega et al. 2023).

The social, ecological, and economic conditions integrated under the doughnut approach suggest that any isolated fisheries management measures are unlikely to be sufficient to achieve a secure and ecologically safe space that is also socially just. Our assessment indicates the need for urgent action and an overarching transition plan that requires an ecosystem-based fishery management plan, together with a commercial and a social plan.

Limitations

In terms of data availability and analytical limitations, it is important to acknowledge that it is not always feasible to establish absolute thresholds for all the indicators. In cases related to economic and social factors (such as return on equity, profit margin, fishers' wages, education, and vessel age), we have adopted the comparative advantage economic theory and benchmarked them against other regions or economic activities with which they compete. These indicators are crucial for describing the short-term relative attractiveness and competitiveness of the fisheries sector.

Regarding ecological ceilings (fuel intensity and fish consumption), instead of using zero values as targets—which is not currently achievable with current technology for the former, and significantly deviates from current social trends for the latter—we have taken a short-term approach. We have used the average oil consumption by the Spanish fleet as a reference value, once again employing the comparative advantage economic perspective, and the world average consumption. It is worth noting that this choice can be replaced by setting zero as the ultimate target if desired.

CONCLUSIONS

The doughnut approach was applied for the first time to the fisheries sector, with a focus on purse-seiners in the northwestern Mediterranean Sea. The study found that this approach was useful in providing valuable information to support the transition of fisheries toward becoming a sustainable blue economy.

The doughnut perspective offers a comprehensive, flexible, and holistic approach based on multiple values that are easy to understand and can be easily incorporated into a cohesive narrative of transitioning to a "safe and just space for humanity." This approach can also be extended to other blue economy sectors, which is an especially noteworthy feature in a context of expanding marine economic activities, and can help to avoid the sometimes conflictual narrative of environment versus economy, as well as the less objective-oriented sustainability narrative that considers the social, environmental, and economic perspectives in isolation. Such approaches are often found in marine political discussions. The doughnut approach can facilitate dialogue between different stakeholders, including decision makers and managers, media, researchers, and NGOs.

Using an "out of the fisheries box" framework can also facilitate the participation of fisheries experts, enabling them to use a common "framework language" in the broader discussions about the socioeconomic and ecological changes that are needed to achieve the Sustainable Development Goals in the context of the blue economy. And vice versa, it provides non-fisheries experts a way of understanding what is happening in fisheries.

Nonetheless, our approach has also limitations. It does not show the linkages and dependencies between the indicators, so it needs to be completed with other tools to properly evaluate trade-offs between management scenarios. There are also technical difficulties. For example, it is not always easy to "translate" the selected ecological and social indicators into the "basic needs and ecological ceilings" framework. This is mainly due to the fact that establishing reference values to compare the current status is not always possible. When instead of using reference values, historical data series is used, we should be careful because we may be hiding shifting baseline tendencies (Pauly 1995), so whenever possible the use of fix reference values is preferable. Finally, further testing of this framework in a temporal context remains to be done, as well as reflecting on how to account for different fleet segments (e.g., purse seiners, bottom trawlers, artisanal fleet), the trade-offs that arise between them, and the interaction between fisheries and other blue economy activities such as offshore energy production, or transport. This is crucial for transitioning toward an ecosystem-based fisheries management approach.

Unsurprisingly, there exists tension between the utilization of general frameworks and sector-specific nuances, as well as between global assessments and regional specifics. The doughnut approach offers a common and adaptable foundational structure that must be customized for specific sectors and regions, rooted in local knowledge and perspectives (Raworth 2017, Raworth et al. 2020). Because of its novelty, it is still too early to determine the extent to which common standard basic indicators will be embraced in these analyses (Warnecke 2023). This case study represents an initial contribution to its potential application in a blue economy sector, with the recognition that it should be further enriched by future studies in other sectors and fisheries. Despite these limitations, this study demonstrates how the doughnut perspective can offer useful insights for fisheries transition toward becoming a sustainable blue economic sector. We believe that the flexible and adaptable doughnut approach can provide a good discussion framework to the broader conversation around what constitutes a successful and sustainable blue economy. Drawing from this experience, we propose that similar approaches could be applied to other sectors within the blue economy, making this an intriguing avenue for future research.

Author Contributions:

Miquel Ortega: conceptualization, methodology, investigation, validation, writing – original draft. Francisco Ramirez and Marta Coll: methodology, investigation, validation, writing: review & editing.

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Data Availability:

Data/code sharing is not applicable to this article because no data and code were analyzed in this study.

