Bycatch Reduction Technologies and Their Adoption in Sri Lanka's Gillnet Fisheries

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ABSTRACT

This is a difficult decision and one that will need significant support from the state, local government, independent authorities, and civil society to gain broad acceptance globally as these technologies all greatly reduce bycatch in gillnet fisheries by allowing removal of incidental species while minimizing impact on target harvests; however this has not been implemented worldwide. Here we summarize the literature on determinants of fishers' adoption or non-adoption of bycatch mitigation technologies, framing our findings through a Diffusion-of-Innovations framework to detect and classify predictors, before directly comparing this literature with quantitative insights from the strongest available evidence regarding Sri Lankan fisher compliance to a thresher shark landings ban policy implemented in 2012 It is based on two contrasting international case studies: the near full voluntary adoption of turtle excluder devices (TEDs) by Georgia (USA) shrimpers by means of collaborative, field-tested extension activities; and a more ambiguous outcome regarding Sri Lanka's 2003 prohibition on thresher shark targeted fishing which has been largely undermined through undocumented bycatch and expressed institutional alienation of fishermen. We find that bycatch reduction technologies appear to succeed more or less depending on how they are implemented (e.g. fisher involvement in design, perceived economic risks, and trust in the regulatory body as opposed to strictly technical efficacy), and this trend holds also for Sri Lanka based on its regulatory history. As no trials have been published on net lighting or other gear-based bycatch reduction devices in the gillnet fisheries of Sri Lanka, the current evidence relevant to adoption in-country is based on research concerning compliance with species bans rather than research relating to gear-technology adoption. This analysis synthesizes existing materials to inform the potential implementation of gear-based bycatch mitigation measures in Sri Lankan gillnets, and does not present new field or survey results.

Keywords: bycatch reduction technology, technology adoption, diffusion of innovations, gillnet, Sri Lanka

INTRODUCTION

A consistent observation in the global literature on bycatch mitigation is that the primary limitation to minimizing bycatch frequently lies not in the lack of appropriate technology, but rather in the failure to implement it. A comprehensive evaluation of forty years of collaboration with fishers in Europe, Asia, Africa, and Latin America revealed that despite significant advancements in gear modifications and bycatch reduction devices proven effective in controlled settings, the uptake of these technologies by fisheries has been minimal relative to the speed of research and development (Suuronen, 2022). This disparity in adoption pertains directly to Sri Lanka's gillnet fishery, a significant and internationally recognized contributor to the mortality of elasmobranchs and mobulid rays annual captures of mobulids by the Sri Lankan artisanal fleet are estimated to surpass the total

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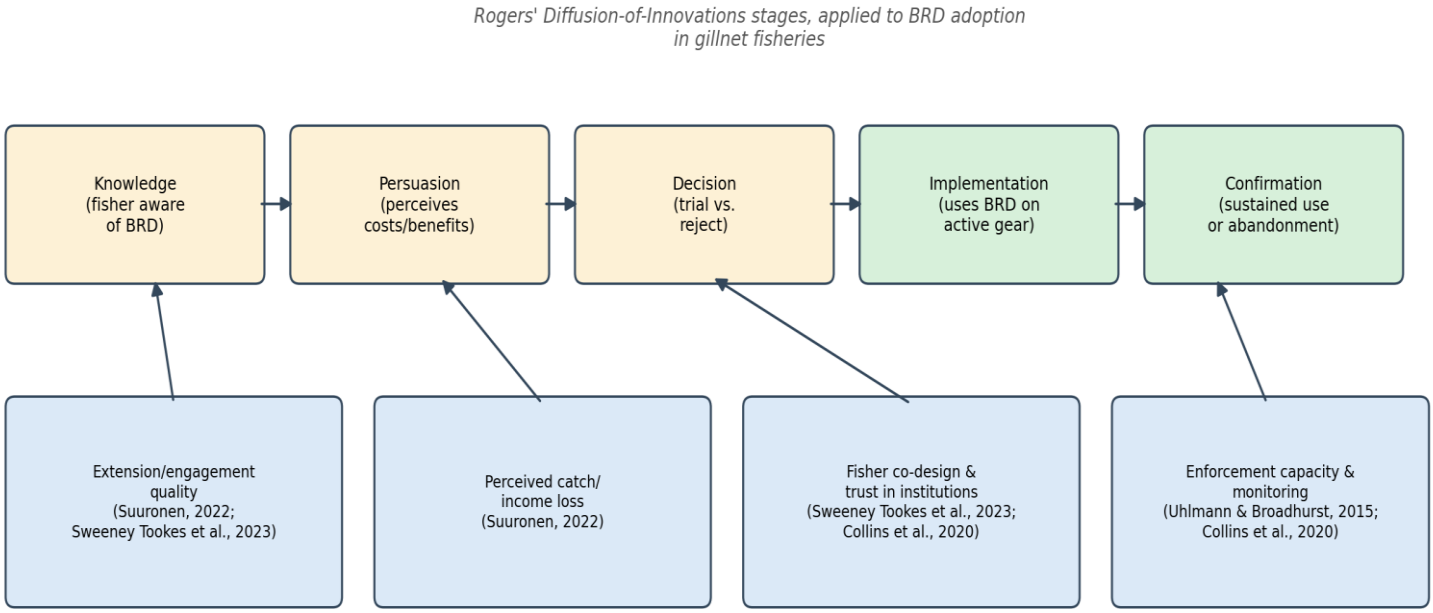
annual mobulid captures of all global industrial purse-seine fisheries, amidst a global extinction crisis for chondrichthyans driven by overfishing (Fernando and Stewart, 2021; Dulv et al., 2021).

