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Behavioural Economics in Marine Fisheries Management: A Systematic Review

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ABSTRACT

Targeted management interventions can influence marine resource user behaviour, yet some remain ineffective. Behavioural economics may offer valuable insights on this topic by identifying which interventions can effectively change human behaviour and how they can be applied. This systematic review ($N = 140$) synthesises evidence from behavioural economics studies conducted in a fisheries context. The results include a table of behavioural mechanisms and examples of evidence for behavioural interventions changing environmental, economic, and social outcomes. There is a growing body of evidence that interventions that activate mechanisms such as social norms or risk aversion can impact environmental outcomes. However, there is a general lack of explicit reporting of the link between behavioural mechanisms, interventions, and outcomes, revealing weak conceptualisation in the field. This hinders the ability of scientists, practitioners, and policymakers to derive actionable insights from the research. Furthermore, the ethics of intervening in human behaviour as well as thorough analysis of unintended consequences need significant attention. To resolve these issues and guide the field forward, this systematic review offers recommendations for both science and policy as well as a conceptual framework that can improve the design of future studies that aim to understand human behaviour in a fisheries setting.

1 | Introduction

Fisheries management is a complex task where human behaviour is both the most important driver of uncertainty and the key to achieving sustainability. Historically, fisheries management has focused primarily on limiting fishing mortality to prevent overfishing. This strategy calls for input from biologists, ecologists, and other natural scientists to set fishing limits. However, sustainable fisheries management may remain elusive without understanding the behaviour of fishers and other resource users (Branch et al. 2006; Hilborn 2007; Wilen 2006). Understanding the complexity of human behaviour is challenging because causal mechanisms are difficult to isolate or predict, and interventions attempting to change behaviour can lead to unintended consequences (Abbott and Haynie 2012; Eikeset et al. 2011). The field of behavioural economics (Box 1) offers conceptual and methodological tools to better understand this complex subject.

Behavioural economics has existed as an academic discipline since the 1970s (Pesendorfer 2006) and began to receive attention in policy circles, company boards, and non-governmental organisations (NGOs) after Professors Richard Thaler and Cass Sunstein published their popular book "Nudge" in 2008. Since then, insights from behavioural economics have informed many domains of public policy, such as retirement saving (Anderson and Robinson 2018; Beshears et al. 2021), health care (Burgess 2012; Vlaev et al. 2019), community safety (Dolan et al. 2010), environmental behaviour (Day et al. 2014; Dolan et al. 2010) and climate policy (Gowdy 2008). The promise of behavioural economics has even led to the establishment of dedicated 'nudge units' (e.g., the UK Behavioural Insights Team and the Dutch Behavioural Insights Network).

Fisheries management approaches, however, have remained largely unchanged for a century (Fulton 2021), despite the wealth of studies on fisher behaviour (Andrews et al. 2020) and available concepts (Box 1). Initial scientific explorations of the potential of behavioural economics to contribute to fisheries management, for example, by working groups at the International Council for the Exploration of the Sea (ICES), have concluded that the knowledge of the field is underutilised (Kraak et al. 2014). In the decade since those explorations, interest in behaviour change interventions has grown, and factors that drive fisher behaviour have been identified (Andrews et al. 2021).

BOX 1 | What is behavioural economics?

The main workhorse of *traditional* economics is the rational actor model which assumes that individuals make optimal decisions that yield the highest expected payoff for themselves. *Behavioural* economics, by contrast, combines insights from psychology, neuroscience, sociology, and decision-making theory to understand why people do not always behave according to a rational actor model. While there is no universally accepted inventory of behavioural economics mechanisms (Carlsson and Johansson-Stenman 2012; Shogren and Taylor 2008; Thaler 2016), here we distinguish three broad categories: First, *social mechanisms* are structures and processes that are influenced by social norms, contexts, or the actions of others. For example, injunctive norms encourage people to behave in the way that they perceive is socially or culturally "normal". Second, *cognitive biases* are subjective thoughts or perceptions that can systematically affect decisions in objectively irrational ways. For example, the status-quo bias means people often irrationally prefer what they are already doing to a new alternative. Third, *risk, loss and time preferences* can lead to decisions that minimise perceived negative outcomes rather than maximise real beneficial outcomes. For example, loss aversion drives people to avoid losses at any cost, even when that loss can bring about an even greater gain. Behavioural economists may employ experimental methods to understand how interventions can trigger these mechanisms that influence behaviour. For example, providing information to one group of participants (a framing intervention) and comparing their subsequent behaviour with a control group is an effective way to understand cognitive bias mechanisms.

In light of its appeal in other policy spheres, and the growing interest within fisheries management, the multidisciplinary ICES Working Group on Maritime Systems (WGMARS) identified the need for a policy-relevant review of the application of behavioural economics interventions in marine fisheries contexts. Systematic literature reviews can identify evidence-based behavioural change strategies with policy-level implications (e.g., for the health sector in Blaga et al. 2018). This systematic review of behavioural economics mechanisms, interventions, and outcomes synthesises and evaluates the state of the literature. By doing so in a policy-relevant manner, the aim is to invite consideration about whether contemporary fisheries management approaches might be improved by integrating insights from this discipline.

2 | Methods

This study follows a pre-registered review protocol, which was published separately (Wieczorek et al. 2021). Developing and peer-reviewing the methodology of a systematic review before it is implemented can avoid some common pitfalls of review studies (Haddaway et al. 2020). Transparently reporting the approach in advance encourages conceptual and methodological rigor and makes the results more easily reproducible (Haddaway et al. 2018). While the full methodology can be found elsewhere (Wieczorek et al. 2021), below is a summary of the approach.

2.1 | Literature Selection

A list of available literature published before 2020 (the time of extraction) was retrieved from three databases: Web of Science (Core Collection); ProQuest (sub-selection of Social Science Core Collection); and EconLit. The search term is detailed in the protocol (Wieczorek et al. 2021) and results were limited to English language papers only. The protocol includes a benchmarking exercise, which indicated that 40% of relevant studies were captured by the search parameters used. Figure 1 details how the list of available literature led to the selection of studies included in this analysis. The initial search returned 1190 studies after deletion of duplicates. Studies were excluded if their titles and abstracts clearly did not match the subject of the review. After this, 301 articles were retrieved in full and were read by the author team. Of these, 161 studies were excluded based on the review eligibility criteria; see Appendix S1 and Wieczorek et al. (2021). For example, experiments that were carried out in a laboratory and involved university students or other actors (rather than fishers) were excluded from the review. This follows other studies (Levitt and List 2007; Velez et al. 2009) that conclude that abstractions in controlled settings may not yield results that can accurately predict real-world behaviour. This selection process left 140 studies to be included in the full analysis. A spreadsheet containing the data for all included papers can be found in the Supporting Information S2.

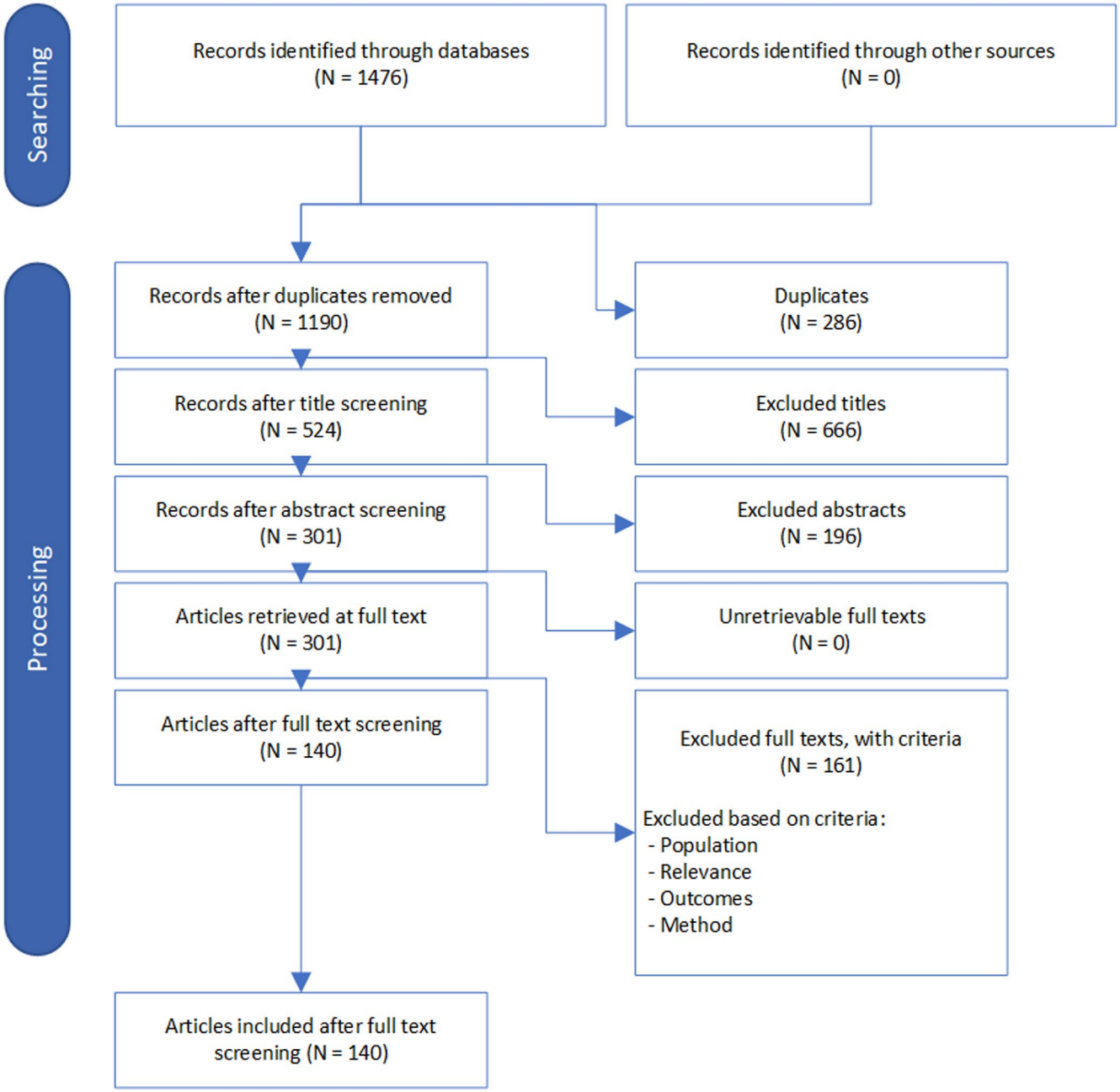

FIGURE 1 | Flow chart of the selection process for the papers in the systematic review (following Haddaway et al. 2018).