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Table S1. Social Foundation indicators

Dimension	Name	Calculation	Data sources	Proposed boundary used as social foundation	Evaluation year	Current status
Business viability	*Return on equity*	= (Number of purse-seiners business with more than the small business average return on equity (ROE) in the region) / (Number of purse-seiners business in the region) *Note:* The analysed are includes three regions: Catalonia, Comunidad Valenciana and Murcia. ROE information for small business is only available in Catalonia region (where 53% of the studied pure-seiners are based), so this region that has been used for all the Mediterranean Spanish coast.	- Purse-seiners ROE: SABI (Sistema de Análisis de Balances Ibéricos). 2021 Official financial information available for 22 purse-seiner business (18% of the active fleet). - Average regional ROE: (Bonal Ferrer *et al.*, 2023)	Logic: competitive ROE against other potential investments. ROE > Average return on equity in the region	2021	0.36
	Return on Assets	= (Number of purse-seiners business with positive return on assets profitability (ROA) in the region) / (Number of purse-seiners business in the region)	- SABI (Sistema de Análisis de Balances Ibéricos). 2021 Official financial information available for 21 purse-seiner business (17% of the active fleet).	Logic: avoid financial distress. ROA > 0	2021	0.75
	Profit margin	= (Number of purse-seiners business with more than 3% profit margin in the region) /	- SABI (Sistema de Análisis de Balances Ibéricos). 2021 Official financial information available	Logic: usual profit margin the high-volume fisheries	2021	0.50

		(Number of purse-seiners business in the region)	for 21 purse-seiner business (17% of the active fleet)	Profit margin > 3%		
Social livelihood	*Number of purse-seiners fishers*	= (current number of fishers) / (average number of fishers of the previous 3 years) Note: data have been worked in full time equivalent units	- (Ministerio de Agricultura pesca y alimentación, 2021) and the same document for the previous years: 2010-2020	Logic: not declining tendency. Used historical data: 2010-2019. 2020 data was excluded to avoid COVID crisis impact.	2021	0.89
	Fishers wage	= (purse-seiners averaged fisher median wage) / (national most usual salary) *Note:* In order to estimate "purse-seiner averaged fishermen median wage" first we have calculated the median business salaries costs par worker using SABI data, then we have subtracted the mandatory business deductions on employee work, then we have ponderated the obtained value using the traditional way of distributing salaries between purse-seiners fleets in the region. At the vessel level the total amount of resources available for salaries are split in parts following the following scheme: each	- Pure-seiners Fisher median wage: SABI (Sistema de Análisis de Balances Ibéricos). 2021 Official financial information available for 21 purse-seiner business (17% of the active fleet). - National most usual salary: (INE, 2023a)	Logic: competitive wages National most usual salary	2021	1.04

		fisherman gets one part; the machinist gets 1.25 and the Captain 1.5. It should be considered as a proxy since there are differences between vessels. We have assumed an average of 10 crew par vessel. To these values we have added the unemployment salary associated to the yearly temporal cessations of activities.				
	Gender disparity	= (Percentage of active women in the sector) / 50% Note: data have been worked in full time equivalent units and include both on land and on-board work	- (Ministerio de Agricultura pesca y alimentación, 2021)	Logic: gender balance 50% representation	2021	0.04
Resilience	*Education*	= (% of Mediterranean fishers with more than "primary studies") / (% of Spanish population between 25 and 64 years with more than "primary studies")	- (Ministerio de Agricultura, 2020) - Spanish population data: (Instituto Nacional de Estadística (INE), 2019)	Logic: no underrepresentation of high-level studies % of Spanish population between 16 and 64 years with more than "primary studies"	2021	0.4
	Fishers age structure	= (% of Mediterranean fishers with less than 42 years) / 50%	- (Ministerio de Agricultura pesca y alimentación, 2021)	Logic: age equilibrium 50% of fishers with less than 42 years	2021	0.67

