



Past, present and future of small-pelagic fisheries in the north-western Mediterranean Sea through fishers' perceptions

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ABSTRACT

Fisheries have transformed significantly in recent decades, and further changes are anticipated to address pressing environmental and social challenges. In this context, there is an urgent need to implement science-based public policies that incorporate local knowledge. It is necessary to better assess fishers' perceptions, including both historical (e.g., perceived changes of abundance of species) and future (e.g., views on potential future changes) perspectives. In this paper, we focus on a case study of small-pelagic fisheries in the Spanish northwestern Mediterranean Sea, using semi-structured interviews, graphical analysis, and a Q-methodology. Based in the information obtained from all the active purse seiners vessels in Castelló de la Plana, the most important Spanish Mediterranean small pelagic purse seine harbour, we show how these methodologies are useful for gathering fisher's knowledge regarding historical biomass trends for small pelagic and accompanying species over the last six decades, contributing valuable information on periods where no scientific assessments were available. When looking towards the future, Q-methodology reveals three fisher discourses regarding how to ensure the future sustainability of fisheries: (i) "We don't need more subsidies we need more fish," (ii) "We need more public support for fishing," and (iii) "The future of the fishery it's not in our hands". These three perspectives highlight internal disagreements about what should be the priorities for implementing public policies. However, results also show consensus that the implementation of adaptive management measures can be of common interest, and that bottom trawling activities should avoid juveniles and spawning ground of small pelagic fish.

1. Introduction

There is a widespread consensus regarding the necessity to "transform the aquatic systems through a holistic and adaptive approach aimed at securing socially, environmentally and economically sustainable value chains that help secure livelihoods, foster an equitable distribution of benefits and support adequate use and conservation of biodiversity and ecosystems" [1]. Furthermore, this transformation is expected to be based on the best available scientific research, data, technical expertise, traditional, and local ecological knowledge (LEK) [1].

Numerous examples illustrate how LEK can be used in combination with scientific knowledge for fisheries decisions. Fisher's local knowledge, among others, has proven to be valuable in providing long-term insights into catch trends, ecosystem relations and evolution, and environmental parameters [2–6]. Additionally, it can be used to understand ecosystem characteristics and biodiversity loss and risks

[7–10], help to define conservation areas [11–13] and can serve as an early warning system for ecological or species changes [14,15], among other applications.

Moreover, fisher's LEK can provide interesting insights not only regarding the past evolution and current status of the fisheries, but fisher's perceptions can also contribute with relevant information on the definition of future fisheries policy and management scenarios by recognising their priorities [16]. As such, several formal processes have already been implemented to incorporate these perspectives into the decision-making processes, ranging from consultations in the regulatory processes, to their incorporation of different typologies of management engagement such as co-management schemes [17]. Nevertheless, very often this knowledge is only used in relation to short-term objectives or short-term management-decision measures [18].

One of the most complex challenges in utilizing existing local knowledge is properly analysing the information within, especially when heterogeneous and competing views emerge within a community

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regarding how to achieve long-term sustainability goals [19]. This situation is frequently encountered when attempting to prioritize sustainable fisheries paths, as common long-term objectives must be connected with short-term available management measures [20]. These measures often vary in nature, encompassing ecological, economic, and social dimensions, and carry different degrees and typologies of uncertainty in their outcomes, so their consequences are difficult to assess [21]. Moreover, the prioritizing exercise should take place over complex systems where the actors are aware that often emerging properties can arise, and both stakes and uncertainties are high. In these contexts, extended peer community's role should be enhanced [22,23].

Various quantitative, qualitative, and semi-quantitative methodological approaches can be employed to comprehend social heterogeneity in prioritizing measures, such as interviews, questionnaires, focus groups, Delphi groups, and anthropological observations. Q-methodology is one among different techniques available for identifying agreement and disagreement, as well as social narratives (discourses) over contentious issues, which has proven to be particularly powerful. It has been utilized in numerous areas, including environmental [24–26] and marine-related management alternatives, perceptions and policies [27–33]. Q-methodology is a mixed quantitative-qualitative methodology originally developed by William Stephenson, which is used to systematically study human subjectivity. It involves ranking a sample of opinion statements based on an instructional condition typically ranging from "most agree" to "most disagree". Multiple rankings (termed as 'Q sorts') obtained from different individuals are then analysed statistically through principal components analysis to identify clusters of opinions with similar ranking patterns, which represent shared attitudes or perspectives, grouped into discrete discourses [34]. This technique offers advantages over other qualitative methods of discourse analysis as it allows consistent comparison of participants' responses, while requiring relatively few participants to give statistically significant results [25, 26].

In this paper, we demonstrate, through a case study in Castelló de la plana (Spain), in the North-western Mediterranean purse seine fishery, how information from fishers can enhance ecological knowledge about the fishery's past and provide a nuanced understanding of what, in their view, needs to be done to ensure the future viability of the activity. This contribution allows managers to identify the perception of fishers about past changes in fish abundance where detailed enough scientific knowledge is not available, and assess consensus and heterogeneity in management alternatives.

This case study is particularly relevant as the Mediterranean Sea is characterized by a high level of complexity in both its marine activities and ecological status. Recognized as a biodiversity hotspot, it faces severe ecological pressures due to intense human activities, making it one of the most threatened marine regions globally [35]. Over 62 % of economically valuable fish stocks in the Mediterranean Sea are outside biologically sustainable limits [36]. This unsustainable exploitation has contributed to declines in populations of small pelagic fish (SPF), particularly European anchovy (*Engraulis encrasicolus*) and European sardine (*Sardina pilchardus*), over the past decades [37,38], resulting in substantial ecological and socio-economic impacts, including the economic viability of the purse seine fishing sector, which heavily depends on SPF catches [39,40].

In light of these challenges, there is an urgent need to transition towards sustainable fisheries management in the region to ensure the long-term health of both marine ecosystems and fishing communities [41]. Our study highlights how policy and management decision-making could benefit from the systematic integration of fishers' information in their processes, even within complex contexts and dealing with long-term objectives.

