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A Global Review of Bycatch Reduction Technology Assessments: Revealing Gaps in Fisher-Focused Metrics

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ABSTRACT

Global fisheries support livelihoods, food security and economies, but the incidental capture of non-target species—termed bycatch—remains a key conservation challenge. We compiled peer-reviewed published studies to assess metrics used to evaluate the effectiveness of bycatch reduction technologies and gear modifications (BRTs) for reducing air-breathing marine megafauna bycatch in global passive fisheries. We assessed 196 studies, including assessments in operational fisheries and controlled experiments, from 114 published articles between 1997 and 2024. These studies tested 28 types of BRTs across five fishing gears. Changes in bycatch and target catch were assessed in 94.4% and 73% of all studies, respectively. By contrast, only 6.6% of studies assessed catch value. We identified and evaluated seven fisher-focused metrics that were divided into quantitative and anecdotal evidence describing how the application of BRTs affects fishers. Relative to quantitative assessments, 9.2% of all studies quantified effects on fishing gear, 8.7% quantified BRT cost, 4.1% quantified economic impact, 3.1% quantified fisher safety, 3.1% quantified BRT ease of use, 2% quantified operational efficiency and 1% quantified fisher perceptions of BRT efficacy. Relative to anecdotal evidence, 10.7% of all studies reported on ease of use, 7.1% on BRT cost, 6.6% on fisher perceptions of efficacy, 3.1% on effects on fishing gear, 1.5% on effects on fisher safety and 0.5% on both operational efficiency and economic impact. Across diverse regions and timeframes, our analysis highlights a persistent lack of fisher-focused metrics in BRT research, emphasising the need for more holistic evaluations that consider fisher wellbeing.

1 | Introduction

Fisheries are ubiquitous throughout the world's oceans and have a major role in people's food supply, food security and income (Asche et al. 2015; Basurto et al. 2025). In addition to economic revenue and nutrition, fisheries are integral to the human culture and traditions of many coastal communities. Commercial fisheries are typically sorted into industrial or small-scale depending on the level of mechanisation, geographical location, access to fishing zones, target species and gear types. While both types of fisheries contribute comparable amounts to producing the world's fish catch, small-scale fisheries employ over

90% of the world's fishers (Béné et al. 2007; Berkes 2001; Viridin et al. 2023).

A prevalent issue common among most (though not all; e.g., harpoon, troll, pole and line and handline) global fisheries is the incidental capture of non-target species (i.e., bycatch). In particular, the bycatch of air-breathing marine megafauna, including sea turtles, seabirds and marine mammals, can be extensive (Alfaro-Shigueto et al. 2010; D'agrosa et al. 2000; Lewison et al. 2004; Majluf et al. 2002; Peckham et al. 2016; Read et al. 2006; Senko, White, et al. 2014; Shester and Micheli 2011; Temple et al. 2021). Bycatch of other organisms, such as bony

fish, elasmobranchs, sea snakes and invertebrates also occurs (Boyle et al. 2016; Cook et al. 2022; Morgan et al. 2010; Oliver et al. 2015; Rao et al. 2021; Van Cao et al. 2014); however, we focus on air-breathing marine megafauna (i.e., sea turtles, marine mammals and seabirds) given their globally ubiquitous bycatch and resulting well-documented population-level impacts (Peckham et al. 2007, 2008; Mancini et al. 2012; Senko, Mancini, et al. 2014; Senko, White, et al. 2014; Taylor et al. 2017). Passive fishing gear such as gillnets, longlines, pound nets, traps and pots can be especially problematic for air-breathing species since they are stationary and in many cases, can remain submerged for extended periods—ranging from hours to even days—during which species may become entangled or entrapped and drown. Moreover, these fisheries tend to be prevalent in regions with limited resources to monitor and manage fisheries bycatch (Shester and Micheli 2011). Although we focus on passive gear, mobile gear can also result in bycatch of at-risk-species, such as elasmobranch and sea turtle bycatch in tuna purse-seine and shrimp trawl fisheries, respectively (Duffy et al. 2019; Finkbeiner et al. 2011).

Several strategies, such as time-area closures, gear switches, bycatch quotas and gear modifications, have been used to address marine megafauna bycatch in both small and industrial-scale fisheries (Senko, White, et al. 2014). In particular, the development of technological and non-technological bycatch reduction tools (hereafter coupled and referred to as BRTs) is a promising approach for mitigating the bycatch of vulnerable marine megafauna species because they address the threat of bycatch across space and time (Lewison et al. 2014; Senko, White, et al. 2014). For example, illuminating nets with LED lights or glowsticks has been shown to reduce sea turtle, seabird, elasmobranch and cetacean bycatch (Almeida et al. 2017; Bielli et al. 2020; Darquea et al. 2020; Gautama et al. 2022; Kakai 2019; Mangel et al. 2018; Ortiz et al. 2016; Senko et al. 2022; Snape et al. 2024; Virgili et al. 2018; Wang et al. 2013; Wang et al. 2010). Other gillnet BRTs include acoustic pingers (Barlow and Cameron 2003; Bordino et al. 2004; Gönener and Bilgin 2009) and echolocation reflectivity (Kratzer et al. 2020; Kratzer et al. 2021; Mooney et al. 2007) to reduce marine mammal bycatch in gillnets. In longline fisheries, converting from J-hooks to circle hooks can reduce sea turtle bycatch (Reinhardt et al. 2018; Sales et al. 2010; Watson et al. 2005), and Hookpods have been developed to release baited hooks at prearranged water depths to mitigate seabird bycatch (Goad et al. 2019; Silva-Costa et al. 2017; Sullivan et al. 2018). Moreover, there are also non-technical methods that involve modifying fishers' current fishing gear or using different fishing techniques, such as reducing the number of buoys attached to the float line of bottom-set gillnets (Peckham et al. 2016), modifying fishing bait (Echwikhi et al. 2010; Swimmer et al. 2005; Watson et al. 2001; Yokota et al. 2009), night setting, side-setting, adding bird-scaring lines/tori lines or weighted lines in longline fisheries to reduce seabird bycatch (Cortes and Gonzalez-Solis 2018; Domingo et al. 2017; Gilman et al. 2008, 2021; Jiménez et al. 2020; Løkkeborg 2011; Melvin et al. 2013; Santos et al. 2019).

Despite the promising efficacy of the aforementioned BRTs, there is a growing body of literature on tradeoffs due to multispecies conflict that result from these modifications. For example, pingers on gillnets have been shown to reduce bycatch

of marine mammals while increasing target catch, which could lead to overfishing of target species (Gönener and Bilgin 2009). Although circle hooks have been effective at reducing sea turtle hooking rates, they have also resulted in increases in target catch of sharks (Andraka et al. 2013; Lima et al. 2023; Sales et al. 2010). Similarly, the use of an underwater shooter designed to reduce bycatch of diving seabirds resulted in a 20% increase in target catch (Gilman et al. 2003). These multispecies conflicts highlight the need to better understand the potential unintended consequences of modifying fishing gear.

With the continuing development of BRTs, experimental testing is required to understand how BRTs perform under diverse fishing conditions and how fisheries operations may be impacted. To further our understanding of the efficacy and adoption potential of BRTs, it is imperative to assess metrics not only related to the use of BRTs during fishing operations, but also their potential impact on fishers and their livelihoods. For example, Senko et al. (2022) found that illuminated nets reduced mean haul back time by over 50% compared to fishing with traditional nets, while the use of pingers resulted in reduced net damages compared to nets without pingers (Gönener and Özdemir 2012). These findings suggest that BRTs can aid fishers in ways that may be useful—especially since fishery interactions with marine megafauna can be costly due to gear damage (Panagopoulou et al. 2017). In many cases, particularly in small-scale fisheries of developing nations that often lack adequate bycatch regulations, the integration of BRTs may offer fishers an alternative way to continue to fish without the restrictions and negative consequences associated with bycatch (e.g., see Senko, White, et al. 2014, 2017). Regardless, the extent to which BRTs may impact fishery operations and fisher outcomes requires further investigation.