2.2 | Literature Review

In total, 15 reviewers were involved in reading literature, which poses a challenge for consistency. In order to streamline the analysis and to ensure the consistent recording of data, we designed an online review tool that included 45 multiple choice and open questions about the article (Wieczorek et al. 2021; Appendix S3). The online tool collated the insights from each of the 140 articles reviewed in full. To ensure that each reviewer was consistently using the online tool, three group calibration exercises were performed at regular intervals. The calibration exercise involved all reviewers independently reading and reviewing the same two articles in a dummy version of the online tool. The author group then met to discuss the decisions that underpinned their interpretations of the study and how they had recorded the insights of the article.

The review aims to identify behavioural economics mechanisms, intervention types, and their outcomes as recorded in the literature. The pre-registered protocol included a preliminary list of behavioural mechanisms. This table was provided to guide the reviewers as they read the articles and entered the information into the online tool (Wieczorek et al. 2021; Appendix S3). Based on the content of the articles, this table was extended and refined and is presented in summary in Table 1 and in detail in Appendix S5. Similarly, intervention types were

recorded with the online tool and the expected categories from the pre-registered protocol have been refined and presented in the Results. The outcomes of interventions were coded as social, economic, and/or environmental, and the review also collected information about unintended consequences when relevant. If articles included explicit policy recommendations, this was also recorded using the online tool.

2.3 | Data Analysis

The online review tool facilitated both quantitative and qualitative analysis of the literature. This analysis is largely descriptive and follows the design presented in the pre-registered protocol (Wieczorek et al. 2021). Some categories were either aggregated or recoded based on insights from the literature during the review. For example, fishing gears (Appendix S3, Q14) were aggregated from 16 gear descriptions to only 10 as redundancies were encountered during the review. The online review tool and details of the aggregated or recoded answers are available in Appendix S3.

Quantitative results are reported as percentages of the total sample. For some categories of information, more than one answer could apply. For example, following Andrews et al. (2020), we recorded whether articles made reference to any of the six factors that influence fisher behaviour (Appendix S3, Q21). These included demographics, environmental factors, economic factors, sociocultural factors, psychosocial factors, and governance factors. In this case, the total number of factors reported may be greater than the *N* of the study (140).

Because the review aimed to collect information that could not be predicted in the protocol or made into a multiple choice question in the online tool, some subjects called for short text summaries written by reviewers (Appendix S3, Q38–Q40). We used thematic analysis to identify patterns and meaning in these subjects. Teams of two or three co-authors used an inductive approach to interpret the data, based on Grounded Theory Analysis (Charmaz 2008, 172). The thematic data was interrogated for emergent patterns using ATLAS.ti, Microsoft Excel, and R (version 4.3.0).

3 | Results

3.1 | Types of Studies at the Intersection of Behavioural Economics and Fisheries Management

Fisher behaviour occurs in a particular context or 'decision environment' (Figure 2). This decision environment is influenced by six key factors (Andrews et al. 2020). Sociocultural factors were most commonly identified as influencing fisher behaviour in the literature (23%, $n=91$), followed by psychosocial (19%, $n=77$), economic (19%, $n=75$), governance (15%, $n=58$), demographic (12%, $n=49$), and environmental (11%, $n=45$) factors. Articles often identified several factors that influence the decision environment, with an average of 2.8 of these factors mentioned per article. The large majority of the 140 studies (74%, $n=103$) involved empirically observing fishers in their real-world context. The remainder (26%, $n=37$) were conducted in a way that could isolate particular factors of interest from the decision environment. One example is an experiment that had commercial fishers toss coins under different conditions to study the relationship between fisher honesty (behaviour) and their perception of regulators (a governance factor in the decision environment) (Drupp et al. 2019).

The literature addresses a range of fisheries issues (Figure 2). Some studies were motivated by clearly-defined management problems such as non-compliance (7%, $n=22$), overfishing and stock decline (5%, $n=15$), changing fishing gear and/or technique (2%, $n=6$), and bycatch (2%, $n=5$). Thirty-three articles (11%) stated explicitly that their aim was to improve regulations and management (11%, $n=33$). However, more often, studies were exploratory or curiosity-driven. For example, many studies simply aimed to better understand fisher behaviour (16%, $n=51$), community and collective behaviour (10%, $n=31$), how regulations were implemented in practice (7%, $n=22$), or fisher attitudes and perceptions (5%, $n=17$). A small number of studies focused on climate change (2%, $n=6$), gender dimensions (1%, $n=3$), safety (1%, $n=3$), and adaptive capacity and resilience (6%, $n=9$).

Figure 2 depicts a typology of studies in the literature. The first (Type A) comprises articles that theorise about a behavioural mechanism (e.g., a cognitive bias), apply an intervention (e.g., a framing experiment), and then report on the outcomes (e.g., a change in preference). Interventions are changes made to the decision environment that activate different behavioural mechanisms and thereby change behaviour. The intervention could be a management intervention (e.g., implementation of a policy, as in van Helmond et al. 2016) or a scientific intervention (e.g., an economic experiment, as in Aswani et al. 2013). Of the 140 articles included in the review, only 54 (39%) fit this description. The second type of article (Type B) aimed to understand a relevant behavioural mechanism without applying any sort of intervention to attempt to change that behaviour. In these studies, the key purpose was to understand behavioural mechanisms through close study. Even though the link between the fisheries issue and behavioural mechanisms was made in these studies, they did not investigate interventions and behaviour change that arises from implementing an intervention. For example, Boonstra et al. (2017) found that social mechanisms (i.e., motivations and attitudes) helped explain compliance outcomes, but in their study, they did not implement or analyse an intervention (such as the impacts of education or regulatory change). Because articles in Type A also specified behavioural mechanisms, a total of 111 papers (79%) therefore identified at least one mechanism that influences fisher behaviour. The remainder of the articles (Type C) aimed to better understand fisheries issues but did not formulate a hypothesis about behaviour at the outset of the research. In other words, the importance of fisher behaviour to the fisheries issue was an incidental finding. For example, Teh et al. (2015) highlight that there are multifaceted drivers of small-scale fishing behaviour that impact megafauna bycatch, but they do not identify a behavioural mechanism that could explain it.

The review found that 90% ($n=126$) of the 140 behavioural economics studies were instigated either solely by scientists (73%, $n=102$) or co-instigated by them (17%, $n=24$). Fishers or local

TABLE 1 | Key behavioural mechanisms (identified in at least five articles in the review).

Category	Mechanism	*n*	Definition	Example from papers included in systematic review
Social mechanisms	Injunctive social norms	49	The tendency to want to comply with cultural and social standards about how one should behave in certain situations	70% of the surveyed fishers from the town of Zorros (Northern Peru) reported that it was their duty to comply with a Manta ray fishing ban. Manta rays were seen as an important part of local culture and legacy and therefore worth preserving (Guirkinger et al. 2021)
	Descriptive norms	33	The tendency to want to comply with what is commonly done by others in a situation	Fishers in Pearl Lagoon (Nicaragua) tended to enforce restrictions on illegal activity depending on social norms related to sea tenure within the community and the behaviour of friends and fishing partners (Stevens et al. 2015)
	Informational influence	28	The tendency to follow information or advice from perceived experts when making decisions or forming opinions	In the Langkawi Global Geopark (Malaysia), fishermen economic groups' shape consensus among fishers about fisheries co-management (Halim et al. 2011)
	Self-image	14	The tendency to make decisions or express statements that align with one's self-identity and self-concept	Recreational fishers in the Great Barrier Marine Park (Australia) report that they choose to comply with regulations due to personal values and morals, rather than risk of punishment (Bergseth and Roscher 2018)
	Bandwagon effect	12	The tendency to adopt certain behaviours, choices, or beliefs because one perceives that many others are doing the same	Using damaging drag-net fishing in Zanzibar (Tanzania) does not offer higher income than the use of more sustainable traps. Yet local fishers are reluctant to change because of comradeship among fishers and the perception that drag-nets are the more widely-used gears (Wallner-Hahn et al. 2016)
	Inequality aversion	7	The tendency to prefer fair outcomes and oppose unequal outcomes	In the northern Gulf of Bothnia (Finland), restricting salmon fishing equally for all fisher groups relative to their catches was preferred over other management interventions, resulting in greater stakeholder commitment to the change (Haapasaari et al. 2007)
	Panopticism	7	The tendency for compliant behaviour to increase when one is aware that they are being watched, even if it is not known when or by whom	In Taiwan, a vessel monitoring system increased compliance by extending the 'eyes' of control authorities, even though that information as such will not replace traditional monitoring (Chang 2011)
	Social preferences	6	The tendency to care about outcomes for others as well as outcomes for oneself	In Brazil, fishers who were more prosocial (measured through an experimental game) were more inclined to report overfishing by peers (Cavalcanti 2020)