				Note: In Spain fishers can start working since they are sixteen and can go on pension at 64, so 42 is in the middle of the working period*.		
	Age of vessels	= (average non-Mediterranean Spanish purse-seiners vessel age)/ (average Mediterranean purse-seiners vessel age)	- (INE, 2023b)	Logic: not older than the direct competence fleet Average Mediterranean purse-seiners vessel age	2021	0.91
Governance and market relations	*Buyers concentration*	= Gini Index	- Purse-seiners sell registers	Logic: buyers concentration should not increase Average buyer's Gini index of purse-seiners sector over the historical data	2021	NA
	Representation of purse-seiners members in regional fishers sectoral representative bodies	= (% of purse-seiners fishers members) / (% of theoretical representation at the local level in Catalonia)	- (*LLEI 22/2002, de 12 de juliol, de confraries de pescadors*, 2022) - Individual revision of the current membership of the "executive bodies" of the Catalan Federació Nacional Catalana de Confraries de Pescadors, and the Valencian Comissió Interfederativa de Cofradies de Pescadores de la	Logic: Equilibrated representation between fleet segments % of theoretical representation at the local level in Catalonia Note: in Catalonia a specific representation by	2021	1 in Catalonia, 0 in the other regions

			Comunitat Valenciana – COINCOPESCA.	fleet segment is mandatory at the local level professional organizations (Cofradias), ensuring a fair representation of all of them. Nevertheless, at the regional level the National Catalan Federation of Cofradías base their representative structures in territorial criteria, so proportional representation of fleet segments is not guaranteed (Federació Nacional Catalana de Confraries de Pescadors, 2018). In the rest of the Spanish coast local or regional representation is not regulated under a sectorial perspective, so have used the Catalan legislation at the local level as a reference for proportional representation.		

	Representation of non-EU fishers in sectoral executive committees	= (% of non-EU members in sectorial executive bodies) / (% of non-EU members in the fishing fleet)	- Individual revision of the current membership of the "executive bodies" of the Catalan Federació Nacional Catalana de Confraries de Pescadors, and the Valencian Comissió Interfederativa de Cofradies de Pescadores de la Comunitat Valenciana – COINCOPESCA.	Logic: Equal representation regardless of the nationality % of non-EU members in the fishing fleet	2021	0

*Official statistics only provide information in reference to 40 years, so we have used this data as Proxy to 42 years.

Social foundation indicators justification and explanation

Business viability

For business viability, we used return on equity (ROE), return on assets (ROA) and profit margin indicators. The ROE index is the most commonly used measurement of a company's profitability, with higher ROE values indicating a more effective use of the companies' own assets to generate profits. In relation to ROE, we calculated the percentage of fisheries business activities that perform above the average ROE for small and medium enterprises in the region (ROE>6,2%). This serves as a proxy for what can be considered attractive from an investor's point of view in comparison with other potential investments (Bonal Ferrer *et al.*, 2023).

Return on assets (ROA) determine how efficiently a company uses its assets to generate a profit. In this case, we used the percentage of activities that have positive returns on assets, as negative ROA is a strong sign of financial distress within a mature company such as most of the purse-seiners in the region (Ministerio de Agricultura pesca y alimentación, 2020).

Finally, the profit margin represents what percentage of sales has turned into profits. For this indicator we calculated the percentage of fisheries business activities that perform with profit margins greater than 3%, a value characteristic of high-volume fishing activities, which is already smaller that the average value of the Mediterranean fleet at around 10% (STECF, 2022). Therefore, indicators show what can be considered the portion of the sector that performs better in terms of business viability.

Social livelihood

The social livelihood dimension recognizes the need to have a thriving social context. As such, it is desirable to have a large enough fishery community where knowledge, experience, and sense of community exist. Additionally, competitive fishers wages are necessary to make work attractive, and a balanced gender relation is essential since it has been shown that even if they are still minoritarian, women play a key and unnoticed role in the Spanish Mediterranean fisheries sector (Herrera-Racionero *et al.*, 2021). Accordingly, within this dimension, we considered the following indicators suitable: the trend in the number of purse-seiners fishers (reference value: not negative compared to the average historical data); fishers' wage in relation to national most usual salary (reference value: fishers should earn at least the same wage as the most interprofessional usual salary -modal salary-); and gender disparity (reference value: gender balance, at least 50% of women's working in the sector).

Resilience livelihood

Not only economic viability is needed but also social and technical resilience is desirable to cope with uncertainties. The identified basis for this resilience includes basic education as a tool for adaptation (reference value: the same percentage of fishers between 16 and 64 years with at least "primary studies" as the average working force); age distribution as a keystone to have a good mix between experience, wisdom, and innovation - in a context where generational renewal has become a major problem (Sala, 2017) – (reference value: no more than 50% of fishers with more than 42 years); and the age of vessels in the context of an aged fleet - since one of the key elements to evaluate the continuity or not of the fisheries' activity (Maynou, 2020) – (reference value: not older than the average age for non-Mediterranean Spanish purse-seiners vessel).