In this paper, we collate peer-reviewed published studies that tested BRTs on air-breathing marine megafauna (i.e., marine mammals, seabirds and sea turtles) in passive fisheries worldwide. Prior reviews have focused on investigating species-specific BRTs (Bull 2007; Gilman et al. 2010; Hamilton and Baker 2015), sensory-based BRTs (Lucas and Berggren 2022), BRTs across fishing gears (Werner et al. 2006) and fisher uptake of BRTs (Campbell and Cornwell 2008; Suuronen 2022). Here, we sought to identify what metrics were used to assess the effectiveness of BRTs for passive fisheries worldwide. As the development of BRTs presents an opportunity for fisheries to mitigate bycatch, the types of assessments performed during testing of BRTs can play an important role in their adoption.

2 | Methods

We conducted a literature review to evaluate information on assessments of BRTs and gear modifications deployed for air-breathing marine megafauna in the following passive fisheries: gillnets, longlines, trammel nets, pots and traps (which include pound nets). Sea turtles included all seven species (Mazaris et al. 2017; Murray 2009), seabirds included all of the 414 species described in Ryan (2018) and marine mammals included cetaceans, pinnipeds (i.e., sea lions, seals and walrus), sirenians (i.e., manatees and dugongs), sea otters and polar bears (Lewison

et al. 2014; Northridge et al. 2013; Senko et al. 2020). While we recognize that bycatch of elasmobranchs, finfish and invertebrates is also concerning, we decided to exclude these groups as they are often targeted or retained in commercial fisheries.

Using Google Scholar and the Consortium for Wildlife Bycatch Reduction database, the latter of which compiles bycatch reduction studies according to fishing gear, bycatch species, bycatch reduction technique and field and non-field studies, we searched for peer-reviewed articles published between 1997 and 2024 (our last search was conducted on November 1st, 2025). Studies collected from Google Scholar made up 65.8% ($n = 75$ studies), while 34.2% ($n = 39$ studies) were found using the Consortium for Wildlife Bycatch Reduction database. The following terms were searched independently and then combined using AND/OR operators: bycatch reduction technolog* OR mitigation* and gear modifi* OR technolog* (* indicates a wildcard). Alongside each search term, we also incorporated the relevant fishery of interest including gillnet, longline, pound net, trammel net, trap and pot (i.e., gillnet bycatch reduction technology, gillnet gear modification, longline bycatch reduction technology). We then included search terms for the taxon of interest including marine mammal, cetacean, whale, dolphin, porpoise, seal, sea lion, walrus, dugong, manatee, sea cow, sea otter, turtle, crocodile/crocodilian, seabird, sea duck and marine bird (i.e., gillnet bycatch reduction technology marine mammal, longline gear modification seabird, pound net bycatch reduction technology sea turtle). We also cross referenced our studies to those listed in a recent literature review examining marine megafauna BRTs, finding no additional studies (i.e., Lucas and Berggren 2022).

Each study was evaluated and filtered using the title and abstract. We removed cases where BRTs were not specifically employed to reduce bycatch of air-breathing marine megafauna in passive fisheries. Given that bycatch can be evaluated in several ways, such as a reduction in net interactions (e.g., approaching the net, bycatch probability, bycatch per unit effort, mortality rates), we included all relevant studies that met our search criteria. Our synthesis focused on primary research articles and did not include review papers. We included assessments of BRTs in operational fisheries (i.e., studies that were conducted with fishers who were legally fishing; e.g., Ortiz et al. 2016) and field-based controlled experiments (i.e., studies conducted under controlled conditions; e.g., Senko et al. 2022). Across these studies, data were captured ranging from on-board researchers, observer programs, electronic monitoring and standardised catch models to experimental trials aimed to test BRT performance under varying field conditions. However, we did not include studies that were conducted in a laboratory setting or assessed how an animal interacted with a certain technology or gear modification strictly from a behavioural standpoint with no interaction with experimental or actual fishing gear (e.g., see Monteiro-Neto et al. 2004). Each study in our analysis had to specifically assess the performance of one or more BRT in order to be included and we only used studies published in English.

In each study, we collected fishing data (gear type and BRT used), sampling procedure (methods, number of replicates, effort) and catch data (target and bycatch species composition, changes in target and bycatch, catch value and changes in catch regarding weight, length or condition). Target catch and bycatch

were assessed according to the species or taxonomic group identified by the study authors. Studies that reported changes in target catch and effects on other commercial species were included in our analysis. BRT effects in target catch and other commercial species were reported as mean catch rate, catch rate, or as quantities not standardised to a rate. We also collected spatial and temporal information and used the 2022 United Nations Country Classification to determine if the study was conducted in a nation with a developing or developed economy (United Nations 2022).

Changes in bycatch rates, target catch rates and catch value (i.e., performance metrics) across BRTs were classified as reduced, increased, mixed effects (i.e., inconsistent results), diminished effect over time (i.e., BRT initially showed to be effective, but decreased over time), an increase in at least one species with a reduction in at least one species, no change (no significant difference), no change in at least one species with an increase in at least one species, no change in at least one species with a reduction in at least one species or not assessed (the study did not collect enough data to draw a conclusion or no data were collected). Individual studies could contain multiple target and bycatch species. When an individual study tested more than one BRT, or multiple variations of the same BRT, we assessed each experiment separately while keeping the relevant study variables the same (e.g., fishing gear type, target and bycatch species).

Within each study, we identified any additional assessments relating to how the BRT could impact the fisher, compiling these findings into a list of fisher-focused metrics (i.e., economic impact, BRT cost, operational efficiency, ease of use, fishing gear effects, fisher safety, fisher perceptions of BRT efficacy; see Table 1 for definitions and examples of each fisher-focused metric). After individually reviewing each study and establishing a final set of fisher-focused metrics, all studies were re-evaluated to ensure the presence or absence of each metric for quality assurance. For BRT studies that included fisher-focused metrics, we assigned data into quantitative or anecdotal evidence. Each metric was assigned a 'yes' if evidence was reported, or a 'no' if absent. To receive a 'yes' in quantitative metrics, the study collected and analyzed data during the BRT experiment (e.g., haulback time was recorded and compared among net types). To receive a 'yes' in anecdotal metrics reported feedback, comments, or observations were made by researchers or fishers involved in the BRT study (e.g., fishers stated the BRT was easy to install). When studies reported multiple findings for the same metric, the information was counted only once. However, if studies conducted multiple experiments and reported similar findings across experiments, we applied the information to each experiment.

3 | Literature Review Results

3.1 | Overview of Peer-Reviewed Published Studies Testing BRTs in Global Passive Fisheries

To obtain a comprehensive understanding of a BRT's efficacy, it is essential to assess a variety of fishery metrics. We observed three assessments of performance metrics: (1) change in bycatch; (2) change in target catch; and (3) change in catch value.

TABLE 1 | Quantitative and anecdotal definitions of each fisher-focused metric assessed in peer-reviewed, published BRT studies.

Fisher-focused metric	Quantitative definition	Quantitative example	Anecdotal definition	Anecdotal example
Economic impact	Researchers quantified economic changes, such as annual profits or cost estimates when using BRTs	'...the gross return for a trap without an (acoustic harassment device) would be about €2600, and for a trap with an (acoustic harassment device), €5200'. (Fjälling et al. 2006)	Researchers described statements on the potential economic impact to the fishery or the fisher when using BRTs	'The tested circle hooks impacted the same size classes of bluefin tuna...thus they seem to ensure that the economic gain is maintained'. (Cambiè et al. 2012)
BRT cost	Researchers quantified implementation or maintenance costs associated with the BRT	'The costs to implement the tori lines are US \$380...'. (Mancini et al. 2009)	Researchers described potential implementation or maintenance costs associated with the BRT	'New buoyless nets are less expensive than conventional because the cost of the buoys is saved (~20% of total net cost)'. (Peckham et al. 2016)
Operational efficiency	Researchers quantified operational changes relating to the handling and processing of fish catch, including hauling time/retrieval time, sorting time and hours at sea	'Illuminated nets significantly reduced the mean haulback time (minutes required to retrieve and disentangle all bycatch and target catch per 100 m gillnet) by 57%'. (Senko et al. 2022)	Researchers described operational changes from field observations or fisher feedback relating to the handling and processing of fish catch, including hauling time/retrieval time, sorting time and hours at sea	'...hauling of the folded-hoop trap, especially in poor weather condition, was more difficult than that of pontoon trap'. (Suuronen et al. 2006)