2. Methods

2.1. Case study and data collection

The case study takes place in Castelló de la Plana, the most important Spanish Mediterranean small pelagic purse seine harbour (Fig. 1a). It is located in the North-Western part of the Mediterranean Sea at the Southern side of the Ebro Delta, an ecologically rich area that serves as a nursery area for many demersal and pelagic species and an important fishing ground [42–45]. The purse seine fleet in Castelló de la Plana, where we have focussed our research, faces a complex ecological, social and economic situation [39]. In 2021 (last year with complete available data) the fleet was composed of 14 vessels providing 12 % of anchovy and 6 % of the sardine Spanish Mediterranean captures (Fig. 1b). The fleet operates in daily trips and commercializes its captures in fresh to be consumed mostly in national markets [46].

Data collection took place in March – May 2023 in Castelló harbour. The 11-active purse seine fishing vessels of Castelló - at the moment of the fieldwork - were included in the analysis, through the participation of 24 fishers. The selection of participants was conducted to encompass all fishing vessels in Castelló de la Plana and include various roles within the purse seine fishery. While prioritizing the inclusion of experienced fishers to ensure the acquisition of relevant historical information, our participants also represent a range of experience levels within the fishery (Table 1).

The information was gathered individually through face-to-face meetings, using different techniques: semi-structured interviews, graphical analysis, and Q statement rankings. An explicit consent agreement on data management, including data gathering and anonymous information clauses were signed by all participants. All the data gathering processes were recorded following previous established protocols (Supplementary material, Data collection protocol). More details on the data gathering and data analysis process are described in the following sections.

2.2. Historical data analysis: graphic analysis and interviews

We used a semi-structured survey and a graphic analysis to assess changes in abundance of target and non-target species on purse seine fishing. Fishers were asked to assess changes in abundance of the two target species of the fisheries (sardine *Sardina pilchardus* and anchovy *Engraulis encrasicolus*), in addition to mention any additional species that they perceived that changed in abundance throughout their local fishing experience (i.e., no species were explicitly mentioned by the interviewer leaving it open to fishers' own choices). We then asked fishers to reconstruct a time series of perceived abundance for each species according to six categories (0 = ABSENT; 1 = RARE [once in a year]; 2 = OCCASIONAL [sometimes in a fishing period]; 3 = COMMON [regularly in a fishing period]; 4 = ABUNDANT [regularly in a fishing period and abundant]; 5 = DOMINANT [always in a fishing period and with great abundances]). Once we collected all the data, we explored them at the species level by creating a cumulative time series of perceived abundance (i.e., using the mean perceived abundance for each year and standard deviation to assess the variability of fishers' opinions). We audio recorded the process of completion of the graphical analysis to facilitate the later interpretation of the results. Then, to detect structural changes in the temporal trend of the mean values, we applied a breakpoint analysis using the Bai-Perron methodology, which identifies shifts in the linear trend of a time series. We used the "strucchange" package in R [48], which implements the Bai-Perron test for multiple structural breaks in linear regression models. Breakpoint detection allows for the identification of significant changes in the trend without assuming a constant trend throughout the entire time series. The Bai-Perron method is robust for analyzing structural breaks in data that may exhibit heteroscedasticity or autocorrelation. By restricting the number of break-points to two, we aimed to balance model complexity and

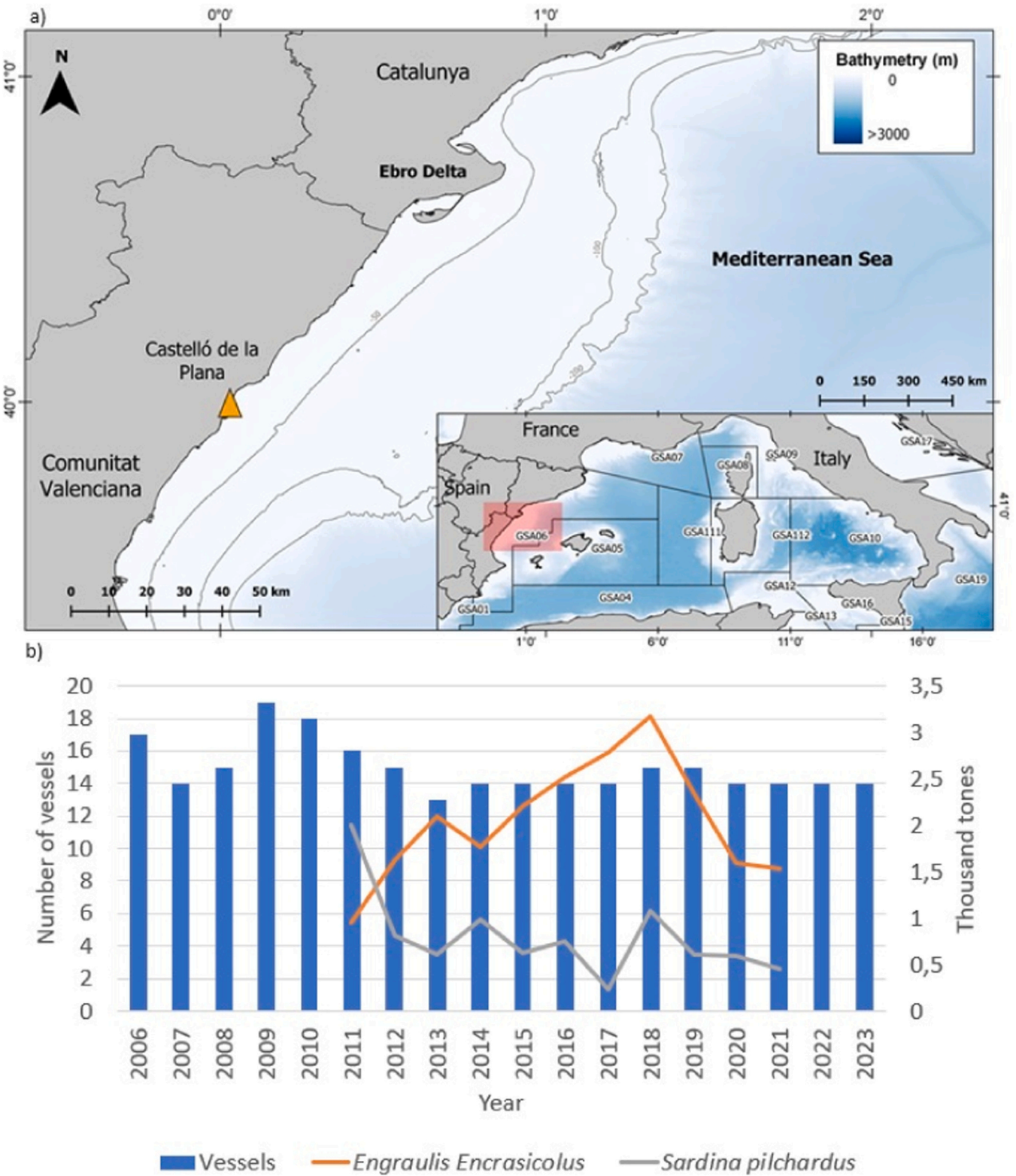


Fig. 1. a) Studied area and b) Vessels and catches of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) in the Castelló de la Plana Harbour. Source [47].

interpretability.