Governance and market relations

This dimension points out the need to consider market-power relations and governance to ensure a successful transition toward a safe social and ecological space. The degree of buyer's concentration Gini index has been chosen as an indicator for market-power relations, as big concentrations can influence market price formation (Coll *et al.*, 2020). Since it is not clear whether perfect equality is the best economic option, an evolutionary perspective has been adopted (reference value: not more inequality than the average historical data). However, it is important to note that diversification/concentration that is a key element on fleet resilience can be driven for other reasons that just industry consolidation, specially when catch systems are implemented (Holland *et al.*, 2017), which is not the case in the Mediterranean Sea that works under an effort regime, any isolated interpretation of this indicator should be cautious. For the governance dimension, we have used two indicators: the *representation of the purse-seiner sector in the regional fisheries representative bodies*, as the capability to represent specific pure seiners interests at the regional scale it is perceived by fishermen as a key element to address their future (Raicevich *et al.*, 2018) (reference value: representation distribution established in Catalan local regulation); and the *presence of non-EU fishers in fisheries representatives' bodies*, since *inclusiveness* (i.e. participation and engage marginalized stakeholder) is considered among the most relevant good governance element in the fisheries context (Aguado *et al.*, 2021). Non-EU low educated workers are considered to be a vulnerable collective (reference value: same proportion than the percentage of non-EU members in the fishing fleet).

Table S2. Ecological indicators

Dimension	Name	Calculation	Data sources	Proposed boundary used as ecological ceiling	Evaluation year	Current status
Target species biomass status	*Sardine biomass*	= (average biomass with near Fmsy values) / (current assessed biomass average)	- (GFCM, 2023) GFCM stock assessment (Torres, 2022a)	Logic: at least not decreasing in comparison with the average historical biomass Used historical data: 2010-2020	2021	1.71
	Anchovy biomass	= (Btarget) / (Bcurrent)	- GFCM stock assessment (Torres, 2022b)	Logic: Btarget	2021	0.73
Target species health status	*Sardine mean size at first maturity*	= historical L50 / last available L50	- (Torres *et al.*, 2022)	Logic: at least not decreasing in comparison with the average historical L50 mean size Used historical data: (2008-2019)	2021	1.04
	Anchovy mean size at first maturity	= historical L50 / last available L50	- (Torres, 2022b)	Logic: at least not decreasing in comparison with the average historical L50 mean size Used historical data: (2008-2019)	2021	1.05
Target species	*Sardine fishing mortality*	Method a4a. = (Fcurrent/Fmsy-1)	- GFCM stock assessment (Torres, 2022a)	Fmsy	2021	2.28

fishing pressure	*Anchovy fishing mortality*	Method a4a. Qualitative advice	- GFCM stock assessment (Torres, 2022b)	Fmsy	2021	0.51
Target species other anthropogenic pressures	*Microplastic presence in Sardine*	= 1 + Number of stomachs with incidence of microplastics in the gut contents/number of analysed sardines	- (Pennino *et al.*, 2020b)	Logic: no microplastics in any sardine No sardine with microplastics	2018	1.58
	Microplastic presence in Anchovy	= 1 + Number of stomachs with incidence of microplastics in the gut contents/number of analysed anchovies	- (Pennino *et al.*, 2020b)	Logic: no microplastics in any sardine0,32 No anchovies with microplastics	2018	1.6
Ecosystem status	*Overexploited commercial stocks*	= 1 + Number of stocks assessed in GSA 6 as overexploited / total number of assessed stocks of commercial species in GSA6 available from recent evaluations	- (GFCM, 2023)	Logic: overexploitation is not produced Zero assessed stocks are overexploited	2021	1.85
	Top predators at risk	= 1 + Number of top predators of small pelagic fish assessed as in risk (over least concern evaluation) / all assess top predators.	- Risk evaluation: (IUCN, 2022) - Top predators list in ALPR region: (Ouled-Cheikh *et al.*, 2022)	Logic: overexploitation is not produced Zero assessed predators are overexploited	Supplementary material Table 4	1.39
Ecosystem pressures	*Out of optimal spawning sea surface temperatures for sardine*	= (Number of days with surface sea temperature over 19^{o} in the spawning period (October-March)) / (average historical number of days with surface sea temperature over 19^{o} in the spawning period (October-March))	- (Saha *et al.*, 2018)	Logic: at least not increasing in comparison with the average historical data Used historical data: (1982-2020)	2021	0.97