(Continues)

TABLE 1 | (Continued)

Fisher-focused metric	Quantitative definition	Quantitative example	Anecdotal definition	Anecdotal example
Ease of use	Researchers quantified aspects relating to the feasibility of the BRT, including the time it took to instal the technology and the learning curve associated with its use	'When researchers observed that weighted branch lines might be tangling more...they began recording the numbers of tangled branch lines...' (Melvin et al. 2014)	Researchers described aspects relating to the feasibility of the BRT from field observations or fisher feedback, including preparation for installation, training and challenges	'LEDs were relatively easy to clip on the float line and remained illuminated throughout the trials'. (Senko et al. 2022)
Fishing gear effects	Researchers quantified aspects relating to how the BRT affected fishers' fishing gear, such as gear damage, gear loss, or changes in bait loss	'...69.8% less net damage was reported from active (pinger) nets (compared to control nets)...' (Gönener and Özdemir 2012)	Researchers described how the BRT affected fishers' fishing gear, such as gear damage, gear loss, or changes in bait loss from field observations or fisher feedback	'There were no incidents of tori lines breaking (during the experiment)'. (Gilman et al. 2021)
Fisher safety	Researchers quantified aspects relating to fisher safety and welfare when using the BRT	'No flybacks occurred during the observation of 26,377 hooks through 32 hauling operations...' (Santos et al. 2019)	Researchers described how the BRT affected aspects relating to fisher safety from field observations or fisher feedback	'Fishers shared they recognised the safety benefits of LEDs as capturing leatherbacks brought the risk of boats being turned over'. (Allman et al. 2021)
Fisher perceptions of efficacy	Researchers quantified aspects relating to fishers' perceptions of the efficacy or overall use of the BRT	'A small percentage of fishermen (8% of the entire sample) were in favour of shifting to 16/0 circle hooks...' (Piovano, Basciano, et al. 2012)	Researchers described fisher observations or opinions on the efficacy or overall use of the BRT	'The fishermen involved in the study were satisfied with the catch performance of the experimental leaders'. (Silva et al. 2011)

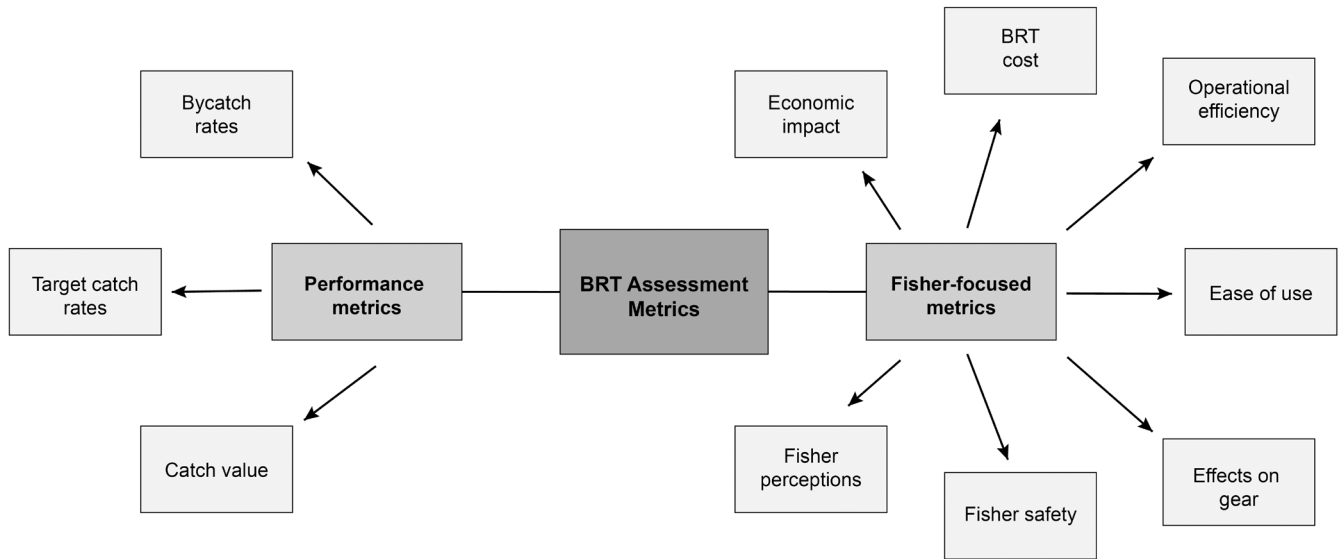


FIGURE 1 | Conceptual map displaying all assessment metrics (10) observed and identified across 196 studies evaluating BRTs for air-breathing marine megafauna in global passive fisheries from 114 peer-reviewed publications from 1997 to 2024. Two assessment categories were observed: (1) performance metrics (bycatch rates, target catch rates, and catch value); and (2) fisher-focused metrics (economic impact, BRT cost, operational efficiency, ease of use, effects on gear, fisher safety and fisher perceptions).

Changes in bycatch and target catch were evaluated in 94.4% and 73% of all experiments, respectively. In contrast, catch value was examined in only 6.6% of studies. We then identified seven fisher-focused metrics (see Table 1). We present a conceptual map outlining all assessment metrics we identified in our review to help guide future experimental studies and evaluations of BRTs (Figure 1). The following sections provide a detailed discussion for each metric identified and key findings. The list of all published studies used in our synthesis can be found in the [Supporting Information](#) (Dataset S1).

Most experiments were on longline fisheries ($n=88$ for pelagic, $n=24$ for demersal, $n=1$ unspecified), followed by gillnet fisheries ($n=49$ for bottom-set, $n=17$ for surface-set (drift)), traps ($n=9$), pots ($n=4$) and trammel net fisheries ($n=5$). Most experiments were conducted in North America ($n=52$; 26.5% of all 196 studies), Europe ($n=51$; 26% of all 196 studies) and South America ($n=43$; 21.9% of all 196 studies), with the remaining experiments conducted in Africa ($n=18$; 9.2% of all 196 studies), Asia ($n=14$; 7.1% of all 196 studies), Mediterranean region ($n=8$; 4.1% of all 196 studies), open ocean ($n=7$; 3.6% of all 196 studies) and Australia and Oceania ($n=5$; 2.6% of all 196 studies; Figure 2). We found a similar number of peer-reviewed published studies testing BRTs for air-breathing marine megafauna that occurred in developed ($n=61$) and developing nations ($n=47$). However, study coverage in developing countries was uneven, with most studies occurring in a few nations, such as South Africa, Peru and Brazil, while several major fishing countries (e.g., India, Thailand, Colombia) had no studies. The uneven representation among developing countries may be due to language biases in reporting or logistical constraints, such as limited resources.

We identified a total of 28 BRTs across the 196 studies from 114 peer-reviewed published studies, 12 of which were

sensory-dependent (Figure 3). Forty-two published studies reported on more than one BRT experiment, in which each experiment was assessed separately. Acoustic deterrents ($n=36$; 18.4% of all 196 studies) and circle hooks ($n=34$; 17.3% of all 196 studies) were employed in most experiments, while the remaining studies used net illumination ($n=20$; 10.2% of all 196 studies), tori lines ($n=18$; 9.2% of all 196 studies), weighted lines ($n=13$; 6.6% of all 196 studies), underwater shooters ($n=9$; 4.6% of all 196 studies), bait type ($n=8$; 4.1% of all 196 studies), night setting ($n=7$; 3.6% of all 196 studies), bait colour change ($n=6$; 3.1% of all 196 studies), echolocation ($n=6$; 3.1% of all 196 studies), net sleeves ($n=5$; 2.6% of all 196 studies), seal-safe net traps ($n=5$; 2.6% of all 196 studies), contrast panels ($n=5$; 2.6% of all 196 studies), hook type ($n=4$; 2% of all 196 studies), added mesh panels ($n=3$; 1.5% of all 196 studies), multi-tool approaches ($n=2$; 1% of all 196 studies), olfactory deterrents ($n=2$; 1% of all 196 studies), seal excluder devices ($n=2$; 1% of all 196 studies), sea lion excluder devices ($n=2$; 1% of all 196 studies), modified monofilaments ($n=1$; 0.5% of all 196 studies), buoyless nets ($n=1$; 0.5% of all 196 studies), hook colour ($n=1$; 0.5% of all 196 studies), leader length ($n=1$; 0.5% of all 196 studies), looming-eyes buoys ($n=1$; 0.5% of all 196 studies), subsurface net setting ($n=1$; 0.5% of all 196 studies), scarybird ($n=1$; 0.5% of all 196 studies) and side-setting ($n=1$; 0.5% of all 196 studies; Figure 4; Dataset S1). BRTs were tested on seabirds ($n=85$; 43.4% of all 196 studies), followed by sea turtles ($n=68$; 34.7% of all 196 studies) and marine mammals ($n=63$; 32.1% of all 196 studies). We were unable to find studies on crocodilians that met our inclusion criteria. In 17 experiments, BRTs were tested on more than one taxonomic group. Target catches consisted of bony fish ($n=173$; 88.3% of all 196 studies), elasmobranchs ($n=49$; 25% of all 196 studies) and crustaceans ($n=3$; 1.5% of all 196 studies), with 9.7% ($n=19$) of studies not specifying target catch.