(Continues)

TABLE 1 | (Continued)

Category	Mechanism	*n*	Definition	Example from papers included in systematic review
Cognitive biases	Framing	13	The tendency to alter choices based on the way information is presented or worded, even if the content does not change	The catch limit in a camping station in Western Australia was framed positively as "Ideally we would like visitors to take no more than 2 fish per day to ensure the sustainability of this wonderful resource," rather than framing non-compliance as a punishable offence (Mackay et al. 2018)
	Status-quo bias	13	The tendency to prefer maintaining the current situation or decision, even when change can bring an improvement	Small-scale fishers in Sabah (Malysia) tend to prefer fishing in locations that they have previously visited even though other locations may be economically more profitable (Teh et al. 2012)
Risk, loss, and time preferences	Loss aversion	14	The tendency to place a higher value on avoiding losses or negative outcomes than on acquiring equivalent gains	Fishers in Vietnam tended to avoid actions that could lead to potential losses. While many programs aim to improve income stability (a gain for fishers), a more effective approach would be to ensure a safety net that would avoid losses in income (Nguyen and Leung 2009)
	Present bias	13	The tendency to prefer immediate rewards, even over larger future rewards	In an experimental game played with coastal fishers in the Colombian Caribbean, players harvested aggressively at the beginning of the game, leading to collapse of cooperation and low profits for all (Maldonado and Moreno-Sanchez 2016)
	Risk aversion	10	The tendency to prefer outcomes with high probabilities towards outcomes with low probabilities	The response of fishers in Yucátan (Mexico) to changing environmental conditions depended on their risk preferences. Fishers who were more tolerant to risk changed their fishing strategies to earn higher incomes from profitable high-risk fisheries (Salas et al. 2019)

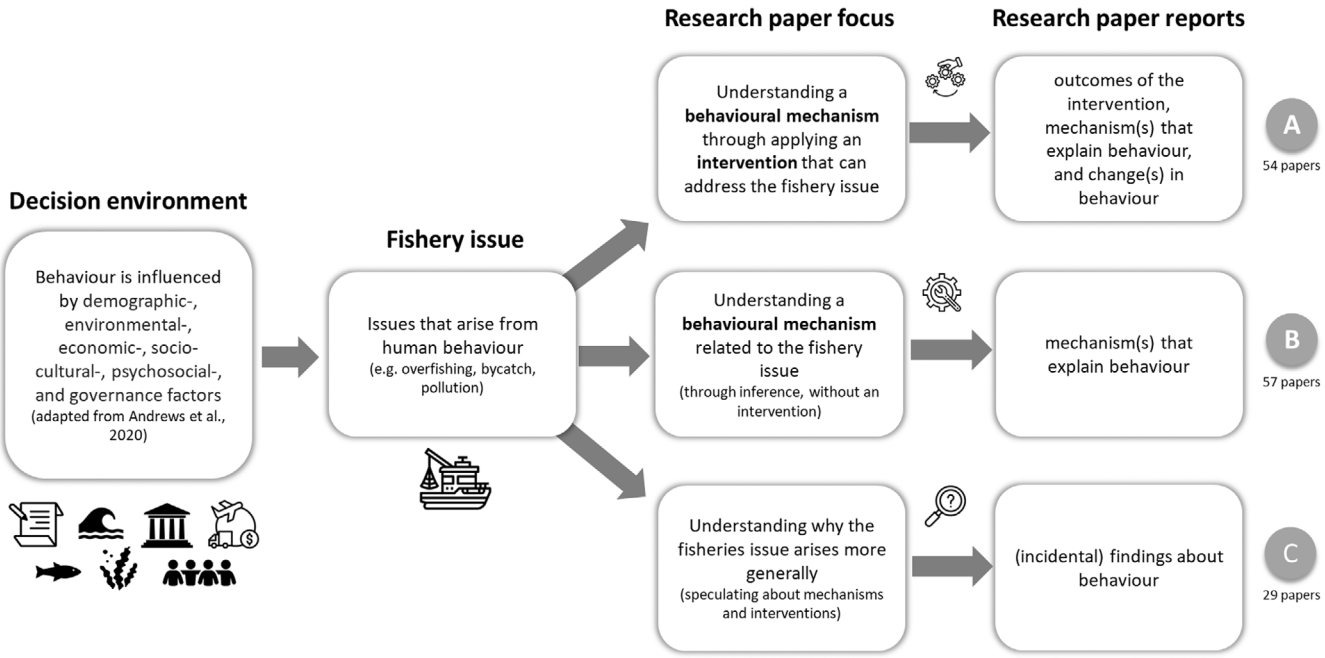

FIGURE 2 | A schematic representation of the way different studies ($N = 140$) researched fisheries issues and the incorporation (or not) of the behavioural mechanisms and interventions into their study design. Type A highlights research papers ($n = 54$) where insights into behavioural economic mechanisms and interventions were gained, Type B ($n = 57$) reported on a behavioural economic mechanism but did not have an intervention, and Type C ($n = 29$) did not have an intervention and also did not specifically focus on a behavioural mechanism.

communities were involved in instigating the research in only 6% ($n = 8$) and 3% ($n = 4$) of the studies, respectively. NGOs or other organisations were involved in 12% ($n = 17$) of the studies, and policymakers were involved in 10% ($n = 14$).

3.2 | Study Locations and Populations

Studies of behavioural economics in fisheries have been carried out on all continents. Most of the 140 studies have been done in the Americas (47%, $n = 66$) and Asia (21%, $n = 29$) followed by Oceania (11%, $n = 16$), Europe (10%, $n = 14$) and Africa (7%, $n = 10$) (Figure 3A). Seven percent of the studies ($n = 10$) did not have a specific geographical focus, and 4% ($n = 5$) were carried out on two continents.

Studies focused mostly on the local (52%, $n = 73$) and regional (34%, $n = 48$) scales, followed by national (11%, $n = 15$) and global (1%, $n = 2$). For 9% ($n = 11$) the scale was not clear or not relevant, and 6% ($n = 9$) were carried out at multiple scales. Most of the 140 studies focused on small-scale and/or artisanal fisheries (39%, $n = 55$ and 38%, $n = 53$ respectively), followed by larger commercial vessels (17%, $n = 24$) and recreational fisheries (16%, $n = 22$) (see Figure 3B). For 18% of the studies ($n = 25$), the fisheries type was unclear or not applicable, and in 21% of the studies ($n = 29$) multiple fishery types were investigated. Overall, hooks and lines, nets, or diving were the three most common gear types in the studies (hooks and lines 31%, $n = 43$, nets 21%, $n = 29$ and diving 16%, $n = 22$, see Figure 3C). Other gear types included demersal trawls and seines (14%, $n = 20$), traps and pots (12%, $n = 17$%), pelagic trawls and seines (5%, $n = 7$), beach seines (4%, $n = 5$) and dynamite (1%, $n = 1$). In 38% of the studies, the gears were either unknown (22%, $n = 31$) or not applicable (16%, $n = 22$) and in 25% of the studies ($n = 35$) multiple gear types were mentioned.

The target level at which behaviour change was intended was specified in 56% ($n = 79$) of the 140 studies. Of these, 54 articles described an intervention that changed behaviour, while in the remaining 25 cases no intervention was explicitly identified, but the article nevertheless reported the level at which behavioural change could be observed. Behavioural change was observed at an individual level in 51% of articles ($n = 40$), for both individuals and groups in 37% ($n = 29$) and for groups in 13% ($n = 10$) (see Appendix S4). Of these 79 articles, (80%, $n = 63$) observed behavioural change at the same level at which an intervention was implemented. For example, 34 articles reported behaviour change as the result of an intervention at the individual level (e.g., a nudge). Observations of changes in behaviour as a result of these interventions were mostly made at the individual level only (94%, $n = 32$) or by observing both individuals and groups (6%, $n = 2$). In other cases, studies reported changes in behaviour at one level, while the intervention had been directed at another. For example, interventions that were aimed at groups (16 studies) were observed to impact groups (56%, $n = 9$), groups and individuals (31%, $n = 5$) and individuals (13%, $n = 2$). An example where an intervention targeted the group but impact was observed at the individual level is the information relay system used by Alaskan flatfish fishers to avoid fishery closures when bycatch quota is reached. The intervention (information relay system) was implemented at the group level, but the study reported a decrease in cooperation levels per fisher (individual) (Haynie et al. 2009).

