Rescue, Restore, Reinforce,

Analyzing Global Strategies to Reduce Bycatch

Grayson McCall October 22nd, 2025

Peru has long been in the spotlight for its fisheries' massive incidental catch, or bycatch, rates. Furthermore, Peruvian fisheries have been discovered to use their bycatch creatures as bait for their targeted species (Wickens, 2013). Cetaceans such as Dolphins have been one of the top species affected by bycatch. Reports estimate that as many as 15,000 dolphins a year are used as bait (BlueVoice.org).

The main species of dolphin affected by their interactions with fisheries are Burmeister's porpoises (Phocoena spinipinnis), dusky dolphins (Lagenorhynchus obscurus sp. Posidonia), common dolphins (Delphinus Delphis), and common bottlenose dolphins (Tursiops truncatus). The reduction of these marine mammals comes at a high cost to marine ecosystems.

Similar to humans, dolphins are complex, social creatures that reside within family groups; often showing signs of depression and anxiety if separated from their group. Dolphins play a crucial role in the overall balance of marine environments. (NOAA.org) As predators, Dolphins are responsible for maintaining the marine food chain and regulating fish populations they feed upon, including sick and diseased fish. They also prevent sickness and disease from spreading to other populations, including humans. (Sunshine Scenic Tours.com)

Peru, while being one of the globe's leading bycatch regions, is not the only country/region that has faced this crisis. This article will explore other regions around the globe where the crisis of bycatch has taken place, analyzing the bycatch species, the fishing activities causing it, and the innovations/strategies implemented to reduce or eliminate bycatch.

California's Pacific Coast, the Gulf of Mexico, and the Baltic Sea will all be examined and evaluated based on the previously mentioned factors. The insights and results from this article's analysis of bycatch mitigation in other regions aim to provide similar strategies for bycatch mitigation and reduction that can be implemented in the Peruvian fishing industry.

Background

Within the fishing industry, Peru stands as a giant, generating billions in revenue through the exportation of fisheries. In 2023, Peruvian frozen fish products alone, such as squid, reached a total export value of $1.565 billion, according to the article Peruvian superfishing takes the world by storm published on Peru.info. Peruvian fishing has long been at the head of fishing exports; Gregory Ferguson-Cradler, author of Coping with crisis: The Peruvian state-owned fishing enterprise Pesca Perú, 1973-1998, states "the late 1960s Peruvian dishing boats harvested more fish than any other country in the world…20% of total global fish yield in 1970 was Peruvian" (Ferguson-Cradler, 2023).

There is no doubt that Peru is a vital member of the fishing industry. However, since the 1960s, Pure has also been at the forefront of the global bycatch crisis. In the ProDelphinus Final Report titled Estimating bycatch rates and abundance of small cetaceans in Pucusana, Peru to guide management and conservation initiatives, (2024) says that since the mid-1990s “over 2,000 small cetaceans were killed annually… with annual catch estimates exceeding 1,000 dusky dolphins and more than 300 Burmeister's porpoises." (Alvarez et al., 2024)

Bycatch is a major threat to marine ecology. The decrease in vital species populations has a significant impact on the survival of different species and the maintenance of balance. Bycatch also significantly harms the sustainability and resilience of fishing communities and economies. (Durant et al., 2025) Peru's fishing industry is primarily made up of small-scale, artisanal fisheries, which account for 40% of the world's fisheries bycatch. (Villar et al., 2024)

Peru's dependence on local artisanal fisheries is exponential. Artisanal fisheries in Peru are responsible for 80% of the fish that feed the population. Simultaneously, 67% of Peru's artisanal fisheries are informal, meaning they lack the formal contracts and structures that characterize the regulated fishing sector. (Future Fish, 2024) Informal Peruvian fisheries, due to their lack of contractual funding, turn to private lenders who often provide unfavorable loans, creating a cycle of poverty and the need to overfish. (Future Fish, 2024) Similarly, the lack of formal contracts leaves artisanal fisheries vulnerable to market shifts, causing informal fisheries to face unstable incomes and job uncertainties. On average, these informal artisanal fisheries earn 38% less than formal fisheries. (Future Fish, 2024)

