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EDITED BY
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REVIEWED BY
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South African Institute for Aquatic Biodiversity, South Africa

*CORRESPONDENCE
Enrico Nicola Armelloni
enrico.e.armelloni@gmail.com

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What do people make of "Ecosystem Based Fisheries Management"?

Marie Briguglio[1], Paulina Ramírez-Monsalve[2], Glenn Abela[1] and Enrico Nicola Armelloni[3]*

[1]Department of Economics, Faculty of Economics, Management & Accountancy (FEMA), University of Malta, Msida, Malta, [2]NIVA Denmark Water Research, Copenhagen, Denmark, [3]Institute for Biological Resources and Marine Biotechnology (IRBIM), National Research Council of Italy (CNR), Ancona, Italy

The topic of Ecosystem Based Fisheries Management (EBFM) and related terminology has attracted considerable scholarly debate and inspired regulatory interventions across Europe. Yet little attention has been paid to the general public's awareness or understanding of this term and its implications for marine policy. We employ a unique and representative data set (n=542) from the United Kingdom (UK) and examine (i) the extent to which the public is aware of the concept of Ecosystem Based Fisheries Management, (ii) the demographic correlates of such awareness and understanding, and (iii) whether the public's understanding converges with scientific notions and regulatory definitions. Our headline finding is that the vast majority of adults in the UK have never heard of EBFM. Participants who attempt to explain what they understood by EBFM associate it primarily with protecting the marine environment and safeguarding fish stocks. While this broadly conforms to scientific and regulatory notions, very few respondents mention socio-economic aspects, regulatory considerations, reliance on science/data or climatic issues. Examination of the correlates of awareness reveals that people who work in marine sectors, who fish more regularly, who have higher awareness of sustainability issues, and who are financially better off are more likely to have heard of EBFM. Among those who attempted a definition, older people were more likely to mention maintaining fish stocks, and people with higher marine education or whose family members worked in the marine sector, were more likely to mention regulatory aspects. Data and climate themes were less likely to be mentioned by those who had never heard of EBFM. Public support can be pivotal for successful implementation of fisheries management, but our findings suggest that there remains a significant gap to be addressed between scientific/regulatory notions and the public's understanding of EBFM. In this regard, we offer some insights for communication of EBFM among the UK public.

KEYWORDS

ecosystem based fisheries management (EBFM), marine education, communication, science-policy interface, public perception

1 Introduction

The topic of Ecosystem Based Fisheries Management (EBFM) and surrounding terminology is one that has attracted considerable scholarly debate in recent years (Prellezo and Curtin, 2015; Ramírez-Monsalve et al., 2016b). This follows a drive towards holistic fisheries approaches that account for the interconnection between ecological dynamics and the biomass of target stocks, habitat dependencies and environmental drivers (Larkin, 1996; Hilborn, 2011; Link and Marshak, 2021). Following some two decades of sometimes ambiguous conceptualization (Lidström and Johnson, 2020), the scientific community seems to have settled on the notion of EBFM as a management strategy applied to fisheries that considers both the physical and biological complexities of the marine environment, as well as the economic and social dimension of the fishing industry and of the communities involved (Link and Marshak, 2021). Table 1 outlines what we consider to be the core themes of EBFM, largely inspired by Link and Marshak (2021) and (inexhaustive yet representative) references provided therein. In short, EBFM envisages fishery planning at the ecosystem level, where humans are part of the ecosystem and where trade-offs between competing objectives can be explored with transdisciplinarity, with due recognition of uncertainty and an explicit consideration of risk (*e.g.*: Hilborn, 2011; Link and Browman, 2014; Link, 2017; Link and Marshak, 2021). EBFM recognizes that science, data and models are needed to deal with ecosystem complexity (Craig and Link, 2023), implying that the best scientific evidence should be used to manage fisheries (Hilborn, 2004). The reflection of (Link, 2010) is of great relevance: much EBFM effort, as least in its early days, can be seen as a *policy-forming advice* (Smith and Link, 2005) oriented to improve actual management instruments or to develop new and more adequate to follow the progress observed in science.

TABLE 1 A list of the elements considered forming the core of EBFM, along with some key scientific concepts and a list of relevant references. The selection of topics is inspired by Link and Marshak (2021).

Core EBFM Theme	Scientific Concepts	Some relevant references
Ecosystem Integrity	• Maintain resiliency of the ecosystem • Minimize risk of ancillary ecosystem impact, including bycatch • Account for cumulative effects of the direct (habitat degradation) and indirect (trophic cascades) pressures	Pikitch et al., 2004; Link, 2010, 2018; Karnauskas et al., 2021; Link and Marshak, 2021
Multispecies sustainability	• Minimize the risk of overfishing • Maximize aggregate biomass of resources • Account for the interactions of species caught in mixed fisheries • Optimize catch and yield across stocks	Hilborn, 2011; Link and Browman, 2014; Hilborn et al., 2015; Link, 2018; Townsend et al., 2024
Science-based policies	• Employ science to support policy developments • Use data are essential to decide strategies and to monitor progress • Evaluate the effect of interventions *a priori* based on models and computer simulation	Hilborn, 2004; Smith and Link, 2005; Link, 2010; Holsman et al., 2016; Freitag et al., 2018; Fulton et al., 2019; Marshall et al., 2019; Dorn and Zador, 2020; Hollowed et al., 2020; Punt et al., 2021; Craig and Link, 2023; Olsen et al., 2023; ICES, 2024a
Risk and uncertainty	• Use risk analysis to assess cost-benefits of interventions • Account for different types of uncertainty in the formulation of scientific advice	Hilborn, 2011; Little et al., 2016; Privitera-Johnson and Punt, 2020; ICES, 2024a
Climate change and environmental variability	• Account for present and probable future environmental conditions, their impact on marine population biological processes, and their effects on productivity • Produce climate-informed management advice	Punt et al., 2014, 2021; Holsman et al., 2016; Bentley et al., 2021; Ruiz-Díaz, 2023; Trenkel et al., 2023
Regulation design	• Plan fisheries at the ecosystem level • Address jurisdictional complexities that emerge from the transboundary nature of the oceans • Reduce bureaucratic oversight and facilitate international cooperation for data collection, research and implementation of a common set of rules	Fletcher et al., 2010; Link and Browman, 2014; Link, 2017; Marshall et al., 2018; Pomeroy et al., 2019; Koehn et al., 2020; Koubrak and VanderZwaag, 2020
Socio-economic continuum	• Go beyond catch share by accounting for market structure and value chain • Account for complexity of the human dimension of fisheries when defining management strategies by having multiple objectives and evaluating trade-offs • Recognize existence value of nature	Christensen et al., 2014; Link and Browman, 2014; Collie et al., 2016; Marshall et al., 2018; Hornborg et al., 2019; Kroetz et al., 2019; Chakravorty et al., 2024

The evolution of EBFM can be linked to a series of global institutional agreements, conventions, and collective decisions (Ramírez-Monsalve et al., 2016b), with two elements providing the foundational framework, namely the United Nations Convention on the Law of the Sea in 1982, and the UN Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries in 1995 (Garcia, 2003). In addition, since the parties to the Convention on Biological Diversity (CBD) committing to this approach in 2000, EBFM has been incorporated into several ocean instruments (Sands and Peel, 2012). In turn, international organizations play significant roles in the development and promotion of EBFM, such as the FAO and the Regional Fisheries Management Organisations (RFMOs). The FAO's role is evidenced through the development of guidelines and frameworks, promoting key international agreements that support EBFM, providing fisheries information, policy advice and technical assistance, and a platform for discussing global fisheries issues through its Committee on Fisheries (Rodriguez-Perez et al., 2023). RFMOs, although still far from fully addressing challenges (Fischer, 2022), play a crucial role in implementing EBFM at a regional level, among other ways by translating international agreements into practical management actions and addressing specific biodiversity and ecosystem objectives in their respective regions (ICES, 2024a).