2.3. Q-methodology

In order to study discourses on future priorities to ensure purse seine fishing viability we used a Q-methodology. The methodology comprises

four stages:

1. Research design: a topic and relevant population are identified. A Q set of statements is created (concourse) by extracting statements from relevant studies, news items, policy documents, etc., or through a limited number of initial qualitative interviews.

Table 1
Participating fishers characteristics.

Role	Individuals (number)	Experience (years)	Fleet coverage (%)
Captain/Owner	11	30–40	100 %
Undercaptain	5	20–30	45 %
Fisher	8	≥40	45 %

2. Data collection: through face to face or online interviews, participants (the P set) rank the statements in a table (the grid) whose shape reproduces a normal distribution, so that it forces participants to reveal their preferences from 'mostly agree' to 'mostly disagree' along the lines of a normal distribution (Fig. 2). The ranking of statements is accompanied by brief qualitative interviews inquiring on specific aspects of the ranking (e.g. about the reasoning behind allocating certain statements at the extremes).
3. Statistical analysis: Principal Component Analysis is used to group participants views into factors based on similarities among Q sorts (the different participant rankings of statements).
4. Interpretation: This phase involves synthesizing the results considering both quantitative and qualitative data. The factors generated during the analysis describe social discourses uncovered with the study, which are then verbally interpreted.

The process of selecting statements for Q-methodology is a challenging task that involves subjective choices and can be influenced by the researcher's perspective [49]. To address this complexity, we followed a two-step approach as outlined by Zografos [34]. Initially, we created a comprehensive pool of statements related to the research topic, known as the *concourse*. This compilation was informed by multiple sources, including extensive field research, stakeholder engagement, scientific literature review compiled in PELWEB [50] and ECOTRANS projects [51] and interviews with relevant parties [52,53]. Furthermore, it incorporated insights from thirteen yearly discussions among local fishermen and scientists in the Spanish Mediterranean region [52–55], as well as an examination of the newly enacted Spanish Fisheries Law for Sustainability and Research [56]. These diverse sources provided valuable perspectives on the essential elements for ensuring the sustainability of purse seine fisheries, resulting in a concourse of 95 potential statements.

To reduce this extensive pool of statements (the *concourse*) into the final list of statements (Q sort) as required in Q-methodology, we conducted six preliminary pilot-tests involving various stakeholders with diverse backgrounds in small pelagic fisheries and the local ecology. Each participant engaged individually in the Q-sorting exercise and was interviewed afterward to ensure that, according to their perspectives, all key elements were addressed and that the texts used were easy to understand. Through those tests, we systematically reduced the number of statements to a final set of 36 (Table 3). This selection was sufficient to

Table 2

Eigenvalues (EV), % of variance explained and number of Q sorts loading significantly at $p < 0.01$.

	EV	Variance explained	Loadings Q sorts
Factor 1	3.92	18.67	7
Factor 2	3.22	15.34	8
Factor 3	3.02	14.39	4

encompass the diversity of viewpoints within the concourse, ranging from business as usual perspectives to different 'fisheries sustainability' discourses such as the sustainability development triple-axis-equilibrium perspective of fisheries regulation (equilibrium between the social, economic and environmental concerns), environmental justice, ecological modernization, conservationism, and sustainability perspectives with a procedural focus [57] (Supplementary material, Table 1). Importantly, this reduction aligns with recommended guidelines for structuring the Q set, suggesting that the concourse should ideally contain roughly three times as many statements as the final Q set [58]. Additionally, the preliminary tests helped ensure that the statements were easily understandable and unlikely to lead to confusing interpretations, enhancing the overall quality of the study.

Fishers were requested to rank the set of Q-statements on an eleven-point scale by arranging each statement on the grid according to how well it represented their views, ranging from -5 ("Mostly disagree") to $+5$ ("Mostly agree"). This ranking, known as the 'Q sort', is designed with a forced-normal pyramidal structure (Fig. 2) that encouraged participants to carefully prioritize their views and perceptions [26]. This approach effectively captured the participants' perspectives and viewpoints.

Also, participants were encouraged to express their opinions during the ranking exercise, and those were recorded. This qualitative data plays a vital role in gaining further clarity on participants' viewpoints and developing a narrative representing their perspectives which helps interpret the results.

Although Q-methodology does not need a large number of participants, it does require that participants differ in their opinions as much as possible in order to try obtain diverse views and identify a range of discourses on the topic [58]. Results of the interviews are shown in the Supplementary Material, Table 2, entitled "Q sorts".

The statistical analysis was carried out with R software using the 'Q method' package [59] to perform multivariate data-reduction techniques (such as principal components analysis [PCA]) and uncover meaningful patterns within participants' responses. The details on the criteria used to assess the similarity between the Q sorts and the factor extraction and rotation method can be found in Supplementary material "Q analysis".

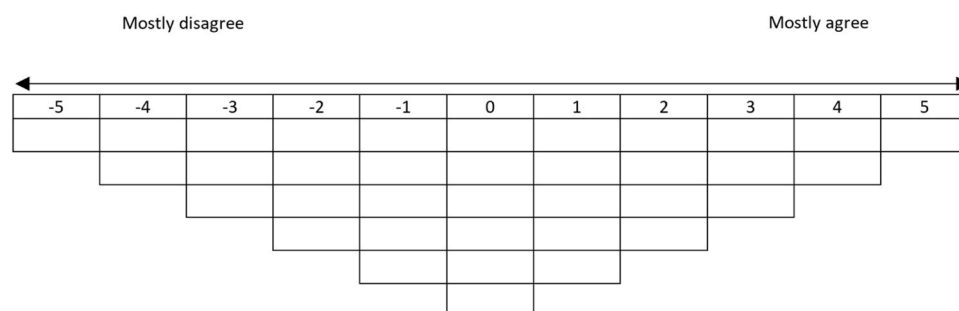


Fig. 2. The grid used to ranked the statements by participants perception. Higher positives values are assigned to the statements with higher level of agreement, while more negative values are assigned to the statements with disagreement.