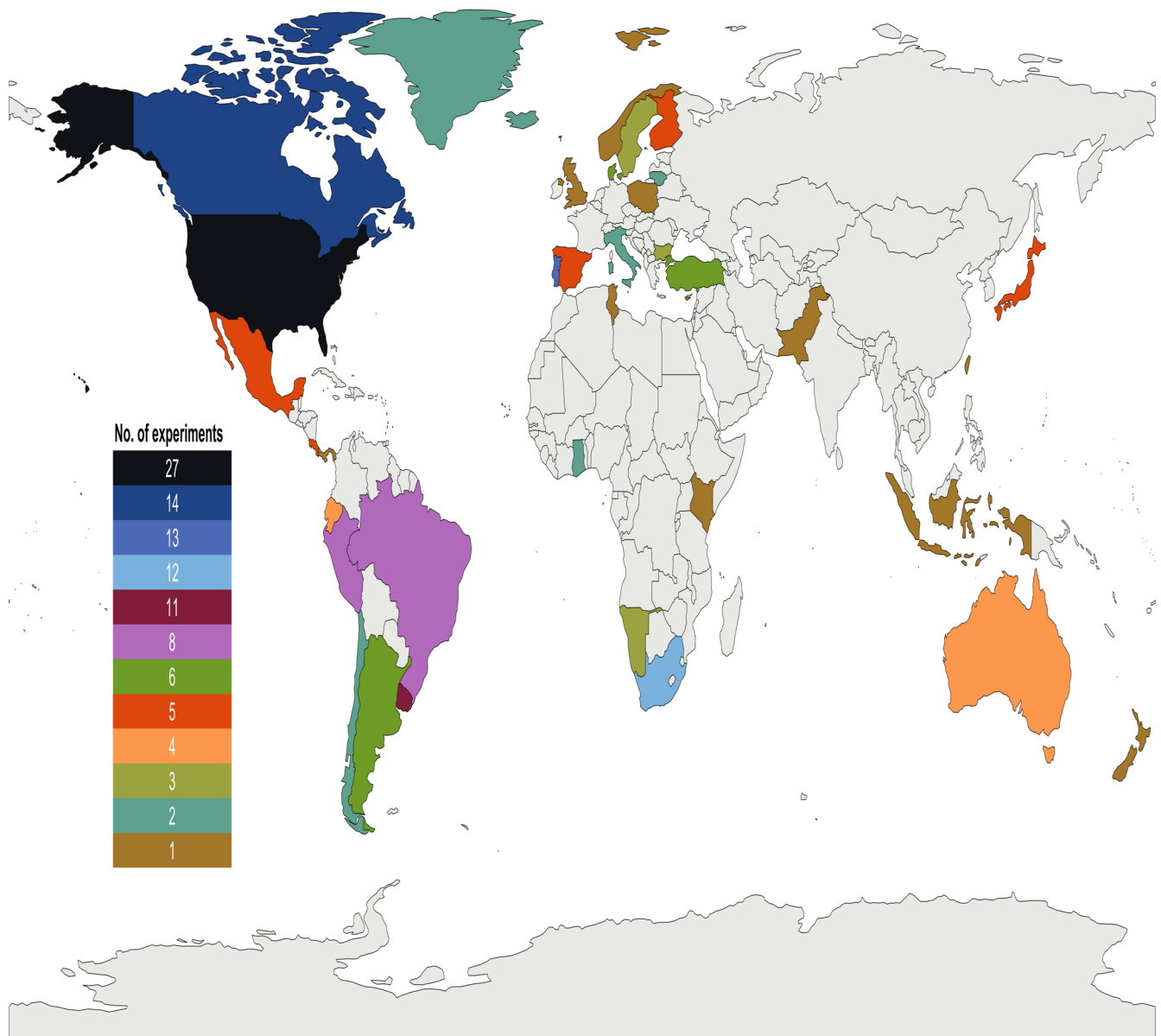


FIGURE 2 | Global distribution of findings from 196 BRT studies on air-breathing marine megafauna in global passive fisheries, based on 114 peer-reviewed studies published between 1997 and 2024. The number of studies observed per published paper conducted per country is represented by different colours.

3.2 | BRT Performance Metrics

3.2.1 | Changes in Bycatch

BRTs were developed to mitigate capture of non-target species. Assessing the extent to which they are able to reduce bycatch is required to understand their effectiveness. We found 66.3% ($n=130$) of studies reported a reduction in air-breathing marine megafauna bycatch, 18.9% ($n=37$) indicated no change, 5.1% reported mixed results, 5.6% ($n=11$) did not assess bycatch, 3.6% ($n=7$) reported an increase, 2.6% ($n=5$) reported no change in at least one species with a reduction in at least one species, 1.5% ($n=3$) reported an increase in at least one species with a reduction in at least one species, 1% ($n=2$) reported diminished effects over time, and 0.5% ($n=1$) reported mixed effects. All studies testing night setting ($n=7$),

net sleeves ($n=5$), multi-tool approaches ($n=2$), buoyless nets ($n=1$), leader lengths changes ($n=1$), seal excluder devices ($n=2$), subsurface net setting ($n=1$) and net side-setting ($n=1$) reported a 100% reduction in bycatch (Figure 4a). Similarly, 77.8% ($n=8$) of studies testing bait type reported a reduction in bycatch, along with 77.8% ($n=18$) of studies testing tori lines, 75% ($n=15$) testing net illumination, 67.7% ($n=34$) testing circle hooks, 66.7% ($n=24$) testing acoustic deterrents, 66.7% ($n=2$) testing added mesh panels, 60% ($n=3$) testing seal-safe trap nets, 55.6% ($n=5$) testing underwater shooters, 53.9% ($n=7$) testing weighted lines, 50% ($n=1$) testing olfactory deterrents, 40% ($n=2$) testing contrast panels and 33.3% ($n=2$) testing bait colour (Figure 4a).

While the primary goal of these studies is to reduce bycatch using innovative tools and modifications, several studies found

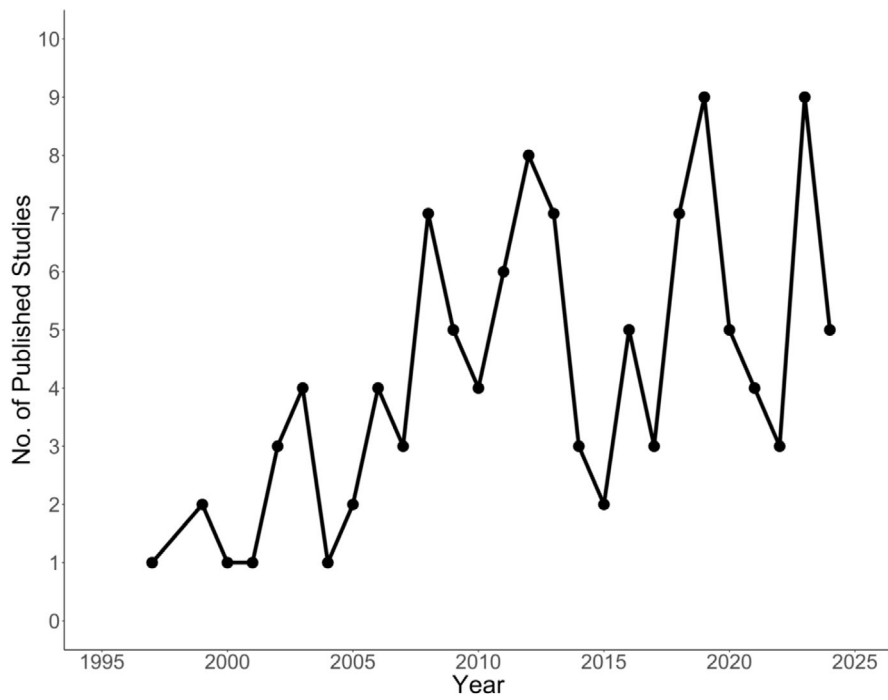


FIGURE 3 | Timeline overview of 114 peer-reviewed published studies between 1997 and 2024 testing the efficacy of BRTs for air-breathing marine megafauna in global passive fisheries.