In the European Union (EU), the concept of EBFM received explicit mention in the 2013 reform of the Common Fisheries Policy (CFP), which declared that *"The CFP shall implement the ecosystem-based approach to fisheries management, so as to ensure that negative impacts of fishing activities on the marine ecosystem are minimized […]"* (Regulation (EU) 1380/2013, art. 2 (3)). In turn, this ecosystem-based approach to fisheries management entails an "*integrated approach to managing fisheries within ecologically meaningful boundaries which seeks to manage the use of natural resources, taking account of fishing and other human activities, while preserving both the biological wealth and the biological processes necessary to safeguard the composition, structure and functioning of the habitats of the ecosystem affected, by taking into account the knowledge and uncertainties regarding biotic, abiotic and human components of ecosystems*" (Regulation (EU) 1380/2013, art. 4 (9)). This definition largely overlaps with the scientific definition used at the time. While some aspects of EBFM have been successfully implemented (Ramírez-Monsalve et al., 2016a; Trenkel et al., 2023), with increased options to make EBFM a practical solution (ICES, 2024a, 2024b), and some notable recent advances (Roux and Pedreschi, 2024), efforts made to implement EBFM in Europe remained for a long time mostly confined to scientific publications (Rodriguez-Perez et al., 2023).

It is well known that stakeholders have a central role to play in implementing science-based policies (Link and Browman, 2014; Safiq et al., 2021; Dickey-Collas et al., 2022), but their limited engagement could be an important factor that jeopardizes the uptake of EBFM (Marshak et al., 2017; Ramírez-Monsalve et al., 2021). Clarity and agreement enables a functional relationship between different groups of people such as scientists and stakeholders (Mackinson et al., 2011). Studies which have recently explored the awareness and understanding of EBFM and Integrated Ecosystem Assessment among stakeholders and professionals in marine science (Trochta et al., 2018; Jones and Seara, 2020; Safiq et al., 2021; Polejack et al., 2023), reveal a general lack of consensus on definitions and main objectives. Even if the majority of interviewees agree on the importance of common themes like ecosystem connections (beyond single species focus), maintenance of biodiversity and reliance on data and stakeholder engagement, there is a tendency to focus on some limited aspects of EBFM. For instance, while some perspectives consider human activity to be the focus of management, others may be more inclined to value managing ecosystems in order to glean societal benefit (as also reported by Hilborn, 2011). It also remains a struggle for some stakeholders to see the interconnection among all the elements that constitute EBFM (Trochta et al., 2018; Jones and Seara, 2020).

Consensus among professionals is crucial for the success of science-based management (Long et al., 2015; Jones and Seara, 2020), but advancing the implementation of marine policy generally and EBFM specifically also requires the public at large to be on board with broad objectives (Walker-Springett et al., 2016; Fulton, 2021; Kemp et al., 2023a). Public engagement is important for fishery management and marine conservation for a number of reasons. First, the everyday behavior of the general public is pivotal for achieving management goals (McKinley and Fletcher, 2010; McKinley et al., 2023). Second, marine citizenship matters in fisheries management and especially in EBFM for reasons linked to social license, that is, the approval by the public of activities and interventions that have environmental consequences (Fleming et al., 2020). This is especially true in cases where regulations have a tangible economic impact because of taxes or market price modifications (Drews and van den Bergh, 2016), as does the implementation of EBFM in commercial fishing management. In such circumstances, citizens are effectively called upon to approve the potential increase of price due to increased sustainability or reduced availability of local fish (Kemp et al., 2023b). Third, public cooperation is required to assist governments to prioritize intervention (Gelcich et al., 2014), generating bottom-up influence on politics and market dynamics. Finally, the public has the potential to contribute to knowledge generation (Martin et al., 2016): in some cases citizen science data can help to provide the data needed to compile the broad range of indicators to monitor on the status of EBFM (Freitag et al., 2018).

At the time of writing this paper (July 2024 to March 2025), our search on the Scopus database for published studies that explicitly explored awareness and acceptance of EBFM among the public yielded exactly zero results. Nevertheless, research on public perceptions of the ocean is a related topic that received substantial attention in the last decade (Jefferson et al., 2021). Within this remit, a handful of studies have sought to understand public awareness of concepts that fall within the scope of EBFM, such as anthropic impacts on ocean and biodiversity (Gelcich et al., 2014; Jefferson et al., 2014), holistic fishery management (Ressurreição et al., 2012; Harrison et al., 2021) and conservation efforts (Easman et al., 2018). Many of these studies employed questionnaires wherein people's opinions were elicited on Likert-type scales (ordinal categories from 1 (low) to 5 (high)) as opposed

to open-ended responses. This literature suggests that the general public has some understanding of the threats to the marine environment, but they generally have poor knowledge of how conservation and management instruments work (Easman et al., 2018), including fisheries management tools (Harrison et al., 2021).

For example, in the Azores, citizens were found to be poorly aware of the existence of a large Marine Protected Area in the Archipelago, of ecolabels pertaining to fish stocks from the Azores, or of the fisheries threats to marine environment (Ressurreição et al., 2012). Self-assessed awareness regarding both anthropic impacts on marine ecosystems (Ressurreição et al., 2012; Gelcich et al., 2014) and various fishery management tools (Harrison et al., 2021), has itself typically been found to be in the low-to-moderate range. In the United States (US), however, Harrison et al., 2021 find respondents to have a good comprehension of the economic importance of the fisheries, that they understand the dangers of overfishing and that they largely agree on the need to manage fisheries at the ecosystem level rather than single species management. US citizens reported high concern for conservation aspects (fish populations, water quality) and low concern for revenues – which, by contrast, constituted a high priority for stakeholders and scientists when defining management strategies (Harrison et al., 2021).

A few studies have specifically surveyed the views of United Kingdom (UK) citizens on marine conservation and policy (Jefferson et al., 2014; Lindland and Volmert, 2017; Easman et al., 2018) and ocean literacy (DEFRA, 2022). This literature suggests some level of comprehension of the complexity of marine systems (for instance, citizens assigned high importance to the food chain) and a basic knowledge of major pressures and threats such as pollution, overfishing, climate change, habitat destruction and marine noise. It is also evident that public perception can be anchored to cultural models which, in turn, can catalyze attention towards particular issues (Lindland and Volmert, 2017). Despite marine fisheries garnering substantial political and public interest (Kemp et al., 2023b), the UK public's level of concern on overfishing, climate change and marine noise remains low compared to that of scientists (Jefferson et al., 2014; Easman et al., 2018), and as in other contexts, the UK public sees pollution (*e.g.* oil spills, plastic) as a bigger threat to marine environment than fisheries (Easman et al., 2018; DEFRA, 2022).

In synthesis, the topic of EBFM and surrounding terminology has evolved over the last decades, and it is slowly making its way to the design of regulatory instruments and management. However, public awareness and engagement, an important aspect for fishery management and marine conservation, has lagged behind in scientific research. We use a nationally representative sample of 542 adults from the UK to answer three research questions related to awareness and understanding of EBFM among the general public. Specifically, we seek to understand (R1) to what extent is the UK public aware of the term "Ecosystem Based Fisheries Management; (R2) what are the socio-demographic correlates of awareness and understanding; and (R3) whether public understanding of the meaning of the term is in line with scientific conceptualizations and policy requirements. In what follows, Section 2 outlines the context, and the materials and methods in use, section 3 reviews the data and provides both a quantitative analysis of the responses received as well as a more nuanced qualitative analysis of the statements. Section 4 concludes the paper with a discussion and recommendations for future research and policy.

2 Materials and methods

2.1 Context

The UK, with a population of approximately 67 million people (Office for National Statistics, 2022) offers an interesting case study due to the significant public focus on fisheries and the evolved regulatory framework which is based on principles of EBFM (e.g. Fisheries Act 2020; UK, 2020). Despite their relatively minor role in the UK economy (0.03% of GDP), and the fact that the UK largely exports what it catches and imports fish/fisheries products for consumption (Harrison et al., 2023), marine fisheries have attracted significant public attention and are still considered a politically sensitive issue in the UK (Kemp et al., 2023b, 2023a). Fisheries were a highly controversial issue already during the European Economic Community negotiations in 1973 (Kemp et al., 2023b), due to the issue of fishing rights, and they resurfaced as a key topic of negotiation in the Trade and Cooperation Agreement (TCA) post-Brexit (EU, 2021). The governance of fisheries in the UK has since undergone transformation, establishing administrative and legislative frameworks (Churchill, 2022). Nevertheless, the substance remains very much influenced by the CFP and its evolution is likely to remain under EU influence (Stewart et al., 2022; Kemp et al., 2023b). The autonomy gained at the beginning of 2021 is still subject to considerable constraints under the TCA (Churchill, 2022). While this does not specifically mention an ecosystem approach or EBFM, it does recommend following the best scientific advice for conservation and management decision that promote environmental, social and economic sustainability, to base decisions on data and precautionary approach, to reduce bycatch, to minimize the impact of fisheries on the ecosystem and to maintain biodiversity (TCA, p. 643).