Table 3

Factor arrays. The columns on the left display the statements along with their analytical perspectives: economic orientation (\$), social orientation (So), and ecological orientation (E). The columns on the right show the statement priorities (ranging from +5 to −5) for each factor: Factor 1, “No more subsidies, more fish”; Factor 2, “More public support for fishing”; and Factor 3, “It’s not in our hands.”.

N°	Statement	Analytical perspective	Factor 1	Factor 2	Factor 3
S1.	The profitability of fishing is sufficient to attract new investors.	\$	−1	0	+1
S2.	Fisher’s salaries have a monthly guaranteed minimum.	\$	+2	+1	−2
S3.	Fisher’s salaries are higher than they are now.	\$	+1	+3	+3
S4.	The modernization of vessels should be subsidized.	\$	−4	+4	−1
S5.	The construction of vessels should be subsidized.	\$	−4	−2	0
S6.	The increase in the number of buyers at the first-sale auction should be promoted.	\$	+1	0	+3
S7.	Commercialization should be improved through product processing.	\$	+1	−5	+1
S8.	Oil should be subsidized if its price rises above the current level.	\$	−5	+4	+2
S9.	VAT on fish sales should be set at a lower level than it currently is.	\$	−2	−2	0
S10.	The economic implications of fisheries should be given more consideration in policy decision-making.	\$	−1	−1	+1
S11.	Local fish consumption should be promoted.	\$	−2	+3	+1
S12.	Obtaining sustainable fishing certifications should be a priority.	\$	−3	0	−2
S13.	Fishing activity in the harbour should be maintained.	So	−3	+1	−1
S14.	More women should be encouraged to participate in fishing activity.	So	0	0	−2
S15.	Training for fleet members should be facilitated before activity begins.	So	0	0	+2
S16.	The incorporation of young people into the fishing industry should be facilitated.	So	+3	+2	+5
S17.	The functioning of fishers’ guild should be improved.	So	−2	−2	0
S18.	Representation of purse seine fishers in fishing organisations should be increased.	So	−1	0	+3
S19.	Fish consumption should be promoted.	So	+2	−1	+1
S20.	Fishing and marketing controls should be increased.	So	+3	−1	−5
S21.	Changes in laws should be made only if there is consensus among administrations, fishermen, NGOs, and scientists.	So	+2	−2	0
S22.	Changes in laws should be made by administrations according to their criteria	So	+1	+1	0

Table 3 (continued)

N°	Statement	Analytical perspective	Factor 1	Factor 2	Factor 3
S23.	after listening to all stakeholders involved in the fishery. Management decisions should be made quickly depending on how the fishery evolves.	So	+2	+2	+2
S24.	The administration should intervene less in fishing activity.	So	−2	−3	+2
S25.	Temporary fishing closures should be increased.	E	+4	+5	0
S26.	The maximum amount of plastic allowed in fish should be regulated.	E	0	−3	−1
S27.	Climate change should be taken into account when managing the fishery.	E	0	−3	−3
S28.	The presence of other predators such as tuna should be reduced.	E	+4	−1	+4
S29.	A higher minimum marketing size should be established than the current one.	E	+1	+2	−4
S30.	More no-catch zones should be protected for the conservation of sardines and anchovies.	E	+3	+2	−1
S31.	Fishing pressure on the biomass of sardine and anchovy should be reduced.	E	0	−1	−3
S32.	Trawling activity in the juvenile and spawning areas of sardines and anchovies should be reduced.	E	+5	+3	+4
S33.	Gases contributing to climate change in the catching process should be reduced.	E	−1	−4	−3
S34.	The ecological implications of fisheries decision-making should be given more consideration.	E	−1	+1	−4
S35.	Decrease the influence of environmental NGOs.	E	−3	−4	−1
S36.	A more holistic view of the marine ecosystem as a whole should be adopted in management decision-making.	E	0	+1	−2

3. Results

3.1. Historical trends

We collected 24 estimates of historical perceived abundance for both target anchovy and sardine species. Moreover, we collected 21 estimates for bluefin tuna (*Thunnus thynnus*), 9 for mackerel (*Scomber scombrus*), and 5 for swordfish (*Xiphias gladius*). The historical perceived abundance of the two main small pelagic purse seine targeted species, anchovy, and sardine, showed a decreasing trend, with a much abrupt tendency for sardine (Fig. 3). The breakpoint analysis identified structural changes in the time series of both species in the following years: 1998 and 2015 for anchovy (Fig. 3a), and 2003 and 2013 for sardine (Fig. 3b). In fisher’s words:

“Sardines remained more or less abundant until 2006. Since then, it has declined to 0 (Q interview 6)”

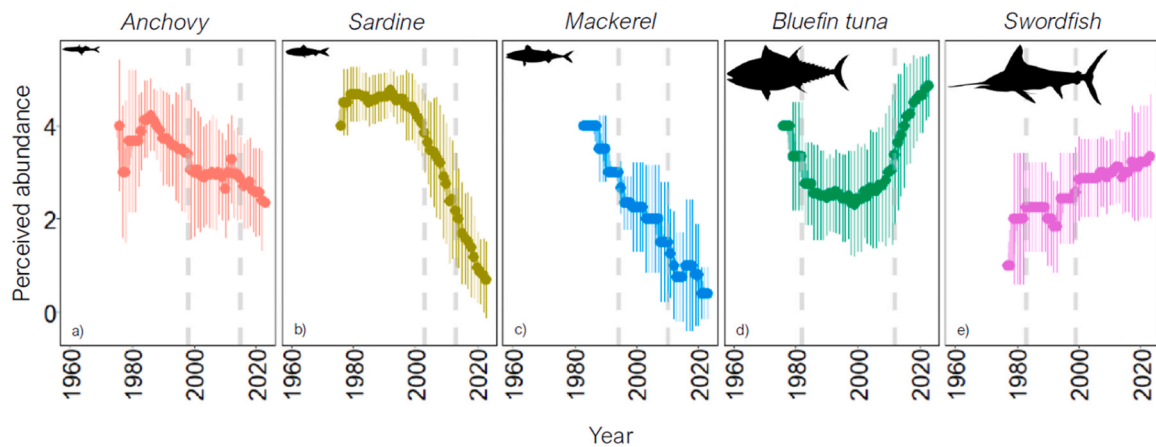


Fig. 3. Historical perceived abundance evolution of Castelló de la Plana purse seine related key species in the area obtained from fisher's perceptions. Breakpoint analysis identified structural changes for each species, indicated by grey dashed lines.