no changes in bycatch when using BRTs. For example, single studies testing looming-eye buoys and modified monofilaments reported no changes in bycatch (Figure 4a). Similarly, no changes in bycatch were reported in 66.7% ($n=4$) of experiments testing modified bait colour, 50% ($n=3$; 1, respectively) testing echolocation and olfactory deterrents, 46.2% ($n=6$) testing weighted lines, 40% ($n=2$) testing seal-safe trap nets, 25% ($n=1$) testing hook types, 20.6% ($n=7$) testing circle hooks, 15% ($n=3$) testing net illumination, 13.9% ($n=5$) testing acoustic deterrents and 11.1% ($n=2$; 1, respectively) testing tori lines and underwater shooters (Figure 4a). In other studies, reported increases in bycatch were found when using BRTs. The single study testing longline lengths reported an increase in bycatch, as did 25% ($n=1$) of studies testing hook type, 20% ($n=1$) testing contrast panels, 11.1% ($n=1$) testing underwater shooters, 10% ($n=2$) testing net illumination and 5.6% ($n=1$) testing tori lines (Figure 4a). No changes in at least one bycatch species with a reduction in at least one bycatch species was reported in the single scarybird study, 33.3% ($n=1$) testing added mesh panels and 5.6% ($n=2$; 1, respectively) testing acoustic deterrents and underwater shooters. An increase in at least one bycatch species with a reduction in at least one bycatch species was reported in 11.1% ($n=1$) of studies testing underwater shooters and 5.5% ($n=2$) testing acoustic deterrents (Figure 4a). Mixed effects were reported in 5.5% ($n=1$) of studies testing tori lines and diminished effects of BRTs over time were reported in 50% ($n=1$) of sea lion excluder device studies (Figure 4a).

3.2.2 | Changes in Target Catch

Implementing BRTs in fishing activities may alter fishers' target catch. We found 43.4% of all BRT studies reported no change in target catch rates, 16.6% reported mixed results, 9.1% reported

an increase in at least one target species with a reduction in at least one target species, 8.7% reported a reduction, 7.7% reported an increase, 3.1% reported no change in at least one target species with an increase in at least one target species, 1% reported no change in at least one target species with a reduction in at least one target species and 27% studies did not assess target catch. Seal excluder devices ($n=2$), buoyless nets ($n=1$), leader length ($n=1$), looming-eyes buoys ($n=1$), scarybird ($n=1$), subsurface net setting ($n=1$) and net side setting ($n=1$) all reported no change in target catch rates compared to control nets (Figure 4b). In remaining studies, no change in target catch was reported in 90% ($n=18$) of experiments testing net illumination, 84.6% ($n=11$) testing weighted lines, 80% ($n=4$) testing seal-safe trap nets, 66.7% ($n=4$) testing echolocation, 52.8% ($n=19$) testing acoustic deterrents, 50% ($n=2$; 2; 1, respectively) testing hook type, sea lion exclusion devices and olfactory deterrents, 44.4% ($n=4$) testing underwater shooters, 33.3% ($n=1$) testing added mesh panels, 20% ($n=1$) testing net sleeves, 16.7% ($n=1$) testing bait colour, 14.3% ($n=1$) testing night setting, 12.5% ($n=1$) testing bait type, 11.8% ($n=4$) testing circle hooks and 5.6% ($n=1$) testing tori lines (Figure 4b).

Few studies showed an increase in target catch when using BRTs, including the single study on modified monofilaments. Additionally, 16.7% ($n=1$) of studies testing bait colour reported an increase in target catch, 13.9% ($n=5$) in testing acoustic deterrents, 12.5% ($n=1$) testing bait type, 11.8% ($n=4$) testing circle hooks and 11.1% ($n=2$; 1, respectively) in testing tori lines and underwater shooters (Figure 4b). Alternatively, several BRT studies reported a reduction in target catch, such as 80% ($n=4$) of studies testing net sleeves, 66.7% ($n=2$) testing added mesh panels, 50% ($n=1$) testing sea lion excluder devices, 25% ($n=2$; 1, respectively) testing bait type and hook type, 20% ($n=1$; 1, respectively) in testing contrast panels and seal-safe trap nets,

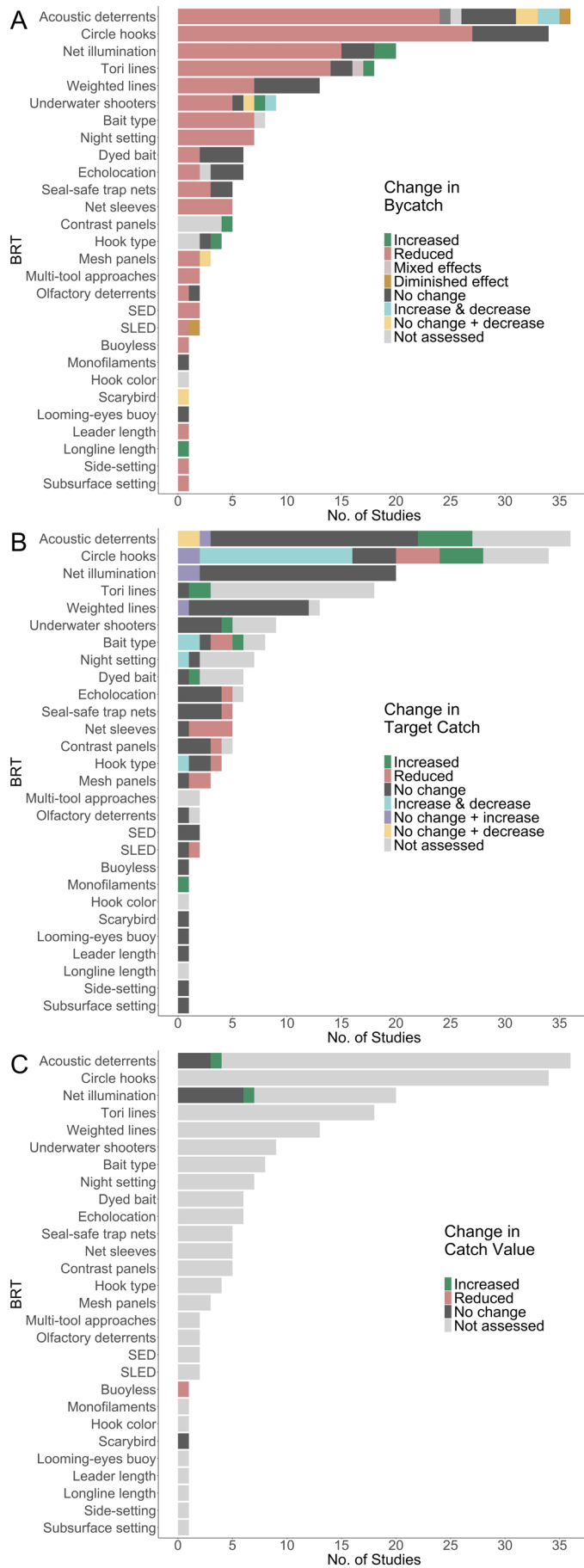


FIGURE 4 | Legend on next page.