The United Kingdom (UK) is also a contracting party to five RFMOs (ICCAT - International Commission for the Conservation of Atlantic Tunas; NEAFC - North-East Atlantic Fisheries Commission; NASCO - North Atlantic Salmon Conservation Organization; NAFO - Northwest Atlantic Fisheries Organization; SPRFMO - South Pacific Regional Fisheries Management Organization). Being a member of these organizations enables the UK to engage in the conservation and management of fisheries resources in different regions of the Atlantic Ocean and the South Pacific (DEFRA, 2025). But while international frameworks and organizations offer guidance and support for EBFM, its actual implementation happens at national and regional levels with countries adapting the approach to their specific contexts and needs.

Of particular relevance to this study is the explicit mention of the "Ecosystem approach" in UK legislation. The 2018 White Paper on Sustainable Fisheries for Future Generations (DEFRA, 2018) makes explicit reference to the "ecosystem approach", by mentioning optimizing yield across the ecosystem, implementing a precautionary approach supported by data, adapting to climate change, reforming the management system if needed to support a diverse fishing fleet using modern technology, and minimizing the impacts on the habitat, vulnerable marine ecosystems and bycatch species. The 2020 UK Fisheries Act (UK, 2020) is of particular relevance as it refers to Joint Fisheries Statements and Fisheries Management Plans, with the former outlining the strategies to be adopted to meet objectives, and the latter revoking the CFP's multiannual plans (Churchill, 2022; Lennan et al., 2022). It is organized around eight objectives, presented in Table 2, with links between the Act and EBFM themes summarized in Figure 1. All the objectives share some common ground with one or more EBFM themes. The ecosystem-based approach is mainly captured by the ecosystem objective, which, in turn, states that the collective pressure of human activities should be compatible with the achievement of Good Environmental Status (as defined in UK, 2010) and that the ability of ecosystems to respond to human induced changes should not be compromised.

2.2 Survey

Our study is based on data collected from a nationally representative sample of adults in the UK, aged 18 and over. A total of 542 online responses were collected in September 2022 from an online panel of respondents who answered a multi-module questionnaire. The sample size was well above the threshold of 384 responses required for a margin of error of 5%. Table 3 compares the sample characteristics to those of the UK population. In the process of data collection, quota-dashboards were monitored for age, gender, region of residence and education. However, given that the self-completion method was used to gather the data, the educational profile is, as expected, slightly upward skewed.

In order to assess participants' awareness and understanding of the term "Ecosystem Based Fisheries Management" (EBFM), they were first asked if they had ever heard of the term. The answer options were "Yes and I know what it means", "Yes, but I don't know what it means", "No" and "Don't Know". From this question, we derived the binary variable *ENever*, taking a value of 1 if the respondent had never heard of EBFM, and 0 otherwise. We use this as our dependent variable in the regression analysis that follows. We also derived a binary variable labelled *EKnowmeans*, which takes a value of 1 if the response is "Yes and I know what it means". Respondents were subsequently asked to describe EBFM in their own words, regardless of their answer to the first question. This in turn yielded the variable *ETried*, indicating that the respondent attempted to describe EBFM. Each response was subsequently examined for content. Any answers with unclear or incoherent contents were coded as such, as indicated by the binary variable *EGarbled*.

We then followed a process of open coding inspired by Grounded Theory (Charmaz, 2001), classifying answers into a set of seven themes that emerge from the data, namely fish stocks, environmental conservation, use of science/data, socio-economic

TABLE 2 Extract from the UK Fisheries Act (UK, 2020) detailing fisheries' objectives.

Objective	Definition
Sustainability	a) fish and aquaculture activities are: i. environmentally sustainable in the long term, and ii. managed to achieve economic, social and employment benefits and contribute to the availability of food supplies, and b) The fishing capacity of fleets is such that fleets are economically viable but do not overexploit marine stocks.
Precautionary	a) the precautionary approach to fisheries management is applied b) exploitation of marine stocks restores and maintains populations of harvested species above biomass levels capable of producing maximum sustainable yield
Ecosystem	a) Fish and aquaculture activities are managed using an ecosystem-based approach so as to ensure that their negative impacts on marine ecosystems are minimized and, where possible, reversed b) incidental catches of sensitive species are minimized and, where possible, eliminated.
Scientific evidence	a) scientific data relevant to the management of fish and aquaculture activities is collected b) where appropriate, the fisheries policy authorities work together on the collection of, and share, such scientific data c) the management of fish and aquaculture activities is based on the best available scientific advice.
Bycatch	a) the catching of fish that are below minimum conservation reference size, and other bycatch, is avoided or reduced b) catches are recorded and accounted for, and c) bycatch that is fish is landed, but only where this is appropriate and (in particular) does not create an incentive to catch fish that are below minimum conservation reference size.
Equal access	a) The location of the fishing boat's home port, or b) any other connection of the fishing boat, or any of its owners, to any place in the United Kingdom
National benefit	a) fishing activities of UK fishing boats bring social or economic benefits to the United Kingdom or any part of the United Kingdom
Climate change	a) the adverse effect of fish and aquaculture activities on climate change is minimized, and b) fish and aquaculture activities adapt to climate change

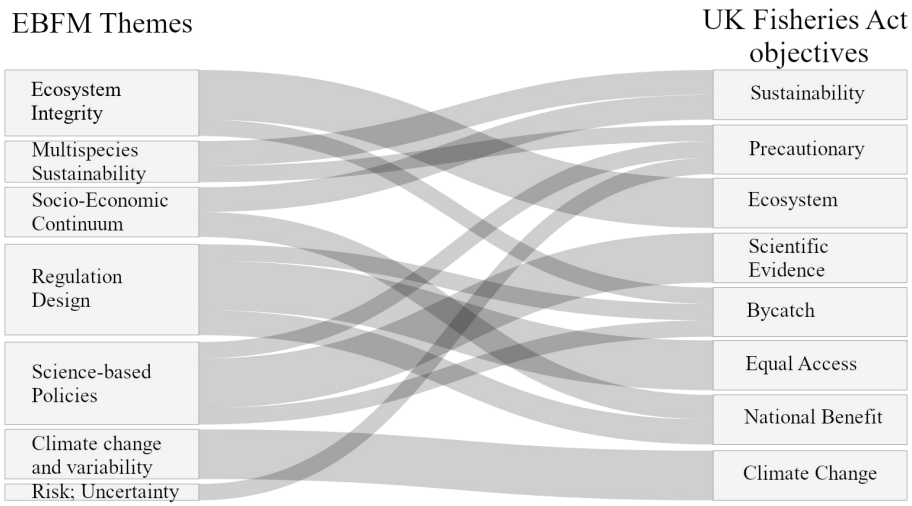

FIGURE 1
Commonalities between the objectives defined by the Uk Fisheries Act (right) and the themes we identified as representing the scientific view of EBFM (left). The linkages identify which of the scientific definitions and Fisheries Act objectives share some common grounds. Links are unweighted and Equi proportional to the UK fisheries objectives (*i.e.*: if a UK fisheries objective treats topics contained in three different scientific definitions, then the ribbons departing from this UK objectives weights 0.33).

TABLE 3 Sample representativeness of the UK population.

	Population Count	Population %	Sample Count	Sample %
Gender	**67596281**	**100.0**	**542**	**100.0**
Male	33104780	49.0	265	48.9
Female	34491501	51.0	275	50.7
Age	**53646829**	**100.0**	**542**	**100.0**
18-39	19187987	35.8	188	34.7
40-64	21722391	40.5	220	40.6
65+	12736451	23.7	134	24.7
Residence	**67596281**	**100.0**	**542**	**100.0**
England	57106398	84.5	455	83.9
Scotland	5447700	8.1	45	8.3
Wales	3131640	4.6	27	5.0
Northern Ireland	1910543	2.8	15	2.8

Population values (count and %) are official statistics relative to year 2021 (Office for National Statistics, 2022); Sample values (count and %) describe the sample of the respondents for our survey.

aspects, regulation design, climate change, and aquaculture. The answers were coded by each author of this publication separately. Subsequently the authors discussed any discrepancies in the coding and reached consensus. This coding process yielded a set of (binary) variables, namely *EStock* (fish stocks), *EEco* (ecosystem integrity), *ESocio* (socio-economic aspects), *EReg* (regulation design), *EAqua* (Aquaculture), *EClim* (climate change), and *EData* (use of science/data), representing each of the seven themes. A value of 1 was given whenever the contents of the statement pertained to a particular category, and 0 when it did not. A single answer could pertain to one or more categories, and is coded accordingly (See Table 4).