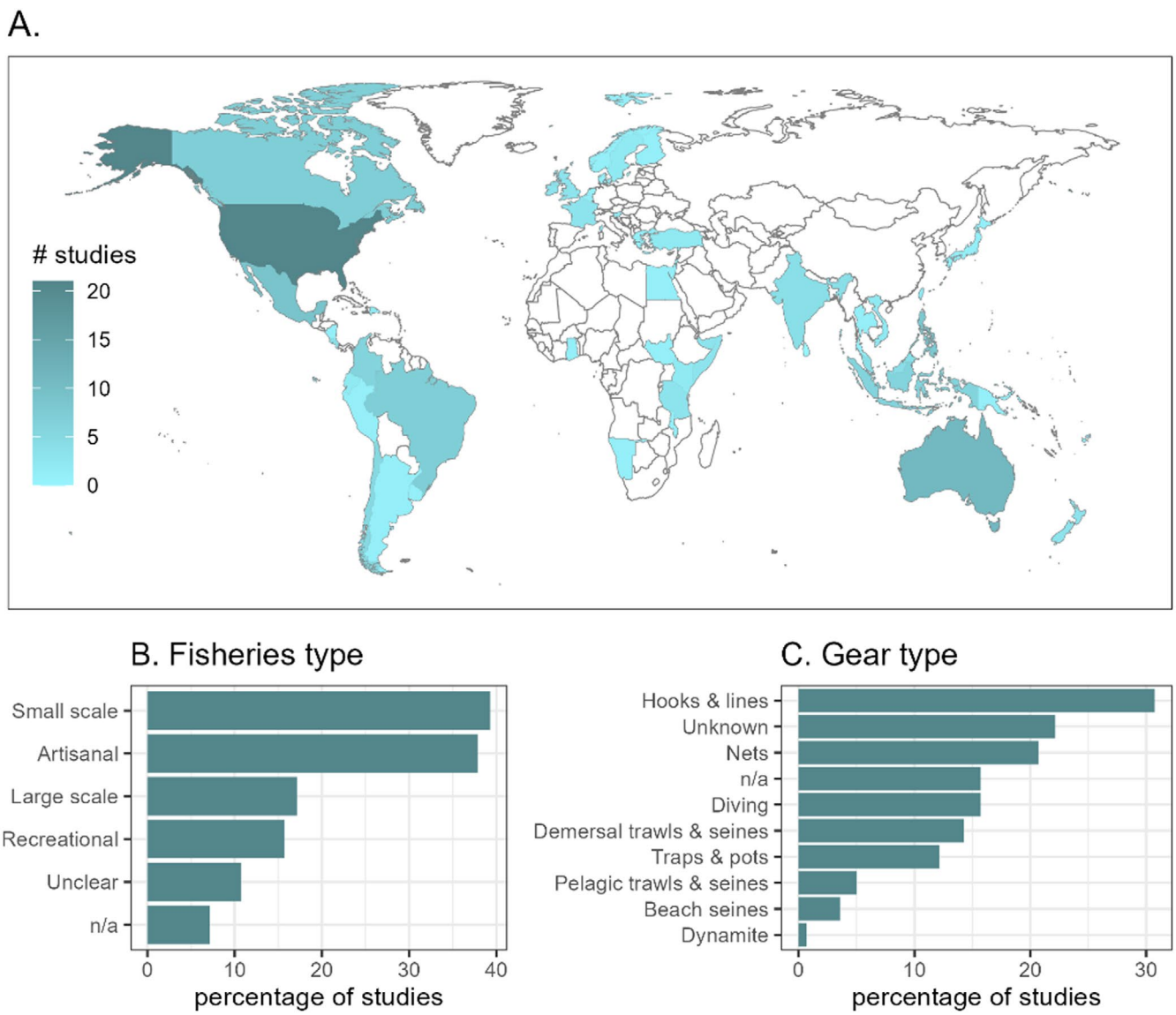

FIGURE 3 | Categorisations of the papers in this systematic review. The number of studies is mapped per country in panel A; 10 studies had no specific geographical focus. Panel B shows the percentage of studies ($N = 140$) by fishery type, and Panel C shows the percentage of studies by fishery gear type. Please note that a reviewed paper could have multiple countries, fisheries, and gear types.

3.3 | How Behavioural Economics Is Studied in Fisheries Contexts

Descriptive methods were most common and included qualitative methods such as interviews and focus groups (26%, $n = 36$), quantitative methods such as structured surveys (13%, $n = 20$), and combinations of qualitative and quantitative methods, hereafter referred to as mixed methods (30%, $n = 49$). Examples of mixed methods include combinations of interviews or scoping studies with fishers for grounded development of quantitative surveys (as in Marshall 2007), Latent Class Analysis combined with focus groups to explore the intersection of motivations and attitudes towards management within and across the different fisher classes (Magee et al. 2018), interviews combined with mapping exercises to explore drivers for or responses to spatial fishery changes (Chan et al. 2017; Teh et al. 2012), or combining social network analysis with statistical regression to explain individual-level fishermen behaviour and how this behaviour relates to the social structure of the fishers (Cox et al. 2016).

Experimental approaches were used in 24% of studies ($n = 39$), including some supplemented with descriptive methods (4%, $n = 6$). These studies mainly included games from common-pool resource or public goods theory (Ertör-Akyazi 2019; Visser and Burns 2015), choice experiments (Arroyo Mina et al. 2016) and scenario-generating games like ReefGame (Cleland 2017) and Microworlds (Stouten et al. 2012). In experimental studies supplemented by mixed methods, the latter served for validation and explaining outcomes (Basurto et al. 2016; Tam et al. 2021). A modelling approach comprised 10% ($n = 16$) of the studies (in 10 cases supplemented with other methods, the majority of these being mixed descriptive (4%, $n = 7$)). Examples of this include discussions with fishers or social network analysis to explain findings (Quynh et al. 2018; Sánchez-Jiménez et al. 2021; Wilson

et al. 2007) or using interviews to inform models (Stevens et al. 2015). The six studies that used a pure modelling approach used empirical data (e.g., satellite or catch data to model fleet behaviour following regulatory changes; Watson et al. 2018).

3.4 | Behavioural Mechanisms

Identifying behavioural mechanisms in the literature was a key aim of this study. The most prevalent behavioural mechanisms (i.e., those that appear in the literature at least five times) are detailed in Table 1. For a complete list, see Appendix S5. Of the three categories hypothesised in the pre-registered protocol (Wieczorek et al. 2021), social mechanisms were most prevalent (56%, $n = 166$), followed by cognitive biases (19%, $n = 56$) and risk, loss, and time preferences (15%, $n = 43$). *Social mechanisms* refer to how our decisions are influenced by others (Kranton 2016). For example, injunctive social norms (17%, $n = 49$) dictate how one ought to behave in certain situations, as prescribed by moral and cultural conventions, and descriptive social norms (11%, $n = 33$) refer to common behaviour in specific situations. Informational influence (i.e., altering actions, opinions, or beliefs based on information received from others) was the third most common social mechanism (10%, $n = 28$). *Cognitive biases* are processes that systematically affect our decisions even though standard economic models indicate that they should be irrelevant. Framing (4%, $n = 13$) and status-quo bias (4%, $n = 13$) were the most common cognitive bias mechanisms in the literature. How a choice is framed will affect how often it is selected, even if its qualities do not change at all (Kühberger 1998) and a status-quo bias reflects the tendency to dislike change, even if the current situation is not desirable per se. Finally, *risk, loss, and time preferences* contradict the idea that individuals always pursue strategies that yield the highest expected payoff. This involves aversion towards losses, risks, and intertemporal trade-offs (Tanaka et al. 2010) and reflects the notion that individuals are not always rationally optimising but rather make decisions that produce outcomes perceived as acceptable (Caplin et al. 2011). Loss aversion (5%, $n = 14$) was the most common of this type of behavioural mechanism in the literature.

There was some geographic difference in the relative prevalence of the three behavioural mechanisms in the literature (Figure 4). For example, for studies based in South America and Africa, there was a higher-than-average number of papers that investigated social mechanisms (67% and 63% respectively). A higher-than-average number of studies focused on cognitive bias in Australia (38%).

3.5 | Interventions and Their Effects

Less than half (39%, $n = 54$) of the 140 studies included in the review studied the effect of deliberately applied interventions on fisher behaviour. Within these articles were eight distinct types of interventions (Table 2). The most common intervention was a game or experiment, such as an experimental analysis of rent dissipation from fisheries closures (Emery et al. 2015). Other examples of interventions are information and education (e.g., Haapasaari et al. 2007), regulatory changes (e.g., Maurstad 2000), and participatory and co-design approaches (e.g., Eklöf and Törner 2005).

Of the 54 articles that reported the application and evaluation of an intervention to change behaviour, 9% ($n = 5$) reported that there had been no measurable effect. For a further 20% ($n = 11$) the effect was unclear. Thus, of the 140 eligible studies, only 38 studies explicitly identified an intervention and reported its effect on the study population. The most commonly reported change in behaviour was in fishery participation, effort, or earnings (34%, $n = 13$) followed by a change in stewardship behaviour (16%, $n = 6$). An improved shared understanding of the fisheries issue was reported in five articles, and a change in trust, cooperation, and collaboration was reported in four articles. More detail is provided in Appendix S6.

3.6 | Outcomes of Behavioural Economics Interventions and Mechanisms in Fisheries

Most ($n = 32$) of the 54 articles that explicitly discussed an intervention (Type A) did not observe or report any measured outcome. The 22 articles that did report an outcome identified social ($n = 12$), environmental ($n = 8$) and/or economic ($n = 6$) outcomes. In this small body of literature, there is no clear indication that certain intervention designs reliably activate certain mechanisms, nor that certain intervention designs trigger certain outcome types (Figure 5). Other than social, economic or environmental outcomes, the review also shows that interventions could result in unintended consequences and changes in relationships between fishers and managers. Each outcome is reported in the subsections below.