FIGURE 4 | Results overview of the three performance metrics assessed for marine megafauna BRTs ($n = 196$) using passive fishing gear in global fisheries from peer-reviewed published studies published between 1997 and 2024 ($n = 114$). Comparisons of reported study results for change in bycatch (A), target catch (B) and catch value (C) are provided for each BRT (bycatch reduction technology or modification) identified. We list the BRTs based on the greatest number of experiments to the fewest in each assessment type. Changes are reported in colour as increased (green), reduced (red), mixed effects (pale purple), diminished effect over time (gold), increase in at least one species with a reduction in at least one species (light blue), no change in at least one species with an increase in at least one species (purple), no change in at least one species with a reduction in at least one species (yellow), no change (dark grey) or not assessed (light grey) corresponding to each metric type.

16.7% ($n = 1$) testing echolocation and 11.8% ($n = 4$) testing circle hooks (Figure 4b). An increase in at least one target species with a reduction in at least one target species was reported in 41.2% ($n = 14$) studies testing circle hooks, 25% ($n = 2; 2$, respectively) testing bait type and hook type and 14.3% ($n = 1$) testing night setting (Figure 4b). No change in at least one target species with an increase in at least one target species was reported in 10% ($n = 2$) of studies testing net illumination, 7.7% ($n = 1$) testing weighted lines, 5.9% ($n = 2$) testing circle hooks and 2.8% ($n = 1$) testing acoustic deterrents (Figure 4b). No change in at least one target species with a reduction in at least one target species was reported in 5.6% ($n = 2$) of studies testing acoustic deterrents (Figure 4b).

3.2.3 | Changes in Catch Value

Evaluating effects on catch value can help understand the potential economic impact of fishing with a given BRT. However, unlike catch rates (see paragraph above), we found only 6.6% of BRT studies assessed changes in catch value: 5.1% reported no change, 1% reported an increase and 0.5% reported a reduction. Of these studies, 30% ($n = 6$) of net illumination experiments reported no change and 5% ($n = 1$) reported an increase (Figure 4c). Notably, one net illumination study found a 15% significant increase in target fish catch value (Gautama et al. 2022). Additionally, 8.3% ($n = 3$) of acoustic deterrent experiments also reported no change, and 2.8% ($n = 1$) reported an increase (Figure 4c). The single study testing scarybird, a device representing a bird of prey shape, found no change in catch value. In contrast, the buoyless net study reported a reduction in catch value (Peckham et al. 2016; Figure 4c). We also found that 15.8% ($n = 31$) of all studies reported a change in the state of fish catch weight, size or condition.

3.3 | Fisher-Focused Metrics in Assessments of BRTs

In addition to evaluating BRT performance metrics, we identified additional metrics that could provide insight into how BRTs impact fishers. For each fisher-focused metric identified, we made the distinction between quantitative and anecdotal evaluations in BRT experiments. For quantitative assessments, 9.2% quantified effects on fishing gear, 8.7% of experimental studies quantified BRT cost, 4.1% quantified the economic impact, 3.1% quantified fisher safety, 3.1% quantified BRT ease of use, 2% quantified operational efficiency and 1% quantified fishers' perception of BRT efficacy (Figure 5). For anecdotal evidence, 10.7% of experimental studies reported on the ease of use, 7.1% on BRT cost, 6.6% on fisher perceptions of efficacy, 3.1% on effects on

fishing gear, 1.5% on effects on fisher safety and 0.5% on both operational efficiency and economic impact (Figure 5). Below, we highlight each identified fisher-focused metric assessed in at least one of the studies we reviewed in our analysis.

3.3.1 | Economic Impact

Understanding the broader economic impact of fisheries is essential for assessing how fishers' annual profits and cost estimates may evolve over time by adopting BRTs. For example, in some pinger studies, researchers calculated net profit changes by comparing control and treatment nets, allowing them to evaluate whether adopting pingers would be beneficial for their particular fishery (Gönener and Özdemir 2012; Mangel et al. 2013). Insights can also be gained into the potential savings a fishery can achieve by reducing net damage caused by bycatch (Allman et al. 2021).

3.3.2 | BRT Cost

Information on BRT cost is critical because it allows for informed considerations regarding how accessible a given BRT can be for fishers. Net illumination and pinger studies reported high investment and maintenance costs (Allman et al. 2021; Bielli et al. 2020; Mangel et al. 2013; Ortiz et al. 2016; Senko et al. 2022; Wang et al. 2010). For example, in one study, illuminated nets were reported to require an investment cost of about 2000 USD for a 2 km gillnet (Bielli et al. 2020). Fisher investment costs can potentially be offset with positive economic changes; for example, nets with pingers yielded higher profitability compared to control nets in one study (Gönener and Özdemir 2012). BRTs, however, can also involve simple gear modifications that are cost-effective. For example, buoyless nets were reported to be less expensive than traditional nets given the reduced number of buoys needed on the float line of a gillnet (Peckham et al. 2016).

3.3.3 | Operational Efficiency

Although operational efficiency can be impacted by a variety of fishing factors, we specifically focused on changes in the handling and processing of catch and bycatch while using BRTs. One study reported an increase in operational efficiency when using illuminated gillnets by reducing the time needed to retrieve and disentangle both catch and bycatch (Senko et al. 2022). Another study reported that reduced haulback time can benefit fishers during poor weather conditions that make fishing more challenging (Suuronen et al. 2006).

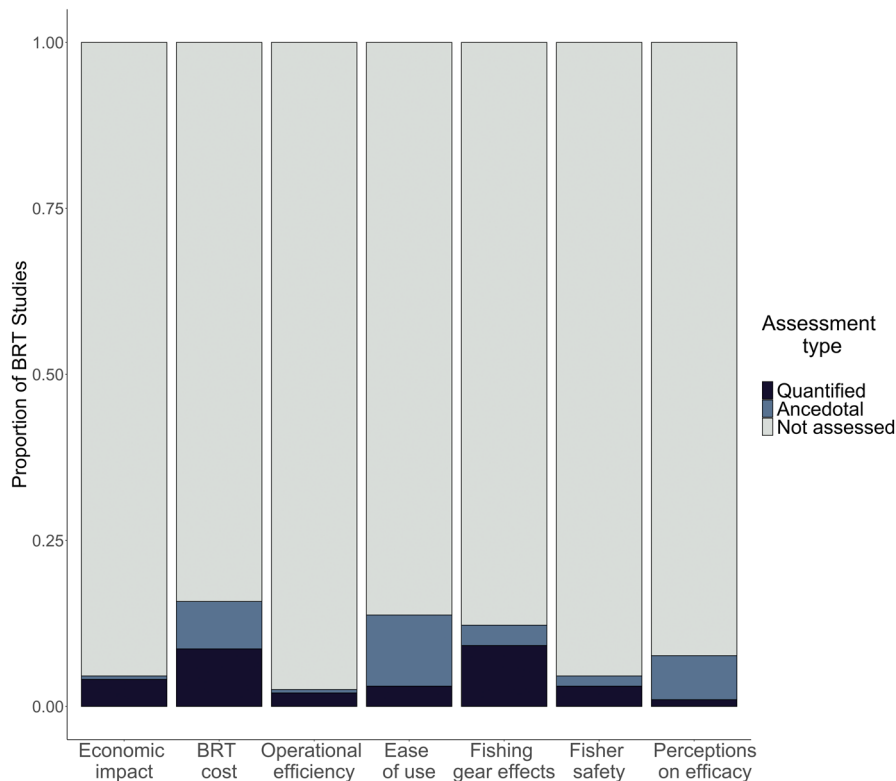


FIGURE 5 | Summary of the proportion of marine megafauna BRTs tested ($n = 196$) with passive fishing gears in global fisheries, based on peer-reviewed studies published between 1997 and 2024 ($n = 114$). We report both quantitative and anecdotal evidence for each of the seven fisher-focused metrics found among studies, including studies that did not report any assessments.

3.3.4 | Ease of Use

For effective fishery implementation, BRTs may require the involvement of scientific experts and external resources, while others can be applied through relatively simple modifications. For example, it was reported that buoyless nets required no training or additional equipment since they are fished in the same way as traditional nets (Peckham et al. 2016). When testing illuminated gillnets, researchers reported that LEDs were relatively easy to clip onto existing gillnet float lines and required no training for adoption (Senko et al. 2022). Easy and affordable installation was also reported when testing sea lion excluder devices in pot fisheries as the design is adaptable (Campbell et al. 2008).