2.3 Research questions R1 and R2 - quantitative analysis

With a view to answering research question 1 (R1 – the level of awareness of the term EBFM among the UK public) and research question 2 (R2 – what are the correlates of such awareness), coded data were first analyzed quantitatively. At this stage of the analysis we discarded, from the whole dataset of 542 responses, 26 responses where the respondent failed to answer the main question as to whether they had heard of EBFM. This allowed us to explore how respondent characteristics correlate with the propensity to declare

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TABLE 4 Example of the matrix of response categorization (extract).

Respondent ID	F_EBFM	Response	EGarb	EAqua	EStock	EEco	EData	EReg	EClim	ESocio
9	3	To keep the right amount of fish in the sea	0	0	1	0	0	0	0	0
12	2	Managing the effect on the planet	0	0	0	1	0	0	0	0
23	3	Conscientious fishing practices to reduce impact on the environment.	0	0	0	1	0	0	0	0
25	2	Not taking too many fish	0	0	1	0	0	0	0	0

The *Response* field contains the definition of EBFM given by respondents, uniquely identified by the code reported in the field *Respondent ID*. F_EBFM is a variable that measures the respondent's answer to the question of whether they had heard of the term EBFM. It takes values from 1 to 3, where 1 corresponds to 'No', 2 to 'Yes, but I don't know what it means' and 3 to 'Yes and I know what it means'. The following columns report on our categorization, where 1/0 means whether the response fits/does not fits categories. EGarb is garbled response; EAqua applies to the theme Aquaculture, EStock applies to the theme fish stocks, EEco applies to the theme ecosystem integrity, EData applies to the theme use of science/data, EReg applies to the theme regulation design, EClim applies to the theme climate change, and ESocio applies to the theme socio-economic aspects.

awareness of the concept. Specifically, we tested whether and how the probability of having heard or being aware of EBFM is linked with demographics, marine exposure and education.

Demographic variables include age (*DAge*, respondents' age), gender (*DGender*, a binary variable with a value of 1 if the respondent is female), education (*DEduc*, a categorical variable with four ordinal levels of educational attainment), the number of children at home (*DChildren*), marital status (*DCivil*, a binary variable with a value of 1 if the respondent is married) and relative income (*DIncome*, a categorical variable of respondents' subjective income level compared to peers).

Exposure to the marine environment was measured by questions as to whether the respondent's family owned a marine vessel (*OBoat*, a binary variable which takes a value of 1 if the respondent or their family owns a vessel), whether they or any member of their household worked in any marine sector (*OWork*, a binary variable where 1 signifies respondent/family member works in marine sectors), and whether they spent time fishing at least weekly (*OFish*, a binary indicator that the respondent engages in fishing at least weekly).[1] Meanwhile, the extent of respondents' *marine education* was proxied by the highest educational level at which they had learned about the ocean or marine environment (*OEduc*, measured on the same scale as *DEduc*), or, separately, by whether they had heard about the Sustainable Development Goals (*ASDG*) – measured on a three-point decreasing scale similar to how we recorded knowledge of EBFM ('Yes and I know what [SDGs] are', 'Yes but I don't know what they are', 'No').

Potential associations between having never heard of EBFM and these characteristics were initially examined through pairwise correlation analysis. In case of any missing observations, the correlation coefficients were computed using standard case-wise deletion (that is, excluding cases that have missing data in at least one of the selected variables). As a further step, and with a view to parsing out the separate effect of each determinant on the probability of having never heard of EBFM, we then estimated the following logistic regression (Logit) model (Equation 1):

$$g(ENever_i) = \alpha + \boldsymbol{\beta}_1 \boldsymbol{Controls}_i + \boldsymbol{\beta}_2 \boldsymbol{Exposure} + \beta_3 Education + \varepsilon_i \quad (1)$$

where $g()$ is the logit link function, $ENever_i$ is a binary variable taking a value of 1 if the respondent had never heard of EBFM, α is the constant term of the model, β_j are vectors of coefficients for vector of explanatory variables j, and ε_i is the Gaussian error term for observation i. $Controls_i$ is a vector of the Demographic variables, $Exposure_i$ is a vector of variables on respondent involvement in fishing/marine activities, and $Education_i$ is a variable serving as an indicator of marine education.

In what follows, results from the Logit model are presented in terms of average marginal effects, these being the average change in the probability of a respondent having never heard of EBFM given a unit change in a predictor variable. For categorical predictors, the marginal effects show the average change in probability of having never heard of EBFM for the given value of the categorical independent variable against the case where the independent variable is at its base level. For instance, the coefficient on $DGender_i$ gives the average change in the probability of having never heard of EBFM if the respondent is female as opposed to the baseline probability when the respondent is male, keeping all other variables constant. All models are estimated with heteroskedasticity and autocorrelation-corrected standard errors. Finally, within our quantitative analysis, we also analyze the sub-sample of respondents who attempted to define EBFM and seek to clarify the links between the themes that respondents touch upon in the replies they provided and their socio-economic characteristics, using pairwise correlation analysis.

2.4 Research question 3 – qualitative analysis

Qualitative analysis was then employed to answer our third research question (R3), on the extent to which respondents' understanding (by which we intend grasp of the concept)

1 Marine sectors specified in the related survey question were marine living resources (e.g. fisheries, aquaculture, seafood); marine non-living resources (e.g. oil, minerals, desalination); marine energy (e.g. offshore wind, ocean energy); port activities; ship building and repair; maritime transport; coastal tourism; marine defence, security, surveillance; marine research and education; marine infrastructure; other marine sectors.

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converges with existing academic conceptualizations (Table 1) and policy objectives defined in the UK Fisheries Act (Table 2). This section considered all 542 observations in our sample, which yielded a total of 214 statements attempting to conceptualize EBFM.

3 Results

3.1 Descriptive data

Table 5 below provides descriptive statistics of the variables used in the quantitative component of our analysis, which is based on 516 responses. In terms of respondents' characteristics, we observe that the average age of our respondents is close to 50 years and that they are evenly split between males and females. The average respondent's household contains one child. Respondents perceive their income to be around the average relative to other comparable households. Only a minority of respondents fish regularly (at least once a week on average). Slightly fewer than a third of respondents' households include members that work in marine sectors (broadly defined), while nearly 15% of respondents' households own some marine vessel, such as a boat or yacht. Our respondents, on average, demonstrate limited marine and environmental education; most have not been educated on oceans or the marine environment beyond secondary school, and a substantial majority have never heard of sustainable development goals (SDGs).

TABLE 5 Data descriptives, describing range (Min-Max), mean, standard deviation (Std. Dev.) and sample size (N) for each of the variables used in the quantitative analysis.

	Variable	Min	Max	Mean	Std. Dev.	N
Awareness and Understanding of EBFM						
Never heard of EBFM	*ENever*	0	1	0.74	0.44	516
Knows meaning of EBFM	*EKnowmeans*	0	1	0.12	0.32	516
Attempted a definition of EBFM	*ETried*	0	1	0.40	0.49	516
Provided unclear answer	*EGarbled*	0	1	0.05	0.21	516
Wrote about fish stocks	*EStock*	0	1	0.16	0.36	515
Wrote about marine environment	*EEco*	0	1	0.21	0.41	516
Wrote about socio-economic aspects	*ESocio*	0	1	0.03	0.17	516
Wrote about regulation	*EReg*	0	1	0.04	0.20	516
Wrote about aquaculture	*EAqua*	0	1	0.02	0.14	516
Wrote about climate	*EClim*	0	1	0.004	0.06	516
Wrote about data/science	*EData*	0	1	0.004	0.06	516
Demographic controls						
Age	*DAge*	18	96	49.80	19.16	516
Gender	*DGender*	0	1	0.51	0.50	516
Education	*DEduc*	1	4	2.38	0.99	516
Marital Status	*DCivil*	0	1	0.55	0.50	516
Number of children	*DChildren*	0	9	0.57	1.11	503
Relative Income	*DIncome*	1	3	1.95	0.70	503
Marine involvement						
Fisher	*OFish*	0	1	0.22	0.42	507
Family works in marine sector	*OWork*	0	1	0.28	0.45	516
Owns a boat	*OBoat*	0	1	0.15	0.35	507
Marine Education						
Aware of SDGs (declining levels)	*ASDG*	1	3	2.58	0.69	499
Marine education level	*OEduc*	1	4	1.89	1.07	404

3.2 Awareness of EBFM (R1)

In response to our first research question, Figure 2 presents the data on the extent of awareness of the term EBFM among the UK public. Data presented in this section is based on our restricted sample of 516 observations retained for quantitative analysis. Seventy-four percent of these respondents have never heard of EBFM, as shown in Figure 2a. Of the respondents who had, fewer than half claimed to know what it meant. This notwithstanding, 40% of the respondents attempted a definition of EBFM (Figure 2b).