This article examines the literature concerning the adoption of bycatch reduction technologies, distinctly apart from the evaluation of their effectiveness, which has been addressed in other studies, and explores the implications of this literature for the implementation of such technologies in Sri Lanka's gillnet fishery. Two divergent international case studies serve as the foundation for the review: the almost complete voluntary implementation of turtle excluder devices (TEDs) by shrimpers in Georgia, USA, prior to federal regulation, largely credited to ongoing fisher involvement in gear co-design (Sweeney Tookes et al., 2023), and Sri Lanka's 2012 prohibition on thresher shark landings, the sole documented study of Sri Lankan fisher reactions to a bycatch-related conservation initiative (Collins et al., 2020). The thresher ban, while a species-retention restriction rather than a gear-based bycatch mitigation method, serves as the most pertinent evidence regarding the reactions of Sri Lankan gillnet and multi-day vessel fishers to bycatch regulations, and is regarded here as a valuable local comparison until any future studies on gear technology adoption are conducted. Similar to other evaluations of fisheries and aquaculture technology implementation in Sri Lanka, this document constitutes a literature-based synthesis rather than a presentation of novel field or survey data.

A Diffusion-Of-Innovations Framework for BRD Adoption

Rogers' (1983) Diffusion of Innovations framework, which models adoption as a sequence of Knowledge, Persuasion, Decision, Implementation and Confirmation stages, has been applied directly to bycatch reduction device adoption in an in-depth analysis of two of the best-documented US case studies: turtle excluder devices in shrimp trawl fisheries and dolphin-safe purse-seine tuna fishing (Jenkins, 2023). That analysis found that extension programmers seeking to influence adoption struggle most to move fishers past the Decision stage, and that the five characteristics Rogers identifies as shaping adoption of any innovation relative advantage, compatibility, complexity, trialability, and observability each mapped onto specific, identifiable friction points in the two US case studies (Jenkins, 2023). Figure 1 adapts this framework to gillnet bycatch reduction technologies specifically, mapping the extension-process and fisher-perception determinants identified in the wider literature onto the stages they are most likely to affect.

Figure 1. Diffusion-of-Innovations stages for bycatch reduction technology adoption in gillnet fisheries, with determinants drawn from the reviewed literature mapped onto the stages they most directly affect.



In this context, the Persuasion phase is where the perceived economic risk is most significant: fishers often fear that a bycatch reduction technology will diminish their marketable catch and, consequently, their income, a

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worry that is particularly pronounced in fisheries with narrow profit margins, where even a slight decrease in catch value can be severely detrimental (Suuronen, 2022). The Decision and Implementation phases are when the involvement of fishers and their trust in the introducing organization seem to be most significant, as evidenced by the comparison of the two case studies presented below. Phase 3 (Confirmation): the extent of continuous enforcement and monitoring often constrained by resources is an important factor influencing implementation sustainability, as it determines whether a technology is maintained or discarded post-implementation (Uhlmann and Broadhurst, 2015; Collins et al., 2020).

Two Contrasting Case Studies in BRD and Bycatch-Regulation Adoption

Turtle excluder devices in Georgia USA: a case of collaborative co-design

The clearest documented example of substantial voluntary development and use of a bycatch reduction device is the Georgia Jumper turtle excluder that resulted from continued collaboration among shrimpers in Georgia, University of Georgia Marine Extension personnel, and Georgia Sea Grant researchers beginning in 1980 with the proposal to federal agencies for a personal shrimper-conceived "jelly ball shooter" (Sweeney Tookes et al. Due to the active participation of shrimpers in the design, field-testing, and modification of the device, rather than being subjected to a federally mandated design, the Georgia Jumper was tested in trials against the federal model in waters abundant with sea turtles, proving to be effective and more cost-efficient, ultimately receiving approval for use in 1987; by the early 1990s, when TEDs became federally obligatory, the majority of the fleet had already voluntarily embraced a TED, necessitating minimal enforcement to ensure compliance (Sweeney Tookes et al., 2023). Fisher interviews in this case study uniformly depicted their interactions with extension agents as favorable and referenced TEDs as a successful instance of fisheries regulation, contrasting sharply with the fisher sentiment recorded in the Sri Lankan case discussed below.