"Sardine has been dropping until it is down to nothing... and what we catch is mainly sardine and anchovy. The rest, such as mackerel, is not even 1 % of our catch, it is insignificant. Swordfish, for example, you can sell one per catch, but not tuna. We have always caught some swordfish, it has always been maintained, it has always entered the net..." (Q interview 2).

On the contrary, a U-shaped trend was observed for tuna (Fig. 3d) with two structural breaks; one in 1982 and another one in 2012. The recent increase is perceived as annoyance by fishers:

"(About tuna) Before there was little and now it is full to excess. Just the opposite of the sardine. At the beginning of the 2000s it was banned and then it started to increase until now. It doesn't let us fish and I think it eats what we are missing (Q interview 7)"

"And the tuna is the same, it wasn't caught before. There have always been, but now there are more, since 2011 or thereabouts it has gone up and there have started to be more or to interact more with us (Q interview 2)."

Mackerel (Fig. 3c) showed a decreasing trend with structural changes in 1994 and 2010, while swordfish (Fig. 3e) showed an increasing trend with structural changes in 1983 and 1999. Nevertheless, caution should be taken in the interpretation of results from these two species due to the limited number of interviews.

The standard deviations of perceived abundance showed lower values for sardines, indicating a more consistent interpretation of their population trends among the interviewees. In contrast, the standard deviations for anchovy and tuna were higher, suggesting greater variability in their perceived abundance, which partially uncover the changes in their average values.

3.2. Q-methodology results

Our initial analysis resulted into 7 factors (with an eigenvalue > 1), but based on the literature we finally retained 3 factors (Table 3), which explain around 48 % of our total variance, which is above the 30–40 % recommended [60], and also each factor has 4 or more Q sorts loading significantly at $p < 0.01$ level when exceeded a factor loading of ± 0.42 based on the equation below: $2.58 \times (1 \div \sqrt{n})$, where n = the number of statements in the Q sample, $2.5 \times (1 \div \sqrt{36}) = 0.416667$ [35,62]. Values are included in the Supplementary Material, Table 3, entitled "Varimax Rotated Factor Matrix with Factor Loadings".

These factors have their own hypothetical Q sort that represents each discourse, the factor array, that is shown in Table 3.

In elaborating factor interpretation and defining the study's discourses, we considered factor loadings, factor arrays, statements at the

extremes of the grid, i.e., +5, +4 or -4, -5, distinguishing and consensus statements, as well as qualitative data from interview transcripts.

To facilitate their interpretation, we named them "No more subsidies, more fish (Factor 1)", "More public support for fishing (Factor 2)", and "It's not in our hands (Factor 3)". Their factor arrays are shown in (Table 3).

In the following paragraphs, we briefly describe the key elements of each narrative, complementing those elements with quotes extracted from the interviews.

Factor 1: "No more subsidies, more fish"

The distinguishing statement of this discourse (S13, at -3) asserts that "Fishing activity in all harbors should be maintained,". This discourse points to a limited role for direct public administration support.

It is characterized by its disagreement that direct public support of fisheries, including fuel subsidies (S8¹, at -5), modernization (S4, at -4) or construction of new vessels (S5, at -4), should be a key element in the sector's future (Table 4).

"You have to be clever, everything that is subsidies is misleading. Subsidies are to help you with misfortune, a one-off help, but for the rest of your life? (Q interview 2)"

It emphasizes the importance of adopting management measures for the ecosystem as a crucial element to ensure the viability of purse seine.

"Fishing activity will be maintained as far as there is enough fish and we fish properly" (Q interview 2)

Table 4

Salient statements for Factor 1; distinguishing statements (at $p < 0.01$) with *.

N°	Statement	Factor score
32	Trawling activity in the juvenile and spawning areas of sardines and anchovies should be reduced.	+5
25	Temporary fishing closures should be increased.	+4
28	The presence of other predators such as tuna should be reduced	+4
16	Training for fleet members should be facilitated before activity begins.	+3
20	Fishing and marketing controls should be increased.	+3
30	More no-catch zones should be protected for the conservation of sardines and anchovies.	+3
12	Obtaining sustainable fishing certifications should be a priority.	-3
13*	Fishing activity in all harbours should be maintained.	-3
35	Decrease the influence of environmental NGOs.	-3
4	The modernization of vessels should be subsidized.	-4
5	The construction of vessels should be subsidized.	-4
8	Oil should be subsidized if its price rises above the current level.	-5

"The most important thing is to protect the resource, if there are no fish, there is no money (Q interview 24)"

In order to do so, it stresses the relevance of reducing bottom trawling in the juvenile and spawning areas of sardine and anchovy (S32, at +5) and the need to implement measures regarding predators of commercial target species, such as tuna, to reduce their presence (S28, at +4). It also supports the need to implement measures that produce changes in the fishing practices of purse seine, such as the increasing of temporary fishing closures (S25 scored at +4), that help the recovery of the ecosystem.

"(About sea bottom trawling) It's a tractor and it eats everything, the fauna, the flora, the soil at the end it's as if a tractor had passed over it and turned the bottom up to a fathom high... it eats the seabed, the algae... it's a disaster (Q interview 3)"

Factor 2: "More public support for fishing"

This discourse is characterized by the belief that the viability of the activity is directly linked to an increase of public intervention and a more limited environmental intervention by public administration (distinguish statement S26, at -3). This includes the extension of temporary closures provided public compensations are offered (S5, at +5), and greater use of direct subsidies such as those for modernization (S4, at +4) or fuel (S8, at +4) (Table 5).