In Figure 3, we show the distribution of the answers from our restricted sample across the seven themes outlined above. Figure 3a shows that the most frequent type of answer was linked to protection of the marine environment; over half (51.7%) of those that attempted an answer mentioned this aspect as a feature of the EBFM framework. This was followed by responses with content related to fish stocks, mentioned by more than a third of those who answered. Regulatory aspects were mentioned by around a tenth of respondents, closely followed by aquaculture and socio-economic aspects. The least-mentioned themes were climate and the centrality of data to EBFM practices. In Figure 3b, we expand on this by showing the share of answers that mention each theme, differentiating between answers of respondents who had heard of EBFM and those who had not. It transpires that the more commonly mentioned themes – protection of the marine environment and fish stocks – were more likely to be associated with EBFM by individuals that were not familiar with the term, whilst other, slightly more nuanced aspects of the topic were more commonly mentioned by respondents that had previously heard of it.

3.3 Correlates of EBFM awareness and themes (R2)

In an attempt to robustly characterize awareness of EBFM, we first report pairwise correlations between the variables indicating respondents have never heard of EBFM (*ENever*), those who try to provide a definition (*ETried*), and the explanatory variables outlined above (demographics, marine exposure and education). We also run the same exercise for the outcome variable *EGarbled*. Our findings are reported in Table 6, where figures marked with an asterisk indicate statistically significant correlations at the 95% confidence level ($p< 0.05$). Being younger, being male, and having children all correlate significantly with having heard of EBFM. Having a higher involvement with the marine sector (fishing more frequently, having family members who work in the sector and owning a boat) also correlate significantly with having heard of the concept. A statistically significant and positive correlation is also found between having heard of EBFM and having a higher level of marine education and some awareness of the SDGs. The correlates of attempting an answer are less clear-cut. Age and educational attainment are again significant, and both are positively linked with a higher likelihood of the respondent trying to define EBFM while being more involved with the marine sector tends to be negatively correlated with having tried to define EBFM. No other variables are significantly correlated with trying to provide a definition. Garbled answers are more likely to be provided by those with a higher number of children in the household.

To test which variables are correlated with awareness of EBFM when controlling for the effects of other characteristics, we run the Logit model regressing the binary variable *ENever* on the range of explanatory variables above. Results are presented in Table 7. As can be noted, we start with simplified models labelled Model 1 and Model 2, where variables such as gender, age and education are statistically significant. However, in Model 3 the effects of these variables are subsumed under the effects of awareness of SDGs, and offer no explanatory power independently of their correlation with such awareness. As a robustness check, in Model 4 we alternate awareness of SDGs with the level of marine-related education received. These two variables are significantly correlated at the 95% level (correlation coefficient -0.34), but marine-related

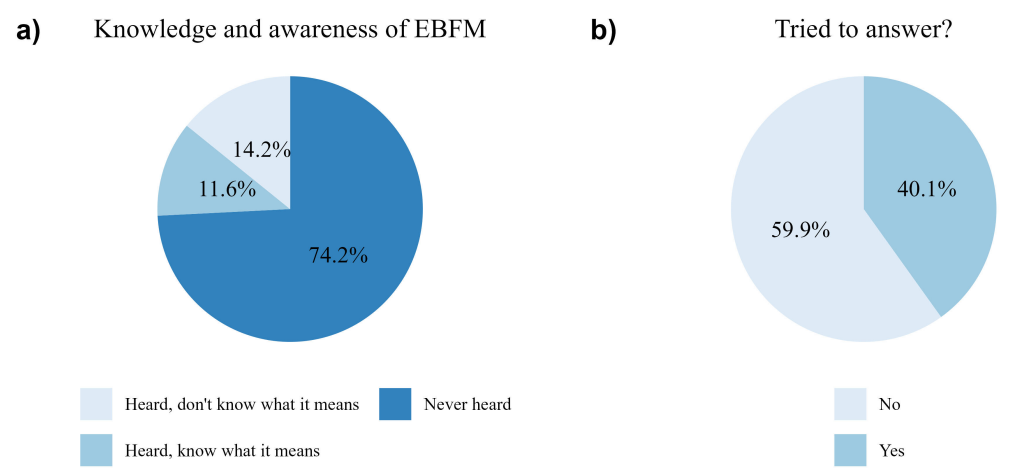

FIGURE 2
Share of respondents that attempted to define EBFM and propensity of EBFM awareness. **(a)** shows the answers to the question "Have you heard about EBFM?"; **(b)** reports the percentages of respondents who attempted to define EBFM (Yes) or not (No). These figures are calculated on the restricted sample of 516 observations used for the quantitative analysis.

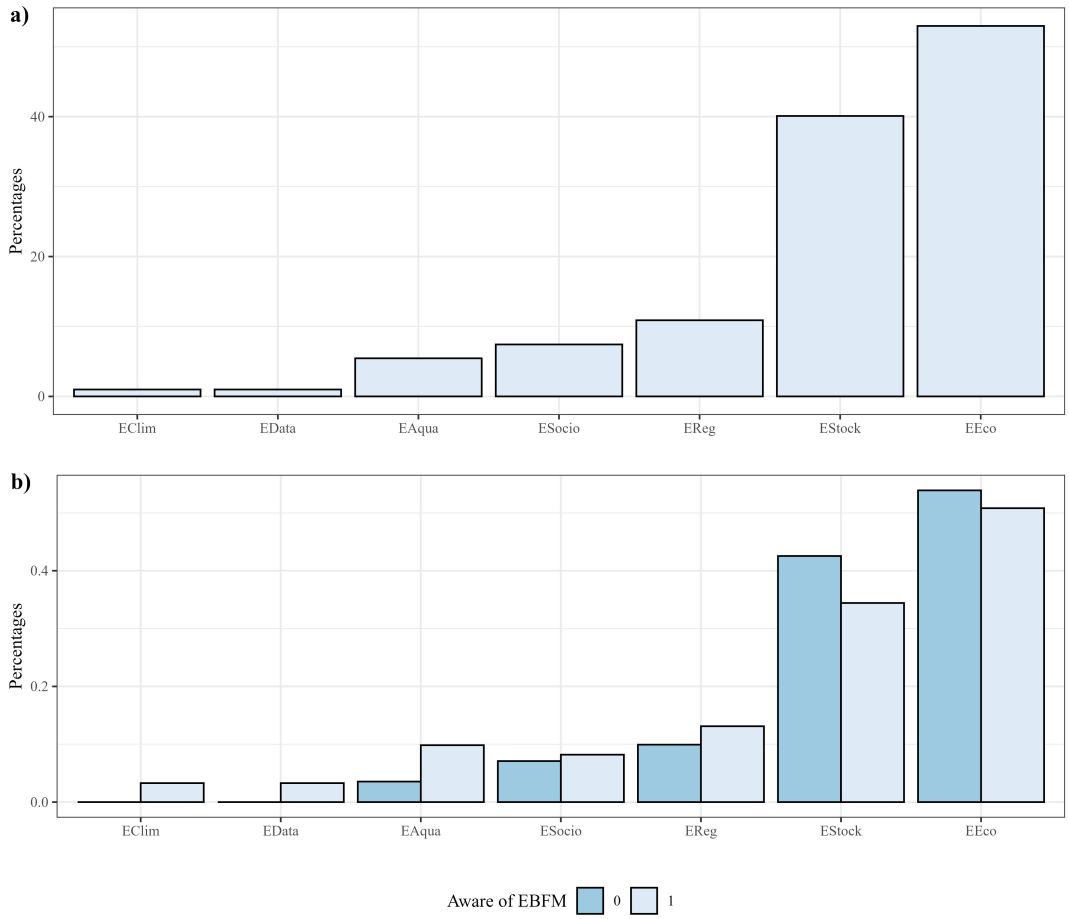

FIGURE 3
(a) percentages of themes mentioned by respondents when defining EBFM; **(b)** percentages of themes mentioned by respondents when defining EBFM grouped by awareness of the term "EBFM" (1= aware; 0 = not aware). Note: one response might apply to multiple themes. These figures are based on the restricted sample of 516 observations used for the quantitative analysis.