	Out of optimal spawning sea surface temperatures for anchovy	=(Number of days with surface sea out of the range 17-24º in the spawning period (April-September)) / (average historical number of days with surface sea out of the range 17-24º in the spawning period (April-September)	- (Saha *et al.*, 2018)	Logic: at least not increasing in comparison with the average historical data Used historical data: (1982-2020)	2021	1.17
Pressures on global ecosystem	*Fuel intensity*	= (l/kg purse seiners GSA6 fleet) / (l/kg Spanish Mediterranean fleet)	- Purse-seiners Spanish consumption: (Scientific Technical and Economic Committee for Fisheries (STECF), 2021) Annex tables. - Spanish Mediterranean fleet captures : (Ministerio de Agricultura Pesca y Alimentación, 2021a) - Oil consumption: (Ministerio de Agricultura Pesca y Alimentación, 2021b)	Logic: at least as better as the average fishing capture in Spain. l/kg EU 27 fleet	2021	0.23
	Fish consumption	= (Spanish yearly average per capita fish consumption) / (world yearly average per capita fish consumption)	- World consumption: (FAO, 2022)	Logic: at least no more than the average world consumption.	2021	2.24

			- Spanish consumption: (EUMOFA, 2021)	world yearly average per capita fish consumption		

The ecological ceiling justification and explanation

Target species status

The biomass state indicator targets the evolution of the biomass of main commercial species, European anchovy and European sardine. Here, we consider that higher abundances of these populations result in enhanced resilience to external factors such as fishing, and environmental change (Pennino *et al.*, 2020a) (reference value: for sardine we use a trend analysis based on the average of the historical data; in the anchovy case, we use Btarget reference coming from the Stock Assessment).

The health of commercial fish populations can be negatively affected by stressors, which may result in a decline in the *mean size at first maturity*; i.e., the size at which 50% of the fish at that size are mature (Albo-Puigserver *et al.*, 2021). To assess the health of the target species, namely European anchovy and European sardine, we measured the change ratio in the mean size of first maturity. The reference value for this indicator is that the mean size of first maturity should not decrease in comparison to the historical data.

Target species pressures

The main anthropogenic pressure on the key stocks for purse-seine fishing is fishing pressure on both anchovy and sardine stocks. The selected indicator reflecting fishing pressure is current fishing mortality over fishing mortality at maximum sustainable fishing (Fcurrent/Fmsy), as the higher the fishing mortality, the larger the removal of part of the population by the fishing sector (GFCM, 2023) (reference value: not exceeding Fmsy).

To consider other anthropogenic pressures on the species of interest for the fishery, we followed the *novel entities* planetary boundaries scheme (Steffen *et al.*, 2015) and included the pollution by micro plastics. We used the percentage of stomachs with incidence of microplastics in the gut contents of both anchovy and sardine as an indicator, since a larger presence of microplastics in stomachs of small pelagic fish has been correlated with lower body condition (thus lower health of individuals) and a higher presence of parasites (Pennino *et al.*, 2020b) (reference value: zero presence of plastics in stomachs).

Ecosystem status

To capture the ecosystem status, we selected two indicators (see Table 1). The first one is the percentage of assessed overexploited stocks, calculated as the number of stocks assessed as overexploited over the total number of assessed stocks of commercial species (GFCM, 2023) (reference value: zero overexploited stocks). The second one considers the percentage of predators at risk, as the number of predators of small pelagic fish assessed as at risk according to IUCN overall assessed top predators in the region (Ouled-Cheikh *et al.*, 2022) (reference value: zero predators at risk).

Ecosystem pressures

To reflect ecosystem pressure at the local level, we targeted environmental factors likely affecting the spawning, and hence biomass, of anchovy and sardine. Based on information on optimal spawning sea surface temperatures (Palomera *et al.*, 2007), we estimated the percentage of change in the number of days out of optimal spawning conditions (Ramírez et al., 2021; Ouled-Cheikh et al., 2022a); the reference value is not increasing regarding the historical temporal data.

Finally, to reflect how the evaluated fisheries and the social context in which they take place affect global ecosystems, we have chosen two indicators that point out two of the major global ecological challenges: climate change and biodiversity crisis (UN Environment, 2019). As a proxy for CO2 emissions, we used *fuel consumption per landed kg by the purse-seiner fleet* (reference value: not exceeding the Spanish fleet average). As a proxy for human pressures on marine ecosystems through consumption, we chose the *total fish consumption per capita in Spain* (reference value: not exceeding the global average).