"It is important that the modernisation of vessels is subsidised. If you don't have good tools, you fail... it's not like it used to be... the fish are further and further away, you need more engine and you need the boat to sail better (Q interview 20)."

Simultaneously, there is a strong sentiment that their role ends once they capture the fish, and they do not perceive any responsibility for enhancing the commercialization of their catch through processing (S7, at -5).

Regarding environmental attitudes, while there is a recognition of the role of environmental NGOs (S35, at -4). Concurrently, there is opposition to prioritizing other environmental elements such as climate change (S33, at -4) or specific pollution measures (S26, at -3) within management criteria.

"We take climate change into account, but of course, we work with diesel. Until they invent an electric boat, the issue of [greenhouse] gases will be there (Q interview 1)".

"Regarding greenhouse gases. Of course, anything that avoids pollution is important, but there are more important things when it comes to recovering the fishing grounds (Q interview 13)."

Table 5

Salient statements for Factor 2; distinguishing statements (at $p < 0.01$) with *.

Nº	Statement	Factor score
25	Temporary fishing closures should be increased.	+5
4	The modernization of vessels should be subsidized.	+4
8	Oil should be subsidized if its price rises above the current level.	+4
32	Trawling activity in the juvenile and spawning areas of sardines and anchovies should be reduced	+3
10	The economic implications of fisheries should be given more consideration in policy decision-making.	+3
3	Fisher's salaries are higher than they are now.	+3
27	Climate change should be taken into account when managing the fishery.	-3
26*	The maximum amount of plastic allowed in fish should be regulated.	-3
24	The administration should intervene less in fishing activity.	-3
35	Decrease the influence of environmental NGOs.	-4
33	Gases contributing to climate change in the catching process should be reduced.	-4
7*	Commercialization should be improved through product processing.	-5

Factor 3: "It's not in our hands"

The "It's not in our hands" discourse suggests that ensuring the viability of purse seine fishing does not require changes to current fishing practices (Table 6). Responsibility is primarily attributed to external actors: the administration, through facilitating the incorporation of young people (distinguish statement S16, at +5); trawler activities (which need to be reduced in juvenile and spawning areas) (S32, at +4); the presence of predators (which needs to be reduced) (S28, at +4); or the number of buyers at auctions (which needs to be increased) (distinguish statement S6, at +3).

"It would be essential to bring in young people, the sector is in a terrible state. Look at me and I'm one of the last ones left (Q interview 9)".

"It would be great to have more people at the auction, the bidding goes from bad to worse, the more people there are the better for us (Q interview 9)".

Regarding environmental attitudes, the discourse rejects increasing the control of fishing and marketing activities (S20, at -5), the notion of enhancing the significance of ecological considerations in decision-making processes (S34, at -4), and other potential measures such as raising the minimum size for marketing (S29, -4), reducing fishing pressure (S31, at -3), or introducing initiatives to address climate change in relation to their activities (S33, at -3).

"I think we are already too controlled, at least here we are very much in line with the law (...) I think the problem with the administration is that the advisors it has don't come to sea. They see things from a very different point of view. If they saw things the way we do, they would do things differently. They have to leave the sector and its people more freedom (Q interview 9)."

"Everything that is ecological or minimum size, we already have it more or less under control (...) As bad as fishing is, I think that our fishery is one of the ones that takes the best care of the sea (Q interview 10)"

All three discourses express with different intensities the need to "decrease trawling activity in the juvenile and spawning areas of sardines and anchovies" as a relevant priority (S32, scored at +5 in factor 1, at +3 in factor 2 and at +4 in factor 3).

"It would be essential to decrease trawling. I feel bad for our colleagues but it would be essential for us (...) we no longer fish in the near seabed, the trawlers are the ones causing the problem, if necessary, they should take drastic measures (Q interview 9)".

Table 6

Salient statements for Factor 3; distinguishing statements (at $p < 0.01$) with *.

Nº	Statement	Factor score
16*	The incorporation of young people into the fishing industry should be facilitated.	+5
28	The presence of other predators such as tuna should be reduced.	+4
32	Trawling activity in the juvenile and spawning areas of sardines and anchovies should be reduced.	+4
18	Representation of purse seine fishers in fishing organisations should be increased.	+3
6*	The increase in the number of buyers at the first-sale auction should be promoted.	+3
3	Fisher's salaries are higher than they are now.	+3
27	Climate change should be taken into account when managing the fishery.	-3
31	Fishing pressure on the biomass of sardine and anchovy should be reduced.	-3
33	Gases contributing to climate change in the catching process should be reduced.	-3
34	The ecological implications of fisheries decision-making should be given more consideration.	-4
29*	A higher minimum marketing size should be established than the current one.	-4
20	Fishing and marketing controls should be increased.	-5

Finally, it is worth noting that even if there are three different narratives in the same fishing community, emerging data also showed two statements that achieved a consensus. Both of those statements point out the need to improve the decision-making process: S23 “Management decisions should be made quickly depending on how the fishery evolves” (scored at +2) and S22 “Changes in laws should be made by administrations according to their criteria after listening to all stakeholders involved in the fishery” (scored at +1 and 0).

“Maybe the solution that works for you today will not work in 2 months because the situation has changed (Q interview 9).”

“You submit papers, they put them in the drawer, and years and years go by and they don’t look at them. If everything can be speeded up, all the better (Q interview 20).”

4. Discussion

4.1. Contributions to assess biomass historical trends

Previous studies have highlighted that local fisheries knowledge in the area can offer valuable insights into the historical biomass evolution of demersal species, as well as information on the presence and abundance of vulnerable marine ecosystems [8,10]. Our case study contributes information regarding the small pelagic components within the ecosystem.

Comparing historical perceptions of biomass with stock biomass assessment data (Fig. 4), the evolution of sardine biomass perception for the period 2004–2020 exhibits a decreasing trend, aligning with the trend reported by the official General Fisheries Commission for the Mediterranean (GFCM) stock biomass assessment at the Mediterranean Sea geographical sub areas (GSA6) level [61]. Therefore, there is a notable coherence between the official GSA6 data and fishers’ perceptions within the available data period, with less variability observed in the fishers’ perceptions (Fig. 4). This suggests that the historical perception may be considered indicative of long-term average trends. The high level of agreement between official data and perceptions of

fishers, coupled with the consistently low standard deviation in the perception of biomass evolution among fishers in the case of sardines, lends credibility to the perceived evaluations for the earlier period of 1980–2000, for which no official data are available. Our data suggest a stabilization of the biomass stock during that period. The availability of longer time series of biomass for other species, provided by local ecological knowledge (LEK), has proven to be useful in fisheries where no official data are available. For example, it has been used to support the establishment of more accurate reference values avoiding the shifting baseline syndrome [62].