education has less explanatory power. Indeed, once all the relevant explanatory variables are included, our results suggest that income, marine work, being a fisher and having awareness of SDGs are the key factors that can distinguish between people who have heard of EBFM and those who have not. More specifically, individuals that feel at least as well off as their peers are in fact significantly less likely to state they have never heard of EBFM in contrast with those who feel relatively poorer. Individuals that frequently engage in fishing or who have family members that work in marine sectors are also significantly more likely to have heard of this term. The same is found for individuals who are more aware of SDG – a higher value of the variable *ASDG*, which signifies lower knowledge of SDGs, is significantly linked to higher probabilities of not having heard of EBFM. Once variation in these conditions is accounted for, no other variables offer additional predictive power. Thus controlling for all explanatory variables simultaneously naturally reduces the statistical significance of a number of covariates which exhibited significant correlation with *ENever* in Table 6, thus offering a more precise understanding of how much each variable in the model is capable of predicting awareness when the effect of other variables is accounted for. The effects of the most significant predictors – income, being a frequent fisher and having individuals working in maritime sectors in the respondent's family – remain consistently statistically significant when substituting marine education for awareness of SDGs.

We now turn to the quantitative analysis of the content of respondents' answers to shed some light on the correlates of what people understand by the concept of EBFM. For this purpose, we once again make use of correlation analysis, the results of which are shown in Table 8. No significant correlations emerge between respondent characteristics and mentioning the marine environment, which was the most commonly named theme in respondents' replies, nor between mentioning aquaculture or social aspects, which, as opposed to the marine environment, were mentioned by very few respondents. On the other hand, those who mention sustaining fish stocks tend to be older, with fewer children at home, with a lower level of SDG awareness and with a lower chance of having relatives working in the marine sector. The positive correlation between age and mentioning fish stocks may reflect the well-established place of such themes in the public discourse, relative to other possible connotations of EBFM. Those who associate EBFM with regulation are conversely more likely to

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TABLE 6 Pairwise coefficients of correlation of EBFM awareness, based on the restricted sample of 516 observations used for the quantitative analysis.

	ENever	ETried	EGarbled
Age	0.330*	0.167*	-0.029
Gender	0.193*	0.020	0.033
Education	-0.200*	0.165*	-0.003
Married/ Civil union	0.029	0.056	0.033
Number of Children	-0.233*	0.003	0.153*
Relative Income	-0.182*	0.027	-0.025
Fisher	-0.489*	-0.144*	-0.016
Marine Sector Work	-0.437*	-0.206*	0.028
Owns a Boat	-0.420*	-0.110*	0.013
Marine Education Level	-0.291*	-0.012	0.064
SDG awareness (declining)	0.585*	-0.038	-0.08

*Indicates statistical significance at *p-value*< 0.05.

have family members who work in the sector, to have higher marine education and to have children. Data considerations are more likely to be mentioned by those who have more awareness of SDGs. People who had never heard of EBFM are generally less likely to provide answers mentioning data and climate, whilst respondents who thought they knew the meaning of EBFM were more likely to mention aquaculture.

3.4 Analysis of understanding and links to scientific conceptualizations and policy requirements (R3)

When assessing the content of the 214 statements that attempted to define EBFM (out of the total sample of 542 responses), the majority (108) contained text related to the theme *Ecosystem Integrity*. Some of these conceptualizations (33) were given in short sentences using statements such as "*eco-friendly*", "*sustainable*", "*not impacting the ecosystem*". Others (14) brought concrete examples on a specific type of impact brought by fishing activities: "*not upsetting the balance of the ecosystem*"; "*not polluting*". A more nuanced conceptualization that goes beyond impact and shows awareness of the relationship between fishing practices and marine environment, was given in half of the statements (54). Some examples are "*Fisheries that are thinking about the entire ecosystem at work*"; "*Fishery management based on the specific ecosystem been fished*"; "*The management of sustainable fishing based on environmental/ecological principles*", "*Fishing in a way that benefits the area in which the fishing is done and allows regeneration of stocks and healthy environment*". Finally, a handful of statements (7) related to the marine ecosystem more generally for example, "*Managing the ecosystem that marine life live in*"; "*How fish in an area support other life*". Examining these responses suggests at least some alignment with the broad idea that ecosystems are a continuum of organisms ("*entire ecosystem at work*", "*not upsetting the balance of the ecosystem*"), and that the status of fished stocks is important for the overall trophic chain ("*How fish in an area support other life*"), which are present in both scientific and policy requirements (as presented in Tables 1, 2).

83 statements contained the term *"fish stocks"*, which can be linked to the EBFM theme *Multispecies sustainability*. In these types of statements, EBFM was associated with "*prevention of overfishing*" (13), and with the concept of "*sustainable fishing*," (18). Many of the statements go beyond the mere mention of the word "*sustainable*". For instance, one statement talks of "*taking out a balanced tonnage so that stocks can recover to previous levels*". Other dimensions can be seen in this conceptualization, ranging from statements signaling control (10), such as "*control of catches*"; "*not going over the quotas*", to a more nuanced understanding which signals *management* (10) of the type and quantity of fish caught in specific areas, of the amount of fishing boats, and of monitoring of fish stocks. Interestingly, a handful of statements (6) has protection of fish as its core, e.g. "*a system to protect fish*". Overall, the public tends to relate the idea of fish stock to conservation efforts ("*reduce overfishing*", "*protect fishes*") but there is no mention of the possibility of balancing the harvest of fishing sectors among different fish stocks so as to maintain a high level of catches. A key difference that emerges between public perception and both the scientific and policy objectives is therefore the idea of *optimization* of fishing strategies.

It was a much smaller number of responses (26) which associated EBFM with a legal or a regulatory body or agency that oversees fisheries (theme *regulation design*). Monitoring outcomes like overfishing, levels of fish stock, the impacts of fishing on the ecosystem, as well as calculating fish quotas, and registering boats are some of the elements mentioned in this kind of response. The understanding expands beyond management of fish stocks (as described in the previous category) to that of the ocean in general. While some responses have a sense of top-down or controlling element e.g. "*regulatory body in place to monitor over fishing*" "*a new way of controlling fishing*", others see EBFM as a system with a more supporting or protecting spirit "*a body of management that endorses sustainable fishing practices*" "*organization that protects aquatic animals like fish*". Some responses relate exclusively to the UK, while others mention the North Sea and Europe. In general, the public's perception of *regulation design* lacks mention of good governance and managing tradeoffs, and tends to be limited to notions of control ("*controlling fishing*"). Another important omission from the public on the theme *regulation design* is related to jurisdictional complexities and international cooperation. This aspect is of special relevance for the UK, and is extensively treated in the law, given that management cannot be conducted in isolation especially for fish stocks shared with other countries, but was not mentioned by our respondents.

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TABLE 7 Correlates of EBFM awareness, average marginal effects estimated from the logit model (Eq. 1) - full sample.