In 1996, the Peruvian government established Law No. 26585, which made the previously mentioned cetacean dolphins and two river dolphins legally protected. (Guidino et al., 2023) Puru has pledged to protect 30% of marine habitats by 2030, yet as of 2024, only 10% are protected. (Carrere, 2024) More importantly, Peruvian conservation efforts must turn to the root of the bycatch crisis, artisanal fisheries. Recently, in 2020, multiple organizations, including Peruvian governmental entities, championed environmental conservation and education efforts in local communities. They established a space for dialogue and training for artisanal fishermen to help develop and manage conservation and sustainable artisanal fishing. (Nature & Culture, 2024)

The Peruvian effort to mitigate bycatch in the region has just recently begun. While the championed conservation implementations and future goals are sure to result in positive mitigation, much more understanding and research must be conducted. Bycatch in Peru is not an easy crisis to confront. The cultural and economic importance of the fishing industry means that possible solutions must not interfere with artisanal production. This article considers these factors while examining the other mentioned regions and their bycatch mitigation strategies. Identifying what works and what does not is the first step to implementing an effective bycatch reduction strategy in Peru.

Case Study Analysis

Peru Analysis

Peru artisans use multiple fishing methods, such as gillnets and longline fishing. Gillnets are panels of netting usually pulled across the surface of the water. Gillnet fishermen in Peru are noted as having 2-4 dolphins per trip, which are often later used as bait. (Campbell et al., 2020) Longline fishing is the method of trolling thousands of hooks behind a vessel. Peru's longline fishermen reportedly state that they use 15-20 dolphins for a 15-day fishing trip. (Campbell et al., 2020) Figure 1 shows the 4 Peruvian harbors, their fishing methods, and the rates/averages of dolphin bycatch and bait use.

			Bycatch (#Dol)		State (%)			Fate of bycatch (found dead) (%)					Fate of bycatch (found alive) (%)				
Port	*n*	Fishery	Mean	Range	Alive	Dead	NR	Discard	Bait	Consume	Sale	NR	Release	Bait	Consume	Sale	NR
Paita	41	Longline	1*	1–3*	74	26	0	38	27	31	0	4	95	0	0	0	5
Salaverry	28	Gillnet	3	1–5	0	100	0	74	17	6	3	0	82	0	0	0	18
Pucusana	24	Both	2	1–7	25	58	17	68	5	26	0	0	100	0	0	0	0
Ilo	54	Longline	1	0–2	53	38	9	56	9	28	3	3	85	3	3	3	6

*n is the total number of surveys completed per site. The column "Bycatch" lists the number of individuals bycaught reported by fishers per trip or season. NR, No response; Dol, dolphins. *Bycatch per fishing season (100% longline fishers). Season: Spring (September–December).*

Another possible mitigation solution was experimented with. To reduce bycatch in gillnets, LED lights were developed to deter marine animals. The results of implementing LED lights in an experiment, as published in the article "An Illuminating Idea to Reduce Bycatch in the Peruvian Small-Scale Gillnet Fishery," showed a 70% reduction in cetacean bycatch and a 74% reduction in sea turtle bycatch. (Bielli et al., 2020) Shown in Figure 2.

Pingers have also been experimented with in Peru. Pingers, which can be applied to both longline and gillnets, did present another possible mitigation solution, shown in Figure 3.

	Probability		**CPUE**
Treatment	Sea turtles	Cetaceans	Rays
Control	0.086	0.048	0.034
Illuminated	0.022	0.014	0.052
% change	−74.4	−70.8	+34.6

The effectiveness is still unclear, and the potential consequences, such as marine animal disruption and environmental condition changes are a significant concern. (Mangel et al.,2013)