Table S3. Indicators scope

Social foundations	Indicator	Sectorial	Regional - Global
Business viability	*Under average economic profitability*		
	Negative economic profitability		
	Minimum profit margin		
Social livelihood	*Evolution of the number of purse-seiners fishers*		
	Fishworker wage		
	Gender disparity		
Resilience	*Primary education.*		
	Fishers age structure		
	Age of vessels		
Transition	*Buyers concentration*		
	Representation of purse-seiners members in regional fishermen representative bodies		
	Representation of non-EU fishermen in sectoral "executive committees"		
Ecological ceiling			
Target species status	*Sardine biomass*		
	Anchovy biomass		
Target species health	*Sardine mean size at first maturity*		
	Anchovy mean size at first maturity		
Target species pressures	*Sardine fishing pressure*		
	Anchovy fishing pressure		
Target species threats	*Plastic presence in Sardine*		
	Plastic presence in Anchovy		
Ecosystem status	*Assessed overexploited commercial stocks*		
	Top predators at risk		

Ecosystem pressures	*Out of optimal spawning sea surface temperatures for sardine*		
	Out of optimal spawning sea surface temperatures for anchovy		
Pressures on global ecosystem	*Fuel intensity*		
	Fish consumption		

Table S4. Top predators at risk table

Species	**IUCN**	**Population trend**	**Evaluation scope**	***Year***
Dentex dentex	Vulnerable	Decreasing	Mediterranean	2007
Epinephelus costae	NA			
Lithognatus mormyrus	NA			
Trachurus mediterraneus	Least concern	Stable	Mediterranean	2007
Trachurus trachurus	Least concern	Stable	Mediterranean	2007
Xiphias gladius	Near Threatened	Decreasing	Mediterranean	2007
Dipturus oxyrinchus	Near Threatened	Decreasing	Mediterranean	2016
Etmopterus spinax	Least concern	Stable	Mediterranean	2016
Galeus melastomus	Least concern	Stable	Mediterranean	2016
Raja clavata	Near Threatened	Decreasing	Mediterranean	2016
Scyliorhinus canícula	NA			
Tursiops truncatus	Vulnerable	Decreasing	Mediterranean	2009
Ichthyaetus audouinii	NA			
Larus michahellis	Least concern	Stable	Europe	2020
Abralia veranyi	Least concern	Unknown	Global	2010
Bathypolypus sponsalis	Least concern	Unknown	Global	2014
Eledone cirrhosa	Least concern	Unknown	Global	2014
Histioteuthis bonnellii	Least concern	Unknown	Global	2014
Histioteuthis reversa	Least concern	Unknown	Global	2010

Illex coindetti	NA			
Loligo forbesii	Least concern	Unknown	Global	2015
Loligo vulgaris	Data deficient	Unknown	Global	2015
Octopus salutii	Data deficient	Unknown	Global	2015
Pteroctopus tetracirrhus	Least concern	Unknown	Global	2016
Rondeletiola minor	Data deficient	Unknown	Global	2009
Rossia macrosoma	Data deficient	Unknown	Global	2009
Sepia orbignyana	Data deficient	Unknown	Global	2009
Todarodes sagittatus	Least concern	Unknown	Global	2010
Conger conger	Least concern	Unknown	Mediterranean	2007
Diplodus cervinus	Data deficient	Unknown	Global	2007
Euthynnus alletteratus	Least concern	Stable	Mediterranean	2007
Lepidorhombus whiffiagonis	Least concern	Stable	Mediterranean	2008
Merluccius merluccius	Vulnerable	Decreasing	Mediterranean	2007
Ophichthus rufus	Least concern	Stable	Mediterranean	2014
Phycis blennoides	Least concern	Unknown	Mediterranean	2007
Sarda sarda	Least concern	Stable	Mediterranean	2007
Seriola dumerili	Least concern	Stable	Mediterranean	2007
Thunnus thynnus	Endangered	Decreasing	Mediterranean	2009
Trachinus draco	Least concern	Stable	Mediterranean	2007
Raja asterias	Near Threatened	Decreasing	Mediterranean	2016
Scyliorhinus canicula	Least concern	Increasing	Europe	2014
Delphinus delphis	Endangered	Decreasing	Mediterranean	2003
Physeter macrocephalus	Endangered	Decreasing	Mediterranean	2006
Stenella coeruleoalba	Vulnerable	Unknown	Mediterranean	2010
Puffinus mauretanicus	Critically endangered	Decreasing	Europe	2020

Puffinus yelkouan	Vulnerable	Unknown	Europe	2020
Caretta caretta	Vulnerable	Decreasing	Global	2015

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