Top-down mandate: Sri Lanka's 2012 thresher shark landing ban

In 2012, Sri Lanka implemented a comprehensive prohibition on the capture, retention, transshipment, landing, storage, and sale of all three species of thresher sharks (*Alopias spp*.), driven by regional conservation obligations associated with the IOTC and a swift fall in their populations. A follow-up assessment employed focus groups comprising two divergent fishing cohorts large inboard multi-day (IMUL) vessels functioning in the EEZ and high seas, alongside smaller outboard fiber-reinforced-plastic (OFRP) vessels that had seasonally pursued threshers before the prohibition, to investigate fisher attitudes toward, and adherence to, the ban (Collins et al., 2020). The research indicated that opposition to the ban was most pronounced among fishers who anticipated significant adverse social and economic repercussions, with their perceptions further eroded by a sense of inadequate involvement from fisheries organizations prior to the ban and doubts regarding its ecological justification (Collins et al., 2020).

While the ban had generally succeeded in limiting intentional thresher fishing, fishers still reported incidental bycatch of threshers that was considered underreported (in part due to a lack of trust and clarity as to reporting requirements), and there were reports of rare illegal landings occurring which would be economically justified by the high market value for thresher meat compared with rising costs of vessel operation (Collins et al., 2020).Even though there is a difference in the prescriptions of species-retention versus gear-based bycatch mitigation device, both require a change in fisher behavior as part of responding to a conspecific-focused conservation strategy and have elements evident in the results from Sri Lanka based on Diffusion-of-Innovations literature such as perceived economic cost, institutional trust and participation in decision-making.

This renders the thresher ban case the most pertinent information regarding the anticipated reactions of Sri Lankan gillnet and multi-day vessel fishers to forthcoming bycatch-related measures, such as gear-based BRDs, while not empirically evaluating a tangible bycatch reduction apparatus.

Figure 2 delineates the two case studies as analogous governance trajectories, spanning from the initial engagement strategy to the compliance result.

Figure 2. Contrasting governance pathways and their compliance outcomes: collaborative co-design of turtle excluder devices in Georgia, USA (Sweeney Tookes et al., 2023) versus the top-down thresher shark landing ban in Sri Lanka (Collins et al., 2020).