3.6.1 | Environmental Outcomes

Of the 140 studies included in the review, 26 articles (19%) analysed or measured an environmental impact of a behavioural economics mechanism or intervention. Of these 26 articles, 14 (54%) presented evidence of a change in environmental outcome due to an intervention (e.g., increased fish abundance after a social marketing program in Day et al. 2014). Fishing metrics such as species abundance (Jaiteh et al. 2016), biomass indices (Bethoney et al. 2017), or total bycatch (Barnes et al. 2016; Pascoe 2010) were the most common way of measuring the environmental outcomes in the literature (23 articles). Other types of environmental outcomes measured and reported included climate resilience criteria (Ojea et al. 2017), biodiversity (Gelcich and Donlan 2015), and marine litter (Brennan and Portman 2017).

3.6.2 | Economic Outcomes

Of the 140 studies, 31 (22%) reported economic outcomes from behavioural mechanisms and interventions. The most commonly reported economic outcome was employment ($n = 20$), for example, accepting lower income in order to remain fishing (Cleland 2017). This was followed by interactions between economic factors and regulation ($n = 13$), such as price fluctuations due to scarcity caused by quotas (Carothers 2013) and changes in fisher wellbeing leading to increased capitalisation of fleets (Andrews et al. 2021). The third largest category of economic outcomes was risk behaviours ($n = 10$), such as aversion to income loss (Nguyen and Leung 2009) or resource scarcity leading

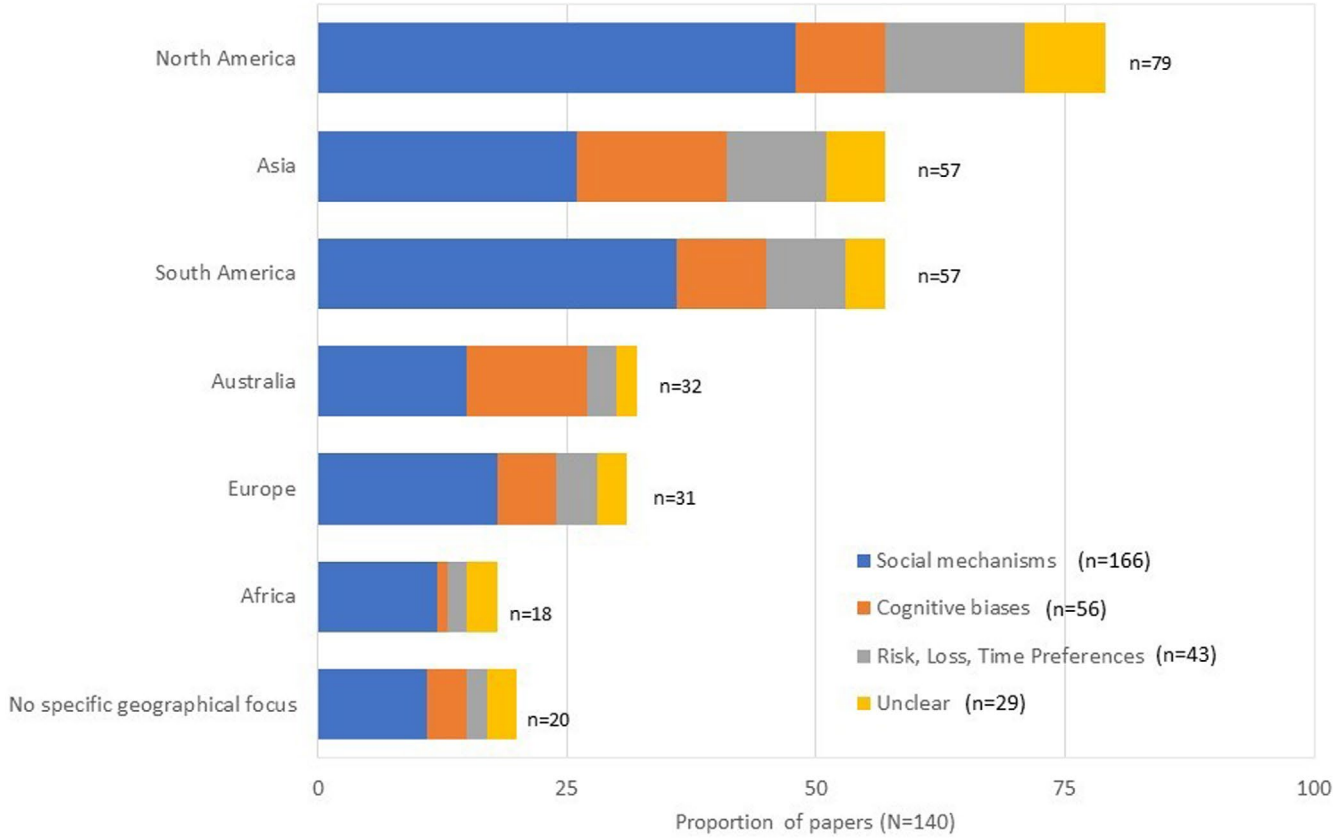

FIGURE 4 | Colour indicates three behavioural mechanisms: Blue = social mechanisms, orange = cognitive biases, grey = risk & loss, time preferences, and unclear = yellow for the 111 papers (out of 140) that reported behavioural mechanisms. There could be more than one location and mechanism per paper.

TABLE 2 | Eight different types of behavioural economics interventions ($n = 54$) in fisheries literature ($N = 140$). The colours of each intervention type correspond to the Sankey Diagram below (Figure 5).

Type of intervention	*n*	%
Game or experiment	24	44
Information provision and education	10	19
Regulatory change	5	9
Social marketing	5	9
Participatory and co-design approach	4	7
Monitoring	3	6
Market-based instrument	2	4
Voluntary approach	1	2
Total	54	100

to increased risk-taking (Morel et al. 2008). Only seven of the 140 studies (5%) demonstrated a clear economic outcome arising from a modelled ($n = 4$) or a real-world ($n = 3$) intervention. Examples include an education intervention leading to fishers diversifying their income sources (Halim et al. 2011) and improved earning and income equality with increased communication (Ertör-Akyazi 2019).

3.6.3 | Social Outcomes

Of the 140 studies included in the review, 22 articles (16%) analysed or measured a social impact of a behavioural economics mechanism or intervention. Changes in social behaviour were most commonly observed ($n = 18$). For example, revealing an individual's contribution to a communal good (social norms) was more effective than regulatory punishment in motivating participants to contribute (Lopez et al. 2012). Community-related outcomes were reported in 14 articles, with one example reporting that the strength of community ties was one factor that affected competitive and cooperative fishing behaviour (Salas et al. 2019) and a model study on common-pool games indicated a peer effect on decisions that lead to overuse of the resource (Maldonado and Moreno-Sanchez 2016). There were 13 articles that reported on social outcomes as measured in a behavioural economics intervention. For example, one study in a real-world context (as opposed to a game or a model) combined reporting, framing and incentive interventions that improved relationships between fishers and management and aligned conservation values (Cote et al. 2021). In a game setting, Rocha et al. (2020) observed that fishers reduced fishing pressure and continued cooperation in the face of environmental thresholds, while social demographic studies linked variables such as age when entering a fishery with conservation (Marshall et al. 2010) or education, employment status, and whether or not the fisher is the breadwinner for the family with cooperative behaviour (Visser and Burns 2015).