Species	No pingers Mean	No pingers range ± 1 SE	With pingers Mean	With pingers range ± 1 SE	% change	P
Dolphins & porpoises						
Total	0.798	(0.678–0.939)	0.502	(0.407–0.619)	−37.2	0.045
Delphinus spp.	0.289	(0.225–0.372)	0.160	(0.114–0.226)	−44.6	0.093
L. obscurus	0.048	(0.029–0.080)	0.043	(0.025–0.073)	−10.4	0.827
T. truncatus	0.051	(0.030–0.085)	0.031	(0.017–0.056)	−39.4	0.360
P. spinipinnis	0.001	(0.000–0.009)	0.000	(0.000–0.004)	−75.0	0.379
Globicephala spp.	0.000	(0.000–0.092)	0.000		−100.0	0.692
Sharks & rays						
Sharks	18.6	(14.0–24.7)	26.3	(19.7–35.0)	29.3	0.088
Rays	0.001	(0.000–0.007)	0.002	(0.000–0.009)	22.2	0.817

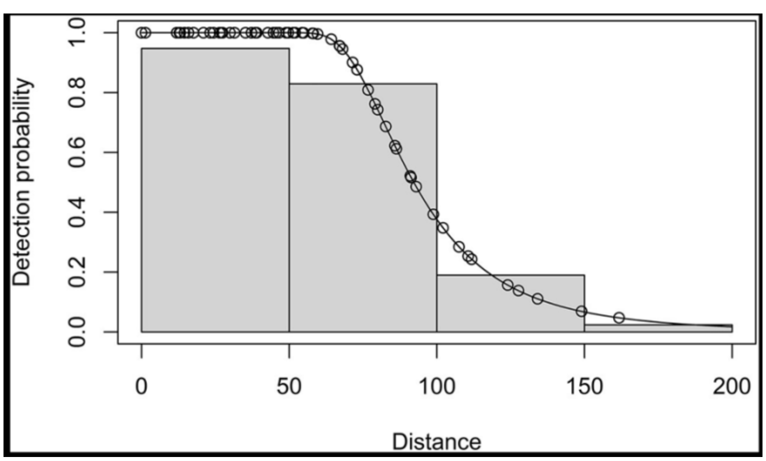
Another concern with the implementation of pingers is the financial expense. As mentioned before, Peru is primarily comprised of informal artisanal fisheries, which require an additional expense that is economically impossible. Figure 4 shows the average cost of a pinger, which doesn't seem expensive to first-world countries but adds up quickly for countries such as Peru.

	Initial pinger cost	Pingers (50USD) + batteries	Initial pinger cost	Pingers (75USD) + batteries
Annual cost of one pinger + batteries	50	61.9	75	86.9
Total annual cost per vessel (43 pingers + batteries)	2150.0	2662.1	3225	3737.1
Savings per vessel in the first year	−576	−1088	−1651	−2163
Savings per vessel in the second year	1768.1	1255.9	1768.1	1255.9

Baltic Sea Analysis

The Baltic Sea covers about 149,000 square miles and has coastlines with Sweden, Finland, and Denmark. The Baltic Sea is home to diverse marine life and fishing activity, which has decreased over time. (Mutton et al., 2025) Due to its diversity and fragile ecosystem, 11.6% of the Baltic Sea as of 2016 is designated as Amrine Protected Areas (MPAs). (Misachi, 2021)

The Harbour Porpoise is the only cetacean in the Baltic Sea, and is currently facing extinction due to bycatch. Primarily, harbour porpoises are bycatch in gillnets, similar to Peru cetacean dolphins. Identical to Peru, the location of sitings and bycatch is also notable. Figure 5 shows the sightings of dolphins by fishermen in Peru. The chart shows that the further out you go, the fewer cetaceans are spotted. Figure 6 displays the relative bycatch risk for harbour porpoise in the Baltic. Notice the detection points in Figure 6 are closer to coastlines.