The evolution of anchovy biomass is more complex. On one hand, the higher standard deviation throughout the period indicates a less coherent historical narrative in the information provided by fishers. However, the observations suggest a possibility of long-term biomass stability or a steady decrease. On the other hand, historical stock assessment trends covering the entire period indicate a gradual decline in the early part of the evaluated period (1980–2006), followed by a noticeable increase, which is not reflected in the information from fishers. Interestingly, the volume of anchovy landings in Castelló de la Plana rose almost a 100 % in the period 2012–2018 in comparison with the average values of the previous decade, but fell again in the latter years, failing to align with the GSA6 stock assessment trend, which shows that biomass remains high [63]. A possible explanation for the discrepancy between perceptions and stock assessment values may lie in the high fluctuations and latitudinal differences observed in small pelagic species in the area [64]. GSA6 spans a vast area that encompasses distinctly different subregions, including the North Catalan Sea, the Gulf of Valencia (where Castelló harbour is located), and the Murcia Region, all of which are assessed together. It has been demonstrated that environmental variabilities can directly impact the annual recruitment, growth, and condition of small pelagic species such as anchovy [37,64, 65], making sub-GSA biomass differences in extended GSA areas unsurprising.

In both cases, when we compared fishers’ perception of biomass evolution with landings in GSA6 (Fig. 4), we observed a higher correlation with the information provided by landings than when we compare it against the assessed biomass. This suggests that fishers’ perception

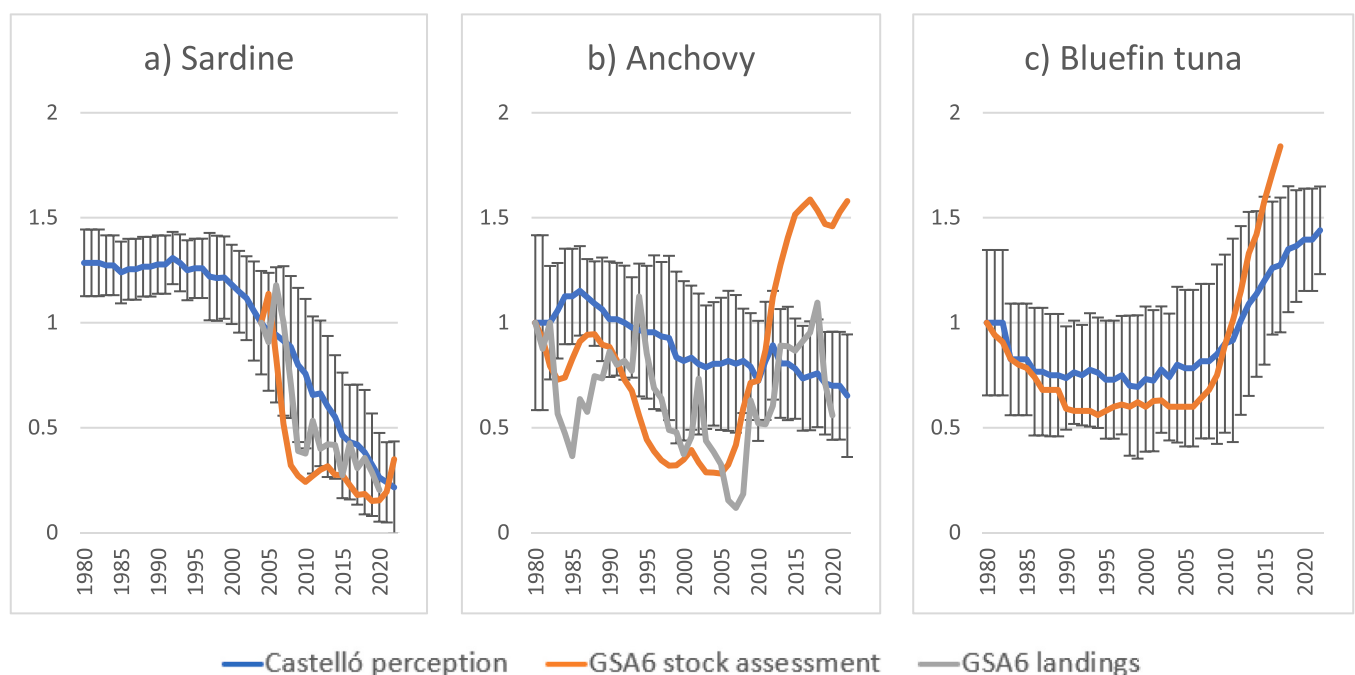


Fig. 4. Comparison between biomass evolution perception in Castelló harbour and the GSA6 stock biomass assessments and landings - a) sardine, b) anchovy - and Mediterranean stock assessment in the tuna case (c). In order to facilitate the comparison between GFCM stock biomass assessment with fisher’s perception, data values have been normalized to one where the first data of the stock assessment is available. Sources [63].

may be even better for predicting catches than biomass, and their perception of the latter is influenced by their own captures.

Finally, although there is no specific assessment for Bluefin tuna in the GSA6 area, the perceived historical biomass evolution aligns with the information provided by the International Commission for the Conservation of Atlantic Tunas (ICCAT) assessment at the Mediterranean Sea level (Fig. 4) and existing GSA 6 food-web models [65]. This highlights a clear increase in Bluefin tuna biomass following the implementation of the tuna recovery plan in 2006, to the extent that it is currently managed through a management plan [66].

Our study contributes to the ongoing discussion about the best ways to gather and analyze historical trends to describe changes in fisheries and ecosystems to support fisheries management. It enriches other studies that highlight complementary strategies, such as the potential to use biomass trends instead of biomass levels to gather information [67], or the potential to request maximum capture levels instead of average capture volumes [68].