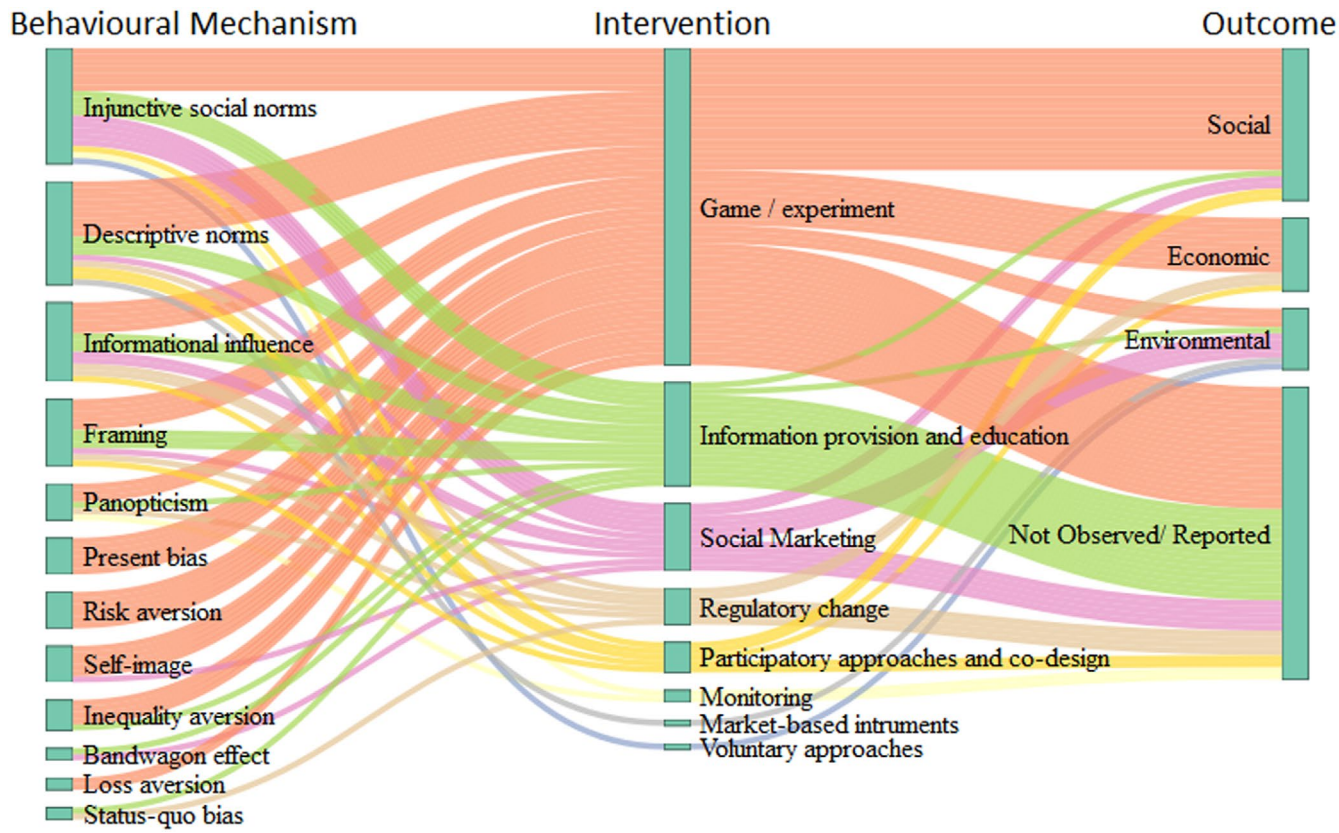

FIGURE 5 | Sankey Diagram visualising the connections between intervention designs (centre), the behavioural mechanisms they activate (left) and the outcomes they generate (right). The colours correspond with the type of intervention (Table 2). The figure shows that there is no strong link between behavioural mechanisms, intervention designs, and outcomes in the literature.

3.6.4 | Relationships Between Managers and Fishers

The relationship between fishers and managers was mentioned in 36% ($n = 51$) of the 140 reviewed studies, qualitatively defined as 'bad/distrust' in 49% of cases ($n = 25$), 'good/trust' for 33% ($n = 17$) and 'indifferent' in 18% ($n = 9$). Of these, 35 articles gave information about whether the relationship between fishers and managers changed or developed during the research. Relationships remained unchanged for 71% ($n = 25$), improved for 23% ($n = 8$) and worsened in 6% ($n = 2$). For the 14 articles that reported fisher-manager relationships as distrustful and somehow changing during the study period, only 43% ($n = 6$) reported an improvement. See Appendix S7 and S8 for more information.

3.6.5 | Unintended Consequences

Unintended consequences are defined as outcomes that were not intended or foreseen by a purposeful management action (Merton 1936). Such consequences can result from implementing interventions. They can also be the direct result of management strategies or management measures (e.g., quota systems, vessel monitoring systems, marine protected areas) and market incentives (e.g., eco-certification). Unintended consequences were mentioned in 22 of the 140 studies (16%). Most of the unintended consequences were negative (60%, $n = 13$), while four were positive (18%), and five were unclear (23%). Of these, nine studies (41%) reported unintended consequences as a direct result of the behavioural change intervention in the study (see Appendix S9).

Examples of positive unintended outcomes include increased ownership by women (Carothers 2013) and improved communication between groups (Cleland 2017). Examples of negative unintended consequences can be found below.

Unintended consequences were thematically coded into five main groups: social (59%, $n = 13$), management/governance (41%, $n = 9$), economic (32%, $n = 7$), environmental (14%, $n = 3$), and communication (14%, $n = 3$), with some studies listing more than one unintended consequence. Social unintended consequences include changes to social practices, norms and values, and social shifts (e.g., Basurto et al. 2016; Carothers 2013; de Melo and Piaggio 2015; Grydehøj and Nurdin 2016) (see Appendix S10). One example of an unintended social consequence is increasing mistrust and marginalisation. For example, interventions by an outside authority to reduce marine litter and make aesthetic improvements led to fear within a fishing village of possible displacement and dispossession of local fishermen (Brennan and Portman 2017). The breaching of social norms and an increase in inequality was an unintended social consequence of income increases following marine protected area management (Basurto et al. 2016). Interventions could also unintentionally affect the perceptions of participants, such as making risks appear to be less manageable as a result of an intervention (Eklöf and Törner 2005). Another example is that of municipal enforcement, whereby the involvement of the municipality reduced the capacity of fishers to solve disputes themselves (Stevens et al. 2015). Finally, unintended environmental and economic consequences occurred when shark fishing was

reduced for conservation tourism and fishers turned to illegal alternative livelihoods or other fishing grounds, increasing pressure on other species (Jaiteh et al. 2016).

3.7 | Ethics

Before any research involving human subjects can be undertaken, it is good practice to undertake an ethics review. While sometimes viewed as a bureaucratic burden, ethical engagement with research participants can ensure that studies leave a positive legacy for research participants, collaborators, and the environment itself in the long term (Brittain et al. 2020). Evidence of engagement with an ethics committee is commonly included in articles by means of an ethics statement. However, 86% ($n = 120$) of the 140 studies reviewed did not include an ethics statement or any reference to ethical considerations. The 20 studies (14%) that did include ethics considerations mostly referred to acquiring informed consent of participants and did not contain a full ethics committee review process. There was no apparent difference between ethics reporting for the set of papers that applied an intervention and those that did not.

3.8 | Policy, Management and Future Research According to the Literature

Only 29 of the 140 papers included in the review described an experimental intervention in a real fisheries management situation (21%, $n = 29$). Of these, 23 articles explicitly describe management and policy implications, leaving a small evidence base from which to draw recommendations. Taking the wider subset of 54 articles that applied interventions (Type A in Figure 2), 39 articles (72%) gave policy or management recommendations. The policy implications described in this literature related to (i) socioeconomic incentives and disincentives ($n = 23$), (ii) communication, education, and awareness ($n = 20$), (iii) community management or co-management ($n = 18$), and (iv) inclusiveness and transparency ($n = 17$). Other policy recommendations also dealt with additional issues such as increasing control and enforcement measures ($n = 8$), and quota distribution or quota ownership ($n = 7$). From the subset of studies that took place in a real fisheries management context (as opposed to in a lab setting or in an abstract study), 74% ($n = 17$) described policy and management implications of their findings.

In addition to policy recommendations, recommendations for future research were provided in 76% ($n = 41$) of intervention papers. These recommendations fall into three main themes: (i) methodological advances and improvements ($n = 33$), (ii) interactions between behavioural mechanisms and regulations ($n = 21$), and (iii) intervention effectiveness ($n = 27$). On methods, the literature recommends conducting studies with larger sample sizes, designing interventions that can be monitored for long-term impacts, improving experimental controls, and accounting for other explanatory variables such as the scale of the intervention or differing cultural perceptions in participants. For example, seven articles recommended interventions that study behaviour at the fleet scale, rather than in individual fishers only. The inclusion of the perceptions of other stakeholders (managers and policymakers, community members) was also recommended. As for better understanding how behavioural mechanisms can be implemented through regulation, the literature calls for research to focus on including scientific insights into regulation design as well as improving understanding of how mechanisms and regulations interact with context (e.g., Lopez et al. 2012). Finally, 27 articles recommend better assessment of intervention effectiveness and impact. This includes understanding why interventions succeed or fail, and monitoring the socioeconomic and environmental impacts. Importantly, some studies showed that an intervention's effect did not last after the initial application (e.g., Fujitani et al. 2012). As a result, 18 articles recommended monitoring long-term impacts in order to better understand the temporal dynamics of behavioural economics interventions.

4 | Discussion and Recommendations

Behavioural complexity is as important as ecological complexity in fisheries management. While the literature on behavioural economics and fisheries is growing, and some studies contain policy-relevant insights, there are many areas that require attention if the field is to confidently advise policy and management.

4.1 | Conceptualisation and Research Design

The large number of studies that are about behavioural economics but which do not report any outcomes highlights a shortcoming of the literature, namely that research design issues make it difficult to attribute outcomes to specific interventions, if such outcomes are measured at all. While all of the 140 articles contributed to understanding fisher behaviour as an integral part of fisheries management, only 54 (39%) contained a study design that theorised a behavioural mechanism, tested the mechanism with an intervention, and reported the outcomes. Thus, the remainder of relevant insights about human behaviour were incidental and the majority of the literature was not explicit about how behavioural mechanisms were conceptualised or how outcomes were measured. Given the field's interdisciplinary nature, this is understandable; researchers that are knowledgeable about fisheries systems may lack training in behavioural economics and vice versa. Furthermore, interventions were implemented at different levels (groups and individuals), making evaluations of their outcomes complex as various mechanisms were activated in different dynamics. Limitations in time and funding can also contribute to the lack of evaluation in this nascent field, which is a broader issue in science overall.