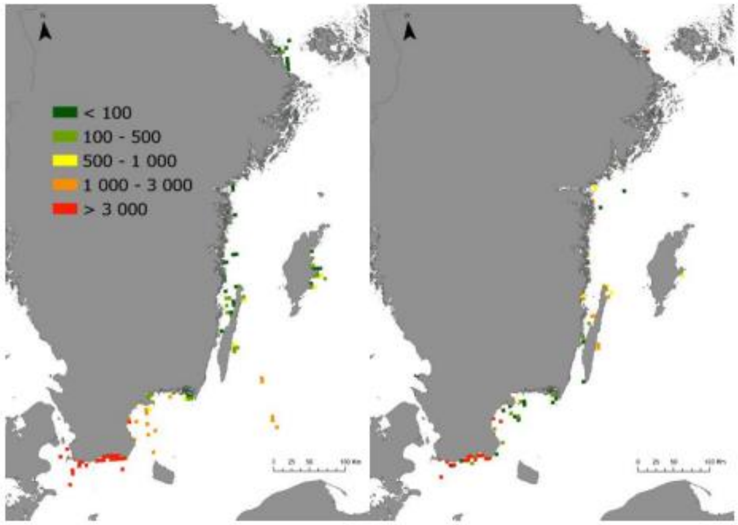
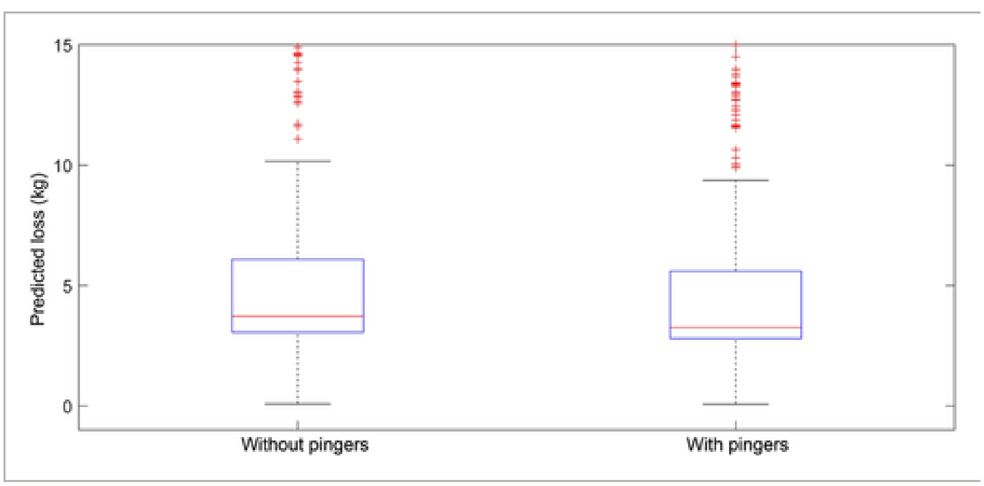


Figure 2: Relative bycatch risk for harbour porpoise, estimated as the probability of harbour porpoise detection during May 2011-April 2013 (data from Carlén et al. (2018)) multiplied by gillnet fishing effort reported to the Swedish Agency for Marine and Water Management for 2019. Top left: Feb-Apr 2019; top right: May-July 2019; lower left: Aug-Oct 2019 (gillnet effort data after implementation of cod fishing ban); lower right: Jan 2019 (gillnet effort data before the cod fishing ban) and Nov-Dec 2019 (gillnet effort data after the cod fishing ban).

The Baltic Sea is also home to a few seal species, such as the grey seal. In the Baltic Sea, seal bycatch is also a concern. In 2012, it was estimated that 2180-2380 grey seals were bycatch in the Baltic, which is around 8%-9% of the total grey seal population. (Westphal et al., 2025) However, progress has been made. In 2003, less than 1% of marine species in the Baltic were grey seals. By 2015, this number increased to 7%. (Westphal et al., 2025)

Like Peru, the experimentation of pingers was explored in the Baltic Sea. One study found that high-frequency pingers were effective at mitigating bycatch, as shown in Figure 7. (Carlén, Cosentino, 2023)



The study by Carlén and Cosentino (2023) found that the use of pingers did not decrease the sellable catch for fishermen. According to Carlén and Cosentino (2023), "This study shows that high-frequency pingers can be used in the Baltic Proper without risking increased seal depredation on static fishing nets. This knowledge is crucial for the management of the industry and for the conservation of the Critically Endangered Baltic Proper harbor porpoise population because relevant authorities can now require the introduction of pingers in the Baltic Sea static net fisheries…"

California Analysis

The California coast is home to a diverse and crucial habitat for marine life. Whales, for example, use the southern coasts of California as a highway for migration, and sharks use the coastal waters as an essential nursery point. (Oceana.org) The California fishing industry is reported to make millions of dollars in revenue. (California Department of Fish and Wildlife, 2009)

California fishermen use gillnets and trolling as their fishing methods. Because sharks use coastal waters as vital nursery areas, a large percentage of bycatch in California consists of shark species, specifically angel sharks. Figure 8 comes from the California Department of Fish and Wildlife, showcasing the top twelve bycatch species.