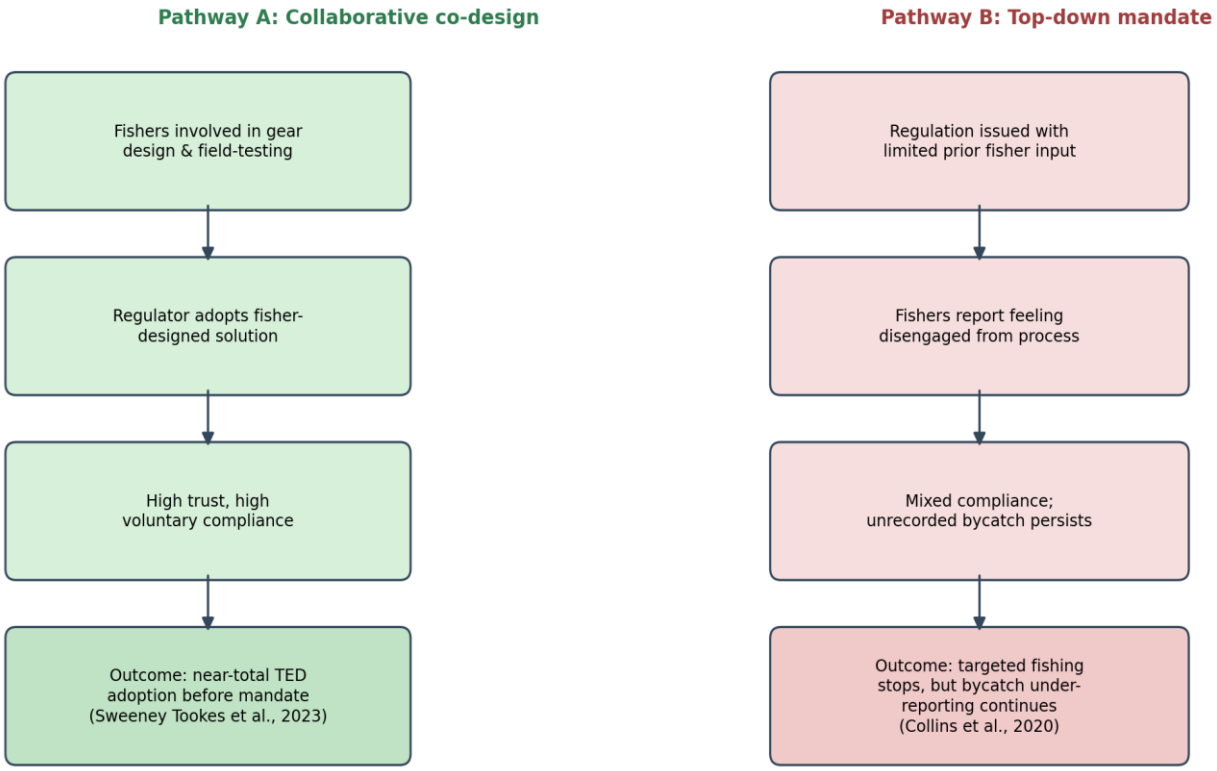


Table 1 summarizes the two case studies against the adoption-relevant factors identified above.

Table 1. Comparison of adoption-relevant factors in two contrasting bycatch-related governance case studies.

Factor	Georgia TED (co-design)	Sri Lanka thresher ban (mandate)
Fisher involvement in design/policy process	Direct fishers designed and field-tested the device	Limited fishers reported feeling disengaged prior to the ban
Perceived economic impact	Minimal loss; TED improved catch quality by excluding turtles	Significant, particularly for fishers previously reliant on thresher income
Institutional trust reported	High described as a positive collaborative experience	Low among fishers most negatively affected
Compliance outcome	Near-total voluntary adoption before mandate took effect	Targeted fishing halted; incidental bycatch persists and is under-reported
Underlying regulatory instrument	Gear-based bycatch reduction device (TED)	Species-retention ban (not a gear technology)

Implications For Bycatch Reduction Technologies in Sri Lanka's Gillnet Fishery

No formal net modification trial for reductions in bycatch has been conducted within the setting of gillnets at this location, and it is worth noting that the evidence presented here (Table 1) reflects findings from an investigation into compliance with a ban on targeting species in the study region, rather than a study on gear

technology uptake. However, the case studies and the larger Diffusion-of-innovations literature described above suggest three consequences: First, the case study contrasts both Georgia and Sri Lanka demonstrates that future gillnet BRD effort in Sri Lanka such as implementing a gillnet BRD pilot study using solar-powered LED net illumination will more likely be successfully adopted sustainably if fishers are engaged from the start of the design and evaluation of the trial as active stakeholders rather than an imposed measure/technology or regulation in places where already established elsewhere, highlighting a broader conclusion that fisher engagement quality surpasses technology efficacy for adoption outcomes (Suuronen 2022; Sweeney Tookes et al. 2023). Secondly, the concerns over possible economic risks articulated in the case studies reveal that proving (not just asserting) a candidate technology does not reduce target catch value is an essential task one has demonstrated without substantiating catch loss through controlled experimental conditions elsewhere (Senko et al., 2022; Burgher et al., 2026) and one perhaps representing a meaningful measurable component of fisher-targeted extension materials to be included as part of any Sri Lankan pilot. Third, the persistent under-reporting of bycatch as evidenced in this study and others (see Collins et al., 2020) indicates that future BRD initiatives must expect similar monitoring and reporting challenges, making it essential for pilot designs to be created upfront with simple low-burden reporting systems incorporated rather than relegating such consideration as an afterthought once technology implementation gets underway.

CONCLUSION

A similar message has emerged repeatedly in the global literature on bycatch reduction: technical efficacy is paramount, but it alone does not guarantee adoption; when fisher participation in design, a clear demonstration of economic effects and institutional trust are also expected to play a much more important role in how such measures translate into implementation on the ground (or water). Sri Lanka had a practice in 2012 where an illegal thresher shark landing prohibition was imposed and, as for other initiatives that are simply too top-down to expect buy-in from fishers who were not previously involved, targeting ceased but much larger volumes of bycatch went unreported due to bickering amongst fishers over protocol use (let alone voluntary buy-in) than the circa complete bind independent standard set by Georgia during the nearly total adoption of hand-made turtle excluder devices. There have been no gillnet fishery trials of any gear-based bycatch reduction devices in Sri Lanka, hence the nation lacks technology-specific adoption evidence; we strongly advocate that a pilot based on these recommendations is commenced immediately in Sri Lanka and should integrate fisher co-design, transparent catch-impact evidence and integrated monitoring as fundamental elements from inception instead of after selection.

Ethical Approval

This study is a literature-based synthesis. It did not involve human participants or animals, and no new field or survey data were collected; ethical approval was therefore not required.

Conflict of Interest

The authors declare that they have no known competing financial interests, professional affiliations or personal relationships that could have appeared to influence the work reported in this paper. No funding body played any role in the design of the review, the selection or interpretation of the literature, or the decision to submit the manuscript for publication.

Data Availability

No new datasets were generated or analyzed in this study. All information discussed is drawn from the published sources listed in the references.

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