4.2. Contributions to the future of purse seine activities

Our consensus statement 23 shows that the purse seining fleet agrees on the need to establish effective and prompt mechanisms that would allow adaptive management. On July 13, 2023, in response to the socio-ecological crisis that has unfolded in the Spanish purse seine fishery in recent years, the Spanish government approved a Mediterranean purse seine management plan [69]. Article 14, "Duration and Follow-up of the Plan," paves the way for a continuous evaluation of the newly established management measures using scientific information. It also aims to establish a participation channel through "periodic meetings" with stakeholders, with the ultimate goal of informing and, if necessary, adapting the management measures. Consensus statement 22 indicates that there is an agreement on the need to integrate fishers in the participation process. Nevertheless, its relative low ranking (+1, 0) among the other statements, and the recorded interviews, points out to a distrust on the public administration capacity to integrate all stakeholders' perceptions in their decision-making process.

Our analysis identifies another element that is shared among all narratives: the necessity to reduce trawling activity in the juvenile and spawning areas of sardines and anchovies (S32). This requirement stems from the perception that the capture of these fish through trawling activities harms the "ecological capacity" of the system and triggers a distributional conflict based on a perceived unfair allocation of damages and benefits, a recurring theme in many environmental conflicts [70, 71]. In the Castelló fishing area, bottom trawling activity occurs in a zone particularly crucial for small pelagic fish, serving as a key nursery area [72–75]. The discard rate can reach up to 30 %, with three of the four main discarded species being the primary targets of purse seiners [76]. Trawling activity is permitted by a region-specific regulation allowing trawling in this area up to three miles from the coast, regardless of depth, which in practice enables trawling at depths as shallow as 20 m in some cases due to the extended deltaic area where fishing activities take place [77]. Consequently, this translates into an impact of bottom trawling activities on the small pelagic system of the area, a fact reported in various forums [78,79], and evaluated as a significant factor in previous research [80]. Our data suggest that the purse seine community would unanimously support a change in the current legislation. The conflict over fishing practices, as addressed by the purse seine fisheries community, also highlights the ongoing, yet limited, efforts to more fully incorporate the interactions between fishing fleets into ecological assessments when developing management plans [81], and the need to continue developing tools and practices that allows an integrated ecosystem approach to fisheries [82–86]. In addition, our analysis also reveals clear divergent narratives regarding the role of public funds, the role of public administration, and potential fisheries management measures in the future of the activity. Recognizing the heterogeneity of perspectives, even within a limited fishery community such as the one

analysed here, is a key element that reinforces the need to implement proper democratic representation systems within fisheries association governance structures. This is particularly crucial in fisheries guilds, which organize local fishers collectively in the Spanish Mediterranean Sea, coordinating fishing activities and making collective decisions [87, 88].

The divergent narratives regarding the relative importance of bluefin tuna recovery for the future of purse seine underscore the need for improved scientific communication and further research into specific problematic aspects. Previous studies suggest that the impact of tuna depredation, compared with other stressors, is limited [80,89]. However, it is vital to acknowledge that these models fail to consider the economic losses associated with the "dispersion" of small pelagics when a tuna approaches a shoal, which are more related to fishing practices than to competitive predation [90]. This identifies a clear need for further research. Additionally, current national legislation prohibits any tuna capture by vessels without a recognized historical quota, which applies to most purse seine operations in the area [91]. Our interactions with fishers and observations onboard indicates that this strict prohibition generates tensions within the purse seine fleet due to involuntary bycatch of large individuals and may become a topic for future discussions in the context of national regulation and the Spanish quota distribution criteria. These discussions occur in conjunction with the bluefin international tuna management plan.

Finally, it is important to point out that while our study is focused on the most significant purse seine harbour on the Spanish Mediterranean coast, and there is a single regulation for purse seine fisheries across the entire Mediterranean coast, with only limited adaptation of some measures at the GSA level [69], the environmental and social variability might mean that the information provided by fishers from other harbours could differ in certain aspects. To address this limitation, a future comparative analysis with other harbours could be interesting. Additionally, it is worth noting that the Q methodology employed in this study effectively identifies all existing discourses within a population group but does not determine which discourse is more predominant. To address this limitation, future studies can utilize in-depth interviews and anthropological research to evaluate discourse predominance more thoroughly.

5. Conclusions

This research demonstrates how local knowledge in fisheries can be systematically collected to shed light on both historical trends and potential future directions. The findings illustrate that incorporating fisher's experiential insights can enhance historical assessments by filling temporal gaps where scientific data may be lacking, and provide region-specific information in cases where scientific data are highly aggregated.

Furthermore, the study emphasizes the value of using mixed quantitative-qualitative methods like Q-methodology, to explore the diversity of perspectives within fishing communities. These perspectives influence the development of potential policy and management scenarios. A notable outcome is the emergence of consensus on the implementation of adaptive management measures that consider all stakeholders involved in the fishery, underscoring the importance of strengthening these mechanisms in fisheries management. This consensus reveals a political opportunity to further develop existing consultation and participation processes.

Similarly, the study highlights the need for an in-depth, integrated assessment of fisheries management, especially regarding the interactions between fishing fleets and the multiple connections, including operational interactions, between fishing predators and practices.

The research also uncovers that, even within a relatively small fishing community, there exist distinct narratives regarding the future of the sector. These narratives offer contrasting views on the role of public administration, the utilization of public subsidies, and the necessity and

characteristics of potential management measures, highlighting the importance of having effective democratic representation within fisheries associations to navigate these differences. Additionally, it underscores the need for implementing conflict management strategies to facilitate the transition in fisheries.

Traditionally, fisheries management has focused on the development of technological, economic, and managerial interventions. Our findings suggest that a systematic inclusion of local knowledge and perceptions, regarding both past and future developments, can significantly enrich the analysis and practices surrounding fisheries transition. Additionally, the research presents methods by which this local knowledge integration can be achieved.

Author statement

We confirm that this work is original and has not been published, nor is it under consideration for publication elsewhere, and that we disclose no conflicts of interest.

CRediT authorship contribution statement

Yesmina Mascarell-Rocher: Investigation, Data curation. **Christos Zografos:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation. **Valerio Sbragaglia:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Marta Coll:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis. **Miquel Ortega:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sara Mohamed Santamaria:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.marpol.2024.106490](https://doi.org/10.1016/j.marpol.2024.106490).

Data availability

Data will be made available on request.

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