Unified language and theory around behavioural economics in fisheries can encourage more robust research designs, efficient development as a field, and a literature that can better inform policy and decision-making. To this end, Figure 6 depicts a conceptual framework that combines the key insights from the reviewed literature. Research designs should frame their problem by describing the *decision environment* (1) and identifying a *fisheries issue* that the study aims to address (2). Once the problem has been framed, researchers should design an *intervention* (3) that activates a theorised *behavioural mechanism* (4). A comprehensive list of these mechanisms is provided in Table 1 and

Appendix S5, and interactions between mechanisms and interventions are depicted in Figure 5. *Changes to behaviour* should be systematically measured (5) so that the *outcomes* of the intervention can be properly assessed (6). Interventions can also produce *unintended consequences* (7), which should be properly recorded so that, along with the outcomes, they can inform recommendations to both *research* (8) and *policy* (9).

Other variables that the literature indicates may be significant when designing behavioural economics studies are age, gender, occupation, years of being a fisher, cultural perceptions, income, and social preferences (cooperative vs. non-cooperative; beliefs on fishing access sharing). It may also be useful to distinguish populations of resource users: those actively engaged in community-based or co-management of resources versus those without community ties, different scales or types of fishing, or differentiating between those for whom fishing is subsistence, recreation, or a main source of income. Understanding how behaviour changes at the individual versus group level by comparing fleet or village scale behaviour compared to individuals is also worthy of further enquiry.

There is therefore significant scope to improve the design of interventions (in the real world or in an experimental setting) that can effectively isolate and measure behavioural mechanisms as they relate to fisheries issues. While quantitative experimental studies may be the gold standard methodology in traditional economics, combining quantitative with descriptive methods has proven useful in the field of behavioural economics in this context (e.g., Haapasaari et al. 2007). Creating a credible counterfactual ex ante can also help to anticipate the outcome of the intervention and avoid unintended consequences. Further, modern causal inference methods can evaluate impacts ex post with observational data (Holzer and DePiper 2019; McDermott et al. 2019). Finally, further methodological rigour and transparency can be achieved by pre-registering the study design and methodology before entering the field.

4.2 | Treatment of Ethics in the Literature

This review shows that very few studies explicitly highlighted ethical considerations. The inclusion of ethics statements in literature might be dependent on journal policy, so its absence does not necessarily imply that no ethics considerations were made. However, given that the field aims to steer human behaviour, coupled with the likelihood of unintended consequences, we strongly recommend a thorough analysis of ethical issues for future research and that an ethics statement be required as part of the text of future publications about behavioural interventions (see examples in Table 3). Even when a full ethics board review is not possible or mandated, scientists have a responsibility to reflect on their research practices and their potential impacts on human participants (Brittain et al. 2020). On a different level, behavioural approaches to public policy may breach democratic ethics, and a focus on the effectiveness of behavioural policy instruments blurs lines between politics, policy, and science (Lepenies and Małecka 2019). While philosophers of science and public policy may engage in discussions about the ethics of policies such as "nudge architecture" (Sunstein 2016), the literature about behavioural economics applied in a fisheries context contained few such considerations.

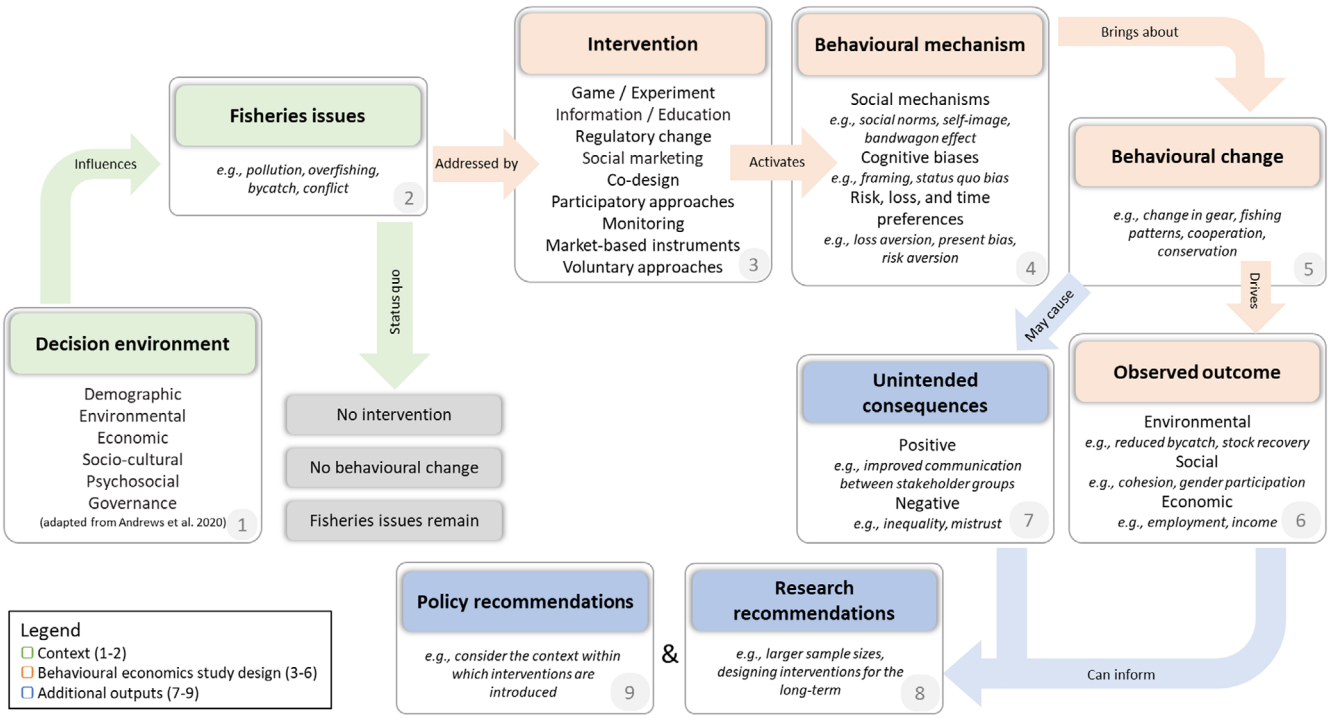

FIGURE 6 | A conceptual framework for behavioural economics studies in fisheries science. Concepts related to the study context are listed in the green boxes labelled 1–2. The concepts necessary for designing a robust behavioural economics study are listed in the orange boxes labelled 3–6. The blue boxes labelled 7–9 show additional findings that are relevant for the development of both policy and behavioural economics science.

4.3 | Engaging With Fisher Communities Through Co-Design Principles

The review indicated that nearly three-quarters of the studies were initiated solely by scientists. Given the conceptual and ethical concerns previously discussed, it is recommended that scientists collaborate with fishers, NGOs, communities, and relevant authorities when designing studies that aim to change behaviour. This collaboration will enable them to collectively define the research problem and to develop suitable environmental, social, and economic monitoring frameworks. Such joint efforts can facilitate a more accurate assessment of the outcomes of any interventions implemented, and the involvement of stakeholders through co-design and co-development principles can also help to anticipate and avoid unintended consequences (Holm et al. 2013; Evans and Terrey 2016; Glicken 2000). Even in studies that rely largely on secondary data (e.g., logbooks), collaborations between fishers and scientists can help to understand data in context (Baker et al. 2023).

That said, collaborations should be conducted carefully. Where fisher-manager relationships were distrustful (14 articles), only 6 cases (43%) reported an improvement in this relationship after the study and/or intervention. Social norms, economic dependence, behavioural psychology, community fragmentation, the level of fishers' reliance on resources, and the dynamics between fishers and governance institutions can all impact the success or failure of stakeholder contributions to fisheries science (Béné and Tewfik 2001; Brennan and Portman 2017; Cox et al. 2016; Eriksson et al. 2015; Grydehøj and Nurdin 2016; Haapasaari et al. 2007; Marshall et al. 2010). Additionally, understanding stakeholders' non-financial considerations, technical limitations, and individual traits (e.g., risk-taking behaviours and preferences) is vital (Andrews et al. 2021; Béné and Tewfik 2001; Cleland 2017; Nguyen and Leung 2009).

Finally, certain geographical regions, such as Australia and North America, have been the subject of a substantial number of studies on behavioural economics. In contrast, most regions in Africa, Eastern Europe, and parts of the Mediterranean and Black Sea have limited representation in the literature. Future bibliometric research would be needed to draw conclusions about authorship in the field of behavioural economics, but work on collaborations in fisheries science more generally shows that the hegemony of Western nations remains evident (Syed et al. 2019). Mughogho et al. (2023) have recently called for more respectful

TABLE 3 | Examples of ethics statements aligning with journal requirements.

Description	Quote	Source	Journal requirements
Describing the ethics procedure in the methodological section	"We followed the usual standards of ethical conduct (no internal Institutional Review Board was in place at the time the study was conceived). All required permits and approvals pertaining to foreign researchers were obtained. In addition, we met with village heads of all involved communities to obtain their verbal approval. All participants took part voluntarily and only after they had given oral informed consent"	Gehrig et al. (2019, 4)	*Plos One* Employs an ethics team: "...a central Publication Ethics team comprised of Editors who have scientific and editorial expertise as well as specialised expertise in the policies, workflows, and industry-wide guidance pertaining to ethics and integrity issues"
Expressing government approval to conduct the research	"Kenya's Office of Science and Technology provided research clearance"	Cinner et al. (2009, 129)	*Conservation Biology* Encourages authors to follow the Society for Conservation Biology Code of Ethics
Reporting institutional clearance of ethics evaluation, within a customised 'ethics statement' section while also referring to a higher standard or requirement	"This study was carried out in accordance with the recommendations of the ethics committee at the Stockholm Resilience Centre with written and/or oral informed consent from all subjects. Before any interviews or experiments took place all subjects were informed of the purpose and intent of the research and all subjects gave either written or oral informed consent in accordance with the Declaration of Helsinki. The protocol and plain language statement was approved by the ethics committee at the Stockholm Resilience Centre"	Drury O'Neill et al. (2019, 14)	*Frontiers in Marine Science* Authors need to include ethics statement in materials including an ethics approval statement and methods and follow the publication ethics section

and inclusive research in Africa, and behavioural sciences and other fields such as development studies show severe underrepresentation of researchers from developing countries (Amarante et al. 2022), even in studies on their home country. Given the need for context-specific intervention design and the limited base of knowledge regarding the suitability of behavioural economics for designing policy implementations, there is a clear need for collaborative behavioural economic research in these regions.