	Model 1	Model 2	Model 3	Model 4
Age	0.0065***	0.0023*	0.0009	0.0027*
Gender: Male	*Base*	*Base*	*Base*	*Base*
Gender: Female	0.0867**	0.0552	0.0384	0.0817**
Education: Up to secondary	*Base*	*Base*	*Base*	*Base*
Education: Post-secondary	-0.0886	-0.0722	-0.0749	-0.0614
Education: Undergraduate	-0.1047**	-0.0630	-0.0462	-0.0804
Education: Postgraduate	-0.1541**	-0.1167*	-0.0602	-0.0717
Civil Status: Not Married	*Base*	*Base*	*Base*	*Base*
Civil Status: Married	0.0365	0.0322	0.0410	0.0358
Number of children	-0.0312**	-0.0069	0.0021	-0.0106
Income: Low	*Base*	*Base*	*Base*	*Base*
Income: Medium	-0.1338***	-0.1009***	-0.1098***	-0.1143***
Income: High	-0.2466***	-0.1961***	-0.1322***	-0.1922**
Fisher: No		*Base*	*Base*	*Base*
Fisher: Yes		-0.1962***	-0.1014*	-0.1586**
Marine work in family: No		*Base*	*Base*	*Base*
Marine work in family: Yes		-0.1010*	-0.0902*	-0.1183*
Family owns boat: No		*Base*	*Base*	*Base*
Family owns boat: Yes		-0.1354**	-0.0470	-0.1477**
SDG awareness: No			*Base*	
SDG awareness: Yes, does not know			0.2239**	
SDG awareness: Yes, know meaning			0.4870***	
Highest ocean education: Up to secondary				*Base*
Highest ocean education: Post-secondary				-0.0788
Highest ocean education: Undergraduate				0.0450
Highest ocean education: Postgraduate				-0.0616
N	503	503	492	402
R^2	0.1905	0.2794	0.3800	0.2928

*Shows statistical significance at $p< 0.1$, ** at $p< 0.05$ and *** at $p< 0.01$.

The remaining themes were populated by a very small number of statements. Six statements (6) connected EBFM to society and coastal communities and considerations of fairness, safety, and wellbeing (theme *socio-economic aspects*). Statements of this nature included "*Fair fishing rights for all*", "*The safety and wellbeing of employees and equipment*"; "*Trying to find a sustainable route for coastal fishing*". Another six statements (6) focused on economic points of view (theme *socio-economic aspects*). Here EBFM was seen as a system that improves economic benefits for fishers, being also a system that takes care of selling and exporting products. An example of these statements includes*"A system designed to balance the environmental effects of fishing with the need to provide food and also to give employment"*. Public perception scratches the surface of the notion of socio-economic value of fisheries but, again, misses the complex concept of exploring tradeoffs.

Only two statements related EBFM to science, data, or monitoring, e.g. "*Managing fish stocks and monitoring methods*", "*Science watch*". Nevertheless, science/data is a critical, and costly, component of the entire EBFM reasoning, which aims to base management on the best available scientific knowledge (as also recognized by UK policy framework). Similarly, only two statements mentioned climate change, namely "*Maintaining a balance so that marine life is not devastated whilst maintaining a*

TABLE 8 Correlates of EBFM themes, average marginal effects estimated from the logit model (Eq. 1) - sub-sample who provided answers.

	EEco	EStock	ESocial	EReg	EAqua	EClim	EData
Age	-0.099	0.284*	-0.045	-0.080	0.020	0.193*	0.025
Gender	-0.074	-0.001	0.044	0.048	0.011	-0.103	0.095
Education	0.126	-0.022	-0.061	0.122	-0.079	0.028	-0.007
Civil Status	-0.089	-0.012	0.009	0.132	0.025	0.083	-0.017
Children	-0.023	-0.188*	0.055	0.143*	0.089	-0.051	-0.051
Income	0.048	0	-0.093	-0.140*	0.008	0.003	0.071
Fisher	-0.009	-0.094	0.037	0.049	-0.088	-0.037	-0.037
Marine Work	-0.093	-0.171*	0.077	0.186*	-0.047	-0.044	-0.044
Boat	-0.074	-0.062	0.033	0.097	-0.006	-0.033	-0.033
Ocean Education	-0.054	-0.028	0.064	0.165*	0.034	-0.023	-0.066
SDG awareness	0.006	0.164*	0.052	-0.084	-0.098	0.068	-0.157*
Never heard	0.022	0.073	-0.021	-0.048	-0.127	-0.151*	-0.151*
Knows meaning	0.003	-0.096	-0.099	0.028	0.190*	-0.035	-0.035

*Indicates statistical significance at *p-value*< 0.05.

balance in operation so that climate change is not affected unduly" and "*I believe it is an environmentally system that helps to reduce global warming and save the fishing industry*". Climate change affects the oceans with an intensity that depends on local conditions and predictions that do not consider the future state of nature can be misleading (Punt et al., 2021).

On the other hand, a non-trivial number of respondents (11) saw EBFM as linked to breeding fish e.g. *"It is large fish pens in the ocean"*. Within this group, some statements (4) also referred to "*sustainable farming*" or "*high eco-standards*". Aquaculture does not typically fall in the realm of the scientific definition of EBFM (although it can be considered to form part of the broader Ecosystem Based Management - EBM), but it is mentioned in the UK regulation (Fisheries Act 2020, sec. 1(2, 4)). UK regulations on aquaculture aim to protect the environment and ensure sustainable practices across the UK (DEFRA, 2015), and cover various aspects of fish, shellfish, and crustacean farming (DEFRA, 2023). Within the context of the 2020 UK Fisheries Act, aquaculture is recognized as part of the broader fisheries sector. The activity therefore falls under the same overarching principles of sustainable management and environmental protection that apply to other fisheries (Fisheries Act 2020, sec. 1(2- 10)). In fact, the Act requires that "*fish and aquaculture activities are managed using an ecosystem-based approach so as to ensure that their negative impacts on marine ecosystems are minimized and, where possible, reversed*" (Fisheries Act 2020, sec. 1(4)).

A core aspect of EBFM (Table 1) which was not mentioned by any of the respondents is the concept of risk (Hilborn, 2011; Little et al., 2016). The risk of failing to achieve a management objective is an inevitable part of fishery management (Little et al., 2016), and stems from both scientific uncertainty (data/models) as well as failure to correctly implement the advice (management uncertainty) (Privitera-Johnson and Punt, 2020). Dealing with risk entails adopting precautionary approaches, which can potentially affect the economic return of fisheries (Little et al., 2016). It is also of public relevance that a risk-averse strategy (based on the precautionary principle) could result in higher market prices of fish and fisheries products in the short and medium term.

Broadly speaking, the answers supplied by our respondents resonate with seven of the eight objectives of the 2020 UK Fisheries Act. Several of the considerations mentioned by our respondents map to the UK's "ecosystem objective", which proposes that fish and aquaculture activities are managed using an ecosystem-based approach to minimize and where possible reverse negative impacts on marine ecosystems, and that incidental catches of sensitive species are minimized or eliminated (Fisheries Act 2020, sec. 1 (4)). The latter is again emphasized in the UK's "bycatch" objective, which includes fish below minimum conservation reference size and other bycatch, that catches are recorded and accounted for, and that bycatch is landed only when appropriate without incentivizing capture of unintended species (Fisheries Act 2020, sec. 1(6)). A number of issues mentioned by the respondents are also in line with the "sustainability" objective, by which fish and aquaculture activities are environmentally sustainable in the long term, economically and socially beneficial, and contribute to food supply, as well as that fishing fleets should be economically viable without overexploiting marine stocks (Fisheries Act 2020, sec. 1(2)). Responses about fish stocks map to the UK's consideration of the "precautionary" objective, which envisages that the exploitation of marine stocks should restore and maintain populations of harvested species above biomass levels capable of producing maximum sustainable yield (Fisheries Act 2020, sec. 1(3)). On the other hand, as discussed, very few of the responses echo the UK's "scientific evidence" objective, which talks of basing management on best available scientific advice, and collecting/sharing scientific data relevant to the management of fish and aquaculture activities

(Fisheries Act 2020, sec. 1(5)). Similarly, few comments resonate with the "climate" objective, namely to minimize impact and to adapt to climate change in the fisheries sector (Fisheries Act 2020, sec. 1(9)). The broader socio-economic considerations received less emphasis among our respondents, in relation to the "national benefit" objective of having activities of UK fishing boats providing social or economic benefits to the UK (Fisheries Act 2020, sec. 1(8)). The objective of "equal access", referring to access of UK fishing boats to any area within British fishery limits (Fisheries Act 2020, sec. 1(7)), was not seen reflected in the responses.

4 Discussion and conclusions

While there is plenty of science available on EBFM (ICES, 2024a), a key limitation for the implementation of EBFM to date has been the lack of awareness and engagement of stakeholders (Marshak et al., 2017; Ramírez-Monsalve et al., 2021). Moreover, the topic of public perceptions on EBFM remains a significant gap in the literature and recent work has drawn attention to the fact that public opinion was scarcely engaged in the discussion leading up to the new fishery management policy (e.g. Kemp et al., 2020). There is increasing emphasis on the importance of gaining support from the public to unleash the potential of positive change in the future of fishery management (Fulton, 2021). On the premise that policy-makers and industry in the fishing sector can benefit from understanding public perceptions on marine conservation and fishing industry (Kemp et al., 2023a), and that such knowledge can also help the UK improve on past performance of fisheries management in UK waters more specifically (Churchill, 2022), we set out to examine the UK public's understanding of the term Ecosystem Based Fisheries Management.