BRTs may also impose additional challenges during fishing operations. Adding acrylic spheres on gillnets to enhance echolocation reflectivity was reported to be labor intensive and acrylic spheres may not always be accessible for global use (Kratzer et al. 2021). Other studies reported BRTs can be difficult to work with given higher gear entanglement with substrates along the seafloor or the gear itself (Kratzer et al. 2021; Peckham et al. 2016). In longline studies, testing of tori lines and weighted lines often resulted in frequent line entanglement (Dietrich et al. 2008; Jiménez et al. 2020; Melvin et al. 2013, 2014). Researchers evaluating the impact of dyed bait for reducing seabird bycatch noted its impracticality due to the additional time required for bait preparation (Gilman, Brothers, and Kobayashi 2007). Similar challenges were reported in circle hook studies, where fishers noted greater difficulty in dehooking sea turtles with circle hooks compared to J-hooks in addition to the

challenge of hooking bait on circle hooks (Gilman, Kobayashi, et al. 2007; Piovano, Basciano, et al. 2012; Piovano et al. 2009).

3.3.5 | Fishing Gear Effects

Assessing how BRTs affect fishing gear provides researchers and fishers the opportunity to gauge the potential benefits or issues that may arise when using them. Acoustic deterrent devices designed to reduce dolphin bycatch experienced lower intensities of sea lion predation (Bordino et al. 2004) and a 69.8% reduction in net damages compared to control nets (Göner and Özdemir 2012). A limited number of studies systematically quantified gear damages when fishing with BRTs. For example, gear damage frequency was evaluated by testing trap-net modifications with different netting materials and by counting the number of holes in the net panels of trammel nets (Ceciarini et al. 2023; Suuronen et al. 2006). Fishing gear effects can also include changes in bait retention; for example, use of an underwater setting chute resulted in a 20.6% reduction in bait loss, suggesting potential cost savings for fishers (Gilman et al. 2003). Further, fishers reported that BRTs like LED lights on surface-set (drift) nets may help prevent collisions with other vessels that destroy their gear (Allman et al. 2021).

3.3.6 | Fisher Safety

Fishers are often exposed to many types of risk and work long hours under shifting weather conditions. For example, Allman

et al. (2021) reported that fishers recognised the safety benefits of using illuminated gillnets because there was reduced leatherback turtle bycatch that could overturn their boat. In weighted line studies, researchers quantified flyback incidents, as fishing crews are frequently at risk of injuries caused by the line snapping (Melvin et al. 2014; Santos et al. 2019). Similarly, safety concerns were raised when testing tori lines in relation to deployment and retrieval (Gilman et al. 2021; Sato et al. 2016).

3.3.7 | Fisher Perceptions of Efficacy

Fisher perceptions of the usability and efficacy of BRTs provide valuable information on their adoption potential. We found two studies that conducted formal interviews with fishers during BRT experiments. In a circle hook study that interviewed 50 fishers, 8% of fishers were in favour of shifting to 16/0 circle hooks during the summer when sea turtle interactions are higher, which then increased to 38% if there were economic incentives included (Piovano, Basciano, et al. 2012). When testing an underwater shooter, feedback from the captain and fishing crew was collected, with reports indicating that the technology improved bait retention and reduced seabird interactions—factors that made them more inclined to adopt it (Gilman et al. 2003). Fishers testing illuminated gillnets believed the tool was useful and helped to reduce sea turtle bycatch (Kakai 2019; Wang et al. 2013). Similarly, fishers testing pingers indicated that they would be more inclined to use the technology if it also helped minimise sea lion depredation (Bordino et al. 2002).

4 | Discussion

4.1 | Performance Metrics

Assessing fishery performance metrics (e.g., changes in bycatch, target catch and catch value) is essential for determining whether a given BRT can be effectively applied in a given fishery. Our analysis revealed that most BRT studies evaluated changes in bycatch, where nearly 70% reported an observed reduction in bycatch. While most BRTs are designed to be species or taxon specific, certain BRTs may not always be ideal for fisheries that interact with multiple taxonomic groups of bycatch species. When developing or refining BRTs, it is crucial to consider that most fisheries often interact with multiple bycatch species rather than one species (Bielli et al. 2020; Domingo et al. 2012; Jiménez et al. 2019; Moreno et al. 2008; Robertson et al. 2018). For instance, assessments of certain BRTs, including net illumination, net sleeves and underwater shooters revealed that these emerging BRTs can reduce bycatch of multiple taxonomic groups, which can be beneficial for fishers (Bielli et al. 2020; Goetz et al. 2011; Moreno et al. 2008; Senko et al. 2022; Sullivan et al. 2018). Our findings also highlight the importance of evaluating potential multispecies conflicts (i.e., a BRT that reduces bycatch of one species while increasing bycatch or target catch of another species) when assessing the efficacy of BRTs, especially when they pertain to at-risk species. Further investigation into how BRTs can be adapted or combined to reduce bycatch, as well as understand the effects across multiple taxonomic groups, is warranted (Senko et al. 2022).

While BRTs may be effective in reducing bycatch, assessing how they impact fishers' target catch rate is equally important. BRTs that negatively affect target catch are likely to be a major barrier to adoption. While an increase in catch rates via BRTs can be beneficial for fishers and encourage higher adoption, future research should also consider the extent of the potential impact on fish stocks populations if catch increases are significantly higher. In a well-managed fishery, higher catch rates can reduce operation costs, but a lack of adequate management can lead to unsustainable fishing. Similarly, while fisheries may target multiple fish species that yield differences in catch rates when testing BRTs, further investigation into tailoring BRTs for fishers' preferred catches—particularly high-value target species—could help address challenges associated with mixed catch rate results.

Given that approximately half of the studies we reviewed took place in developing countries, understanding potential changes in market prices for these regions should be of interest for researchers and practitioners. All fisheries rely on the profits generated by the sale of their catch; thus, it is imperative to incorporate assessments of catch value in future studies. Positive economic changes resulting from using BRTs have been highlighted in fisher interviews as an important factor for adoption that can encourage uptake of BRTs if shown to be maintained or increased (Piovano, Basciano, et al. 2012).

4.2 | Fisher-Focused Metrics

Throughout our review, we identified and evaluated seven additional assessment metrics that can be incorporated into experiments to gain deeper insights into how BRTs impact the fishers who use them. While performance metrics were widely assessed throughout BRT studies, inclusion of fisher-focused metrics was comparatively low. Yet, assessing fisher-focused metrics may offer additional valuable insights into the applicability, economic and social impacts of BRTs. Along with evaluating catch rates and market value, assessing the economic impacts of BRTs can help understand the potential changes in annual profits or revenue fluctuations that help fishers make informed decisions about adopting BRTs.

Similarly, incorporating assessments of BRT costs is crucial to further understand their financial impact on fishers, including affordability. High cost of BRTs can limit opportunities for voluntary adoption, as challenges in production and distribution can drive up their overall expense. It can become difficult for fishers to attain and also maintain the BRT without subsidies (Pascoe et al. 2010; Squires and Garcia 2013), which may create disparities among fishers who may be interested in using BRTs. To help promote and facilitate BRTs adoption, emphasis can be put on improving or developing additional BRTs that allow fishers to modify their existing fishing gear at no extra cost (or ideally at reduced operating costs). Performing these assessments can help ensure that BRTs are both effective in reducing bycatch and also economically viable for fishers to use long-term.

We identified a diverse range of BRTs varying in different types of technological complexity and design modifications. BRTs that are relatively easy to install and maintain can provide fishers

with different levels of experience the opportunity to fish more sustainably. Laborious and complex BRTs can leave fishers feeling unsure as to how to properly install, use, or respond to technical issues that may ultimately discourage fishers from continuing its use (Duarte et al. 2019). Given the wide variety of fishing gear types, future research should explore the applicability and compatibility of specific BRTs with fishers' gear, as BRTs may not always be transferable across different gear types or environments (Nguyen et al. 2013).