4.4 | Social Mechanisms for Environmental Targets

Enhancing the understanding of human behaviour can inform new approaches to fisheries issues and there is strong evidence supporting the influence of social mechanisms on environmental outcomes. The literature contains many studies of both injunctive norms (how one ought to behave) and descriptive norms (how one sees the majority behave). Additionally, the social context in which fishers make decisions restricts their capacity to act and respond to policies (Drury O'Neill et al. 2019). Voluntary programs that engage stakeholders using the collaborative principles previously discussed can be viable alternatives to highly restrictive management policies (e.g., Bethoney et al. 2017) and processes that involved fishers in policy design (such as co-management and cooperation) were found to be effective in achieving desired environmental outcomes (as in Day et al. 2014). Pro-environmental education programs, marketing campaigns, and activities such as social learning can be effective in changing fisher behaviour and achieving environmental outcomes, especially when coupled with longer term strategies of additional activities such as increased fisheries use rights, long-term monitoring and evaluation, and identifying continuous funding resources (Day et al. 2014). Community-based institutions and adaptive co-management in fisheries management that increase transparency were frequently highlighted as promoting sustainable resource use (Cote et al. 2021; Eriksson et al. 2015; Ertör-Akyazi 2019; Finkbeiner et al. 2018). Demographics, community make-up, and individual preferences showed important consequences for ecological sustainability (Barnes et al. 2016; Fitzpatrick et al. 2017; Fujitani et al. 2018). Social networks and communication between fishers (Barnes et al. 2016; Cox et al. 2016; Finkbeiner et al. 2018) as well as education (Ram-Bidesi 2015; Sánchez-Jiménez et al. 2021) were shown to play an important role in improving sustainability. Yet fisheries management tools are overwhelmingly based on leveraging governance, economic, and informational influence mechanisms to change behaviour. Acknowledging the human dimension of fisheries management and tapping into social norms may lead to improved economic outcomes and these gains may be greater than those achieved by increased regulation and enforcement (Arroyo Mina et al. 2016; Ertör-Akyazi 2019; Lopez et al. 2012; Stevens et al. 2015).

4.5 | Policy and Management Recommendations

While 'top-down' policy instruments such as penalties are often employed in fisheries management, this review showed that there may be cases where 'bottom-up' behavioural mechanisms such as injunctive and descriptive social norms could be more efficient than the status quo. Other studies show that behavioural interventions can be complementary, enhancing top-down policies and interventions through tools such as workshops and scenario deliberation (Sánchez-Jiménez et al. 2021) or by paying greater attention to the role of gender (Drury O'Neill et al. 2019; Revollo-Fernández et al. 2016). Behavioural economics principles can also improve existing community-based resource management approaches. Examples include 'perception experts' from within the community to ensure stakeholders' concerns are addressed (Beyerl et al. 2016), and using participatory and social learning processes to improve the effectiveness of monitoring and regulation (Brewer 2013).

In the literature, changes in behaviour and related outcomes were often observed as incidental findings rather than targeted interventions, making policy evaluation difficult. Any policy-oriented study of fisher behaviour should therefore conceptualise the connection between the proposed policy intervention and the behavioural mechanism it aims to activate. Along with this robust study design and conceptualisation, more deliberate monitoring before, during, and after policy interventions is also necessary. For example, it would be useful to establish baseline measurements before implementing any change to policy. To complement the baseline indicators, an interdisciplinary monitoring framework should be established to enable long-term assessment of intervention effectiveness, which can include strategies for identifying and securing stable and long-term financial resources for monitoring. Establishing control sites, where the intervention will not be applied, can help in determining whether the policy instrument used was successful or not, thus making the less accurate post-intervention counterfactual analysis redundant. Furthermore, interventions may have diminishing effectiveness over time. For example, the end of the fishing season may be a constraining factor in cooperative bycatch avoidance programmes (Haynie et al. 2009) or social norms may change, reducing the effectiveness of non-monetary (dis)incentives (de Melo and Piaggio 2015). Enforcement is also a challenge, with compliance and risk aversion declining over time in marine protected areas without sufficient monitoring (Fujitani et al. 2012).

These challenges of measurement, design, and enforcement can be addressed by co-producing and prioritising context-specific indicators in collaboration with relevant stakeholders. Such a co-design process would identify context-specific behavioural mechanisms on both individual and group or fleet levels and would be beneficial to the design of the intervention itself, as well as determining its impact on relevant social, economic and environmental outcomes (see Section 3.6 and Appendix S6–S10). Behavioural sciences experts need to be better included in the design and monitoring processes so that interventions can be theoretically sound, effective, and sustainable.

5 | Limitations and Future Research

This systematic review had an ambitious scope and was conducted in a large multidisciplinary team. The methodology contained multiple calibrations to minimise and manage subjectiveness, also giving the group of co-authors a chance to address definitional issues and cross-check to ensure consistency.

Despite this, however, the consistency of the review of the literature may vary intra-individually, and the pre-registered protocol had several weaknesses. First, the online tool standardised the literature analysis among fifteen co-authors, but differences in interpretation of the data collection questions remained. Moreover, some of the predetermined categories (e.g., for the behavioural mechanisms) required amendment during the review. The protocol also predetermined the search terms, which the benchmarking exercise revealed only captured 40% of the list of pre-selected literature that the authors had deemed relevant for the review. The search was also limited to English, which, in a review of biodiversity conservation literature, excluded up to 35% of the relevant scientific documents (Amano et al. 2016). More automated approaches to systematic reviews (e.g., those that use large language models) show promise as complementary tools to improve evaluation of large bodies of literature (Schadeberg et al. 2023; Spillias et al. 2024) and may be able to overcome language barriers in the future (Khraisha et al. 2024). Finally, one intangible outcome of this review is the collective understanding of the literature and concepts among all co-authors, who are variously involved in policy-oriented research.

The interactions between behavioural economics mechanisms and other drivers of behaviour are an area that deserves a closer future research focus if policymakers and scientists are to better understand how interventions impact behaviour. Economic interventions are the mainstay of fisheries management and compliance strategies (e.g., Chang 2011; de Melo and Piaggio 2015) and these economic (dis)incentives may interact with the behavioural mechanisms that this review investigated. For instance, economic need and dependency, coupled with regulation and increased resource scarcity, can lead to higher risk-taking and affect safety at sea (Morel et al. 2008; Salas et al. 2019).

This review specifically looked at behavioural economics, but clearly other social sciences can contribute insights into the study of fisher behaviour. While quantitative methods can robustly test specific behavioural economics hypotheses or measure the impacts of interventions, such an approach lacks the ability to ask 'why' questions which are sometimes more adequately addressed by qualitative social science. Furthermore, the literature analysis did not assess how many of the research projects followed co-design and co-development principles or modes in which stakeholder groups are key in defining the problem and collaborated in instigating the research (Chambers et al. 2021; Evans and Terrey 2016; Glicken 2000; Holm et al. 2013). It is therefore worth investigating the extent to which the inter- and transdisciplinary nature of research teams impacts the robustness and effectiveness of behavioural economics interventions in fisheries.

6 | Conclusions

The budding field of fisheries behavioural economics shows promise for improving the effectiveness of programs that aim to change behaviour. The literature contains many examples of social norms, cognitive biases, and risk preferences leading to changes in social, economic, and environmental outcomes. The interventions in the literature offer alternatives to traditional fisheries management approaches that rely on rational economic theory. The abundance of real-world applications of behavioural economic theory shows that social science can engage with management science in a practical way, but the diversity of approaches and results in this review underscores the necessity of rigorous conceptual and methodological work. Working at the intersection of human behaviour and ecology, as in fisheries management, calls for interdisciplinary approaches that can take social and economic as well as environmental contexts into consideration. This body of literature shows that such an approach can do away with trade-offs and rather reveal win-win outcomes. Furthermore, the application of an adaptive transdisciplinary approach that includes stakeholders in research formulation, design, and long-term monitoring can resolve ethical issues and anticipate unintended consequences, as well as mitigate the risk of eroding the effectiveness of the intervention over time. Looking forward, researchers exploring behavioural economics in a fisheries context would benefit from coalescing around a stricter conceptual understanding of the necessary components of a study of human behaviour. Few articles in the review theorised adequately about behavioural economics mechanisms and interventions, leading to the impression that the field has developed in a rather ad hoc and reactive way. The use of unified language and concepts, as proposed above, can more effectively harmonise scientific approaches, leading to more robust policy-relevant results.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The complete list of articles included in the review, as well as data underlying the findings such as summary statistics and qualitative analyses are available as Supporting Information Appendix 1 and Data 1.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.