Our study yielded responses from participants living in all four regions of the UK, with diverse ages (over 18) and evenly split between male and female, representing the UK population structure. They held different educational levels and hailed from different household sizes with different income levels. They included people who fish, those who own a marine vessel and those whose family members worked in some marine sector (broadly defined). However, our survey was an online self-completed instrument, meaning that all respondents were literate. This potentially biases the extent of awareness and understanding upwards, at least relative to that which prevails among the general population. A more representative, albeit also more expensive sample could have been gathered through a phone survey. A second limitation is that respondents were asked to write their understanding in a short statement. It is plausible that with more time, they may have elaborated further aspects of EBFM. Moreover, while we did our best to eliminate subjectivity in the coding of the statements, there remains room for interpretation and re-classification. There are further limitations associated with the concepts being measured by our survey. For instance, respondent interaction with the marine environment and ocean literacy could have been more comprehensively assessed to include other recreational activities (like diving) and non-formal education. On the other hand, a longer questionnaire could have added burden on respondents, reducing the number of completed questionnaires or inducing fatigue and associated careless responses. Our sample was limited to UK respondents, a choice which we justify by virtue of the evolved legislation, public interest and relevance of the legislation to the rest of Europe. Broader sampling, in different languages could reveal different nuances across Europe.

From this sample, our headline result is that the level of awareness and understanding of EBFM among UK citizens is relatively poor. Only one in four adults had heard of EBFM as of September 2022, and of these, fewer than half thought they knew what it meant. When pushed to elaborate (whether or not they were aware of the term), the public's understanding was mainly focused on preventing over-fishing and protecting the marine environment, particularly among those that had not previously heard of the term. Understanding was neither as broad nor as deep as scientific and legislative accounts, with respondents referring to vague concepts such as '*sustainable*', '*healthy*', '*balanced*'. Far less emphasis was made by the public on some dimensions which are critical to the scientific conceptualization of EBFM, such as the use of data/science, the role of uncertainty, or the importance of accounting for climate variability. Also, very few respondents mentioned practical aspects linked to the implementation of EBFM such as regulatory systems, the need for socio-economic trade-offs and the importance of monitoring. This echoes the relatively poor level of understanding found in other studies on awareness of how marine environmental management works (e.g.: Ressurreição et al., 2012; Easman et al., 2018; Harrison et al., 2021).

We also note that awareness of EBFM is higher among those who feel better off financially, those who fish regularly, individuals whose family members work in the marine sector, and those who are aware of the sustainable development goals. This is in line with the literature which find links between environmentalism and concern (Easman et al., 2018). It also hints that stakeholders (for instance those who work in the sector) are more likely to be informed than the general public. The evidence that people with a close relationship with the sea tend to know more about marine conservation instruments can be described in terms of psychological distance, or the effect of personal experience in the construction of a system of beliefs and concerns (Newell et al., 2014). If the quest is to bring most citizens onboard, then a suggestion would be to target different segments of society and not just those who already have close links to the marine environment. Indeed, the relationship between people's backgrounds and their capacity to understand a concept constitutes an important goal for public perception and ocean literacy research (Jefferson et al., 2015; McKinley et al., 2023). Our own results offer some pointers as to how to segment audiences for targeted communication (high/low income, more/less aware of SDGs, not/working in marine sectors).

More generally, communicating science to the public is a much debated topic (e.g.: Martin et al., 2016; Fulton, 2021; Kelly et al., 2022). Information and dissemination are often mandatory components of publicly-funded projects and finding the right

communication strategy for the different audience segments matters (Drews and van den Bergh, 2016; Walker-Springett et al., 2016; Fulton, 2021). Studies reveal a heavy reliance on mass and social media for gathering information regarding environmental conservation (Gelcich et al., 2014), a finding that has been also observed in the UK (Easman et al., 2018). Though social media have the potential to revolutionize the communication of scientific content especially among the younger generations (Kopke et al., 2019; Knupfer et al., 2023), their long-term effect on public engagement are still to be understood (Koch et al., 2023; Sun et al., 2024). There are multiple strategies known to be effective in creating the basis for successful communication of scientific concepts to the public, including those which draw upon environmental psychology (Walker-Springett et al., 2016; Fulton, 2021). Indeed, it is not just a matter of the communication channel but also the framing of the message, that is, the way in which a message is described to obtain an intended result (Newell et al., 2014; Lindland and Volmert, 2017; DeGolia et al., 2019). Clarity, having some common ground with the target system of values, and understanding that people's priorities/expectations align with their backgrounds are important considerations. On a practical level, efforts in the domain of ocean literacy, (that is the understanding of our impact on the ocean and its impact on us) offer potential for improving public awareness on marine conservation issues, including EBFM (Calouste Gulbenkian Foundation, 2025; Ocean Conservation Trust, 2025). Ongoing initiatives such as those by the International Oceanographic Commission (UK-IOC, 2025) or the Welsh Ocean Literacy Coalition (Wales Coasts and Seas Partnership, 2025) could be more explicit about mentioning EBFM and the role of the public as consumers and citizens. Furthermore, the use of professional communicators for the dissemination of scientific projects (a mandatory component of the EU-funded Horizon 2020 projects) is considered to have had an high impact in the outreach potential (Fulton, 2021).

We also noted that scientific and operational aspects of EBFM such as data and uncertainty, or regulation, trade-offs and monitoring may seem abstract or technical for non-experts. Nevertheless, public awareness of these concepts matters since they can contribute to costs (Little et al., 2016) that may be ultimately borne by the public in their role as consumers or taxpayers. Moreover, people tend to offer more support and to engage in projects/conservation effort where awareness is high (Lindland and Volmert, 2017; Easman et al., 2018). Addressing the lack of understanding of the importance of data, for instance, could also yield ancillary benefits in the shape of participation in citizen science, in turn enabling a virtuous circle where people are learning and contributing (Kelly et al., 2019, 2022), and creating the motivation for long term engagement (Maki et al., 2019). Communication campaigns can also focus on the role of uncertainty and acknowledging that failure cannot be excluded when dealing with human intervention on complex natural system. Uncertainty can be understood when properly explained (Van Der Bles et al., 2020), and clear statements on technical uncertainty should not undermine trust (Gustafson and Rice, 2020).

EBFM considers the physical and biological complexities of the marine environment as well as the economic and social dimensions of the fishing industry and of the communities involved. By this consideration, any definition of EBFM which does not consider ecosystem, economics, society and policies as a part of a continuum cannot be really considered to be in line with the scientific idea of EBFM. As such, the UK public demonstrated having a rather limited understanding of EBFM. But public understanding can be an important driver for policy motivation and support (Lindland and Volmert, 2017) – especially in the UK, where fishery management is based on ambitious objectives that are in line with scientific concept of EBFM. Lack of support may also be reflected in market dynamics (demand for products from ecosystem-based fisheries), in matters of social license (for instance the extent of objections to certain suppliers) and in poor uptake of citizen science (and the quantity/quality of participation). It is plausible that the poor level of awareness and understanding among the public could be due to ambiguous and non-binding wording in legislative instruments (Prellezo and Curtin, 2015), as well as the complexity of communicating EBFM – even among professionals (Craig and Link, 2023). EBFM has struggled long enough for a scientific consensus to emerge as to its meaning, and its transposition from plan to action is far from complete. It should not be surprising that the public does not quite know what to make of it, yet.

Data availability statement

The datasets presented in this article are not readily available because the dataset used for this present research is of restricted nature pending the approval of EU commission. Requests to access the datasets should be directed to marie.briguglio@um.edu.mt.

Ethics statement

The studies involving humans were approved by University of Malta (UM), Faculty Research Ethics Committee on the 30 June 2022 (reference FEMA-2022-00286). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. PR-M: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. GA: Writing – review & editing, Data curation, Formal analysis. EA: Conceptualization, Visualization, Writing – original draft, Writing – review & editing, Investigation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that no Generative AI was used in the creation of this manuscript.

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