For fishers, changes in operational efficiency, including improved handling and sorting time, can be important factors to encourage fisher use of BRTs (Senko et al. 2022). Trawl fishers found turtle excluder devices beneficial, as they improved handling and sorting times, expediting the fishing process (Alessandro and Antonello 2010; Sala et al. 2011; Vasapollo et al. 2019). Minimising time spent retrieving and sorting catch reduces the physical effort required to haul and clean nets as well as potentially improving catch quality and reducing waste (Senko et al. 2022). In fisheries with high marine mammal bycatch, fishers often report that cetaceans and other large vertebrates cause extensive net damage that can be costly for fishers to repair (Buscaino et al. 2009; Lauriano et al. 2004; Panagopoulou et al. 2017). Assessments of fishing gear effects when using BRTs, including changes in net damage, bait loss and gear loss, can provide useful information that benefit fishers. For instance, fishers may be more inclined to adopt BRTs if they demonstrate reduced net damage, as fishers will be able to experience lower repair costs, extend the lifespan of their fishing gear and have more efficient fishing operations. Additionally, if BRTs alleviate common risks associated with fishing activities, fishers may be more willing to adopt them. Assessing the impacts of BRTs on fisher safety can reveal potential usage hazards, including how to properly address or prevent BRT malfunctions and allow researchers the opportunity to instill social responsibility and enhance safe working conditions for fishers.

4.3 | Recommendations and Caveats for Developing Comprehensive Assessments of BRTs

Our study included primary literature to capture detailed assessments of BRTs that could answer our research questions through specific study designs, methods and results. This approach ensured that BRTs were evaluated based on empirical evidence as opposed to secondary interpretations in synthesis papers. However, we acknowledge that limiting our search to individual BRT studies narrows the broader context often provided in synthesis research. Meta-analytic syntheses are useful in estimating pooled effects of various BRTs and can enhance generalizability. Synthesis studies can clarify conflicting findings among BRTs, which are relatively common when assessing certain BRTs, such as circle hooks and pingers (Andraka et al. 2013; Gönener and Bilgin 2009; Lima et al. 2023). More recently, net illumination studies have been shown to reduce sea turtle bycatch, but to date, have been relatively ineffective for seabird mitigation (Field et al. 2019; Senko et al. 2025). It is also important to consider that BRT performance may vary under different conditions. For example, assessing BRTs in controlled experiments may differ when applied in real fishing conditions

(Cox et al. 2007). Inadvertently, BRTs that work well in experimental settings may introduce unintended consequences for fishers, underscoring the need to evaluate BRTs across multiple study approaches.

It is imperative that BRTs undergo various stages of experimental testing not only to understand how to successfully reduce bycatch, but to understand subsequent impacts on fishery operations and fisher wellbeing. We found that most BRT studies have largely concentrated on assessing changes in bycatch and target catch, where these metrics may serve as the first indicators in determining whether a given BRT will be effective under actual fishing conditions. Prioritisation of performance metrics may derive from BRTs being specifically created to address fisheries bycatch and prevent a negative effect on catch rates that may discourage fisher uptake of BRTs (Steins et al. 2023). Maintaining a narrow focus with assessments only on bycatch and target catch rates after the efficacy of the BRT has been established may indicate a potential bias toward resource management objectives and not fisher livelihoods. Yet, information learned from bycatch rates can help determine additional assessment metrics fishers may consider valuable, including operational efficiency and quantifying reductions in net damage.

Given the importance of maintaining fishers' catch (Hall and Mainprize 2005), we found surprisingly few BRT studies incorporating assessments of catch value. In some cases, the lack of catch value assessments may be due to target catch rates serving as a proxy for potential changes in market value (Gilman et al. 2003; Mangel et al. 2013). However, even anecdotal information from fishers could provide a valuable proxy on catch value. Assessments of catch value can help understand the profitability of fishing with BRTs, since catch rate results may not always translate to catch value if there are discrepancies between the capture of high and low value species. Results for catch value assessments are often based on particular species and the location of the study, which often make assessments and wider applicability challenging. However, to assess catch value, prior studies have tracked the market price assigned to commercial species by local buyers (Wang et al. 2010), or by conducting market surveys with local fishers (Peckham et al. 2016).

Fisher perceptions of BRTs are often assumed rather than systematically measured, which can undermine how well we understand the efficacy of BRTs from fishers' point of view (Campbell and Cornwell 2008). We identified evidence of seven fisher-focused metrics that can be of interest for fishers considering using BRTs, offering insights beyond general performance changes (Figure 1). To improve adoption potential, where possible, future BRT studies should include fishery efficiency and human wellbeing metrics in assessments of BRTs. While incorporating all available fisher-focused assessments may be challenging, prioritising the most beneficial and relevant fisher-focused metrics for a given fishery will likely be valuable.

Future research can also examine how perceptions of fishers and scientists may differ with respect to the use of BRTs. Assessing fisher attitudes on fishing technologies can disclose potential inequities, cultural shocks and community norms researchers may be unaware of (Jenkins 2022). Offering fishers opportunities to actively participate and voice their opinions throughout

the study design and experimentation of BRTs can help foster a sense of ownership in the research.

Compliance with alternative bycatch management measures, such as BRTs, may rely on voluntary adoption by fishers, which is often influenced by commercial costs and how the tool performs relative to traditional fishing practices (Cox et al. 2007; Suuronen 2022). When voluntary compliance is low, adoption depends on the strength of the fishery's management framework and the ability to instill an effective monitoring regime for that particular bycatch reduction measure (Kirby and Ward 2014). Fisheries with weak monitoring, control, surveillance and enforcement capacities, along with inadequate incentives for compliance, face greater risk of noncompliance.

To develop solutions that effectively address conservation issues and enhance people's livelihoods, studies must encompass a broad range of assessment metrics often extending beyond basic scientific expertise. The inclusion of fisher-focused metrics in BRT studies can be enhanced with the collaboration of a diverse scientific team. Interdisciplinary collaboration with social scientists, psychologists, anthropologists and economists can help identify the appropriate assessments to further our knowledge of the impacts and adoption potential of BRTs. For example, information that may be difficult to quantify in the field can be supplemented by conducting structured interviews with participating fishers. While several interviews with fishers have been conducted exploring the limitations of BRTs (Duarte et al. 2019; Jenkins and Garrison 2013; Steins et al. 2023), these assessments do not have to be independent of fishery trials. Interviews with fishers can occur before, during or after the conclusion of the experiment, prompting fishers to immediately reflect on their experiences while giving researchers the opportunity to identify potential setbacks and achievements (Gilman et al. 2003; Piovano, Basciano, et al. 2012). Identifying factors that matter most to fishers can serve as a foundation for developing more meaningful and effective assessment of BRTs by integrating the human dimension into scientific objectives.

5 | Conclusion

Based on the findings of our review, we compiled a conceptual map of possible assessment metrics researchers can use to help improve how to evaluate BRTs that meet both scientific and fisher needs. We found that the majority of BRT studies in our review centered on assessing two major performance metrics (i.e., bycatch and target catch rates), while comparatively fewer studies included assessments of catch value and the seven fisher-focused metrics. Yet, assessment metrics do not have to be mutually exclusive and can be used to inform additional relevant metrics. Moving forward, BRT projects should consider including a variety of assessment metrics that provide insight into the efficacy of reducing bycatch and how well it aligns or benefits fisher needs. We recognize that incorporating numerous assessment metrics may be challenging and often unfeasible given the conditions of the fishery or the research timeline and aims; however, it may be beneficial for researchers to consider discussing what metrics fishers consider most valuable. Researchers can use fisher feedback to develop more robust and comprehensive assessments that fully evaluate the socioeconomic implications of fishing with BRTs.

While it is commonly known that enhancing fishing performance can incentivize fishers to use BRTs, diffusion of innovation emphasizes the need for innovation to also align with people's beliefs and values for successful implementation (Tookes et al. 2023). We recommend that researchers, practitioners, managers and decision-makers consider possible advantages and repercussions fishers may experience with BRT use and implementation that can be fostered by including fisher-focused assessments. Doing so emphasizes the importance of interdisciplinary approaches by combining conservation science with technologies that meet ecological, social, economic and human wellbeing needs.

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Data Availability Statement

The data that supports the findings of this study are available in the [Supporting Information](#) of this article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** faf70068-sup-0001-DataS1.xlsx.