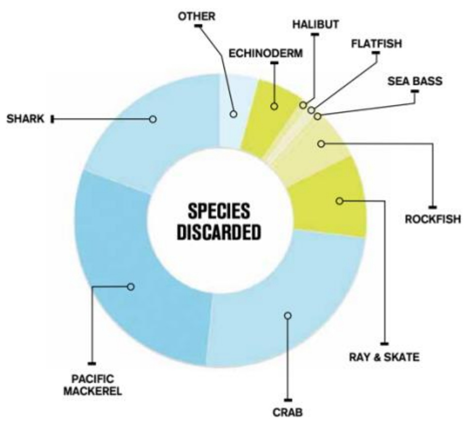
Species	Observed Discard Mortality Rate % (number discarded dead/total discard)	PSA Vulnerability Score	IUCN Classification	Rate of Catch in Observed Sets
Pacific angel shark	12% (18/154)	1.80	Near threatened	30%
Brown smoothhound	40% (25/62)	1.77	Least concern	4%
California skate	10% (30/298)	2.12	Least concern	22%
Bat ray	26% (61/238)	Not available	Least concern	26%
Rock crab	77% (437/570)	0.96	Not available	38%
Barred sand bass	39% (7/18)	1.52	Least concern	3%
Giant sea bass	Unknown	Not available	Critically endangered	2%
White shark	Unknown	Not available	Vulnerable	Unknown
Brandt's cormorant	100% (4/4)	Not applicable	Not available	<1%
Sublegal halibut	58% (28/48)	1.50	Least concern	59%
California sea lion	100% (34/34)	Not applicable	Least concern	6%
Humpback whale	Unknown	Not applicable	Least concern	Unknown

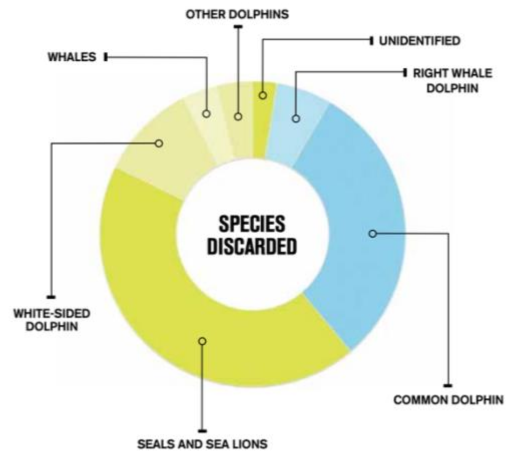
California both drifts and sets gillnets, discarding 63% and 65% of their catches, respectively, as seen in Figure 9. (Keledjian et al., 2014) In California, set gillnets can reach up to two miles long, and are reported to have caught 94 great white sharks alone. (Keledjian et al., 2014).

WORST IN FISH DISCARDS

FISHERY	TARGET FISH	DISCARD RATE
Snapper-grouper longline	Snapper, grouper	66%*
California set gillnet+	Halibut	65%*
Southeast shrimp trawl	Brown, pink, white shrimp	64%
California drift gillnet+	Swordfish, thresher sharks	63%*
Gulf of Alaska flatfish trawl	Flounder, sole	35%
Northeast bottom trawl	Groundfish, whiting	35%
Mid-Atlantic bottom trawl	Scup, flounder, sea bass	33%
Atlantic HMS longline	Swordfish, tuna	23%
New England/Mid-Atlantic gillnet	Monkfish, groundfish, skates	16%

In 2010, drift gillnet fishermen reported 49 dolphins and 16 endangered sperm whales found in drift gillnets (Keledjian et al., 2014). From 2009 to 2014, drift gillnets were also reported to entangle humpback whales, averaging a total of 100 marine animal kills per year—figures 10 and 11 showcase the species bycatch in set and drift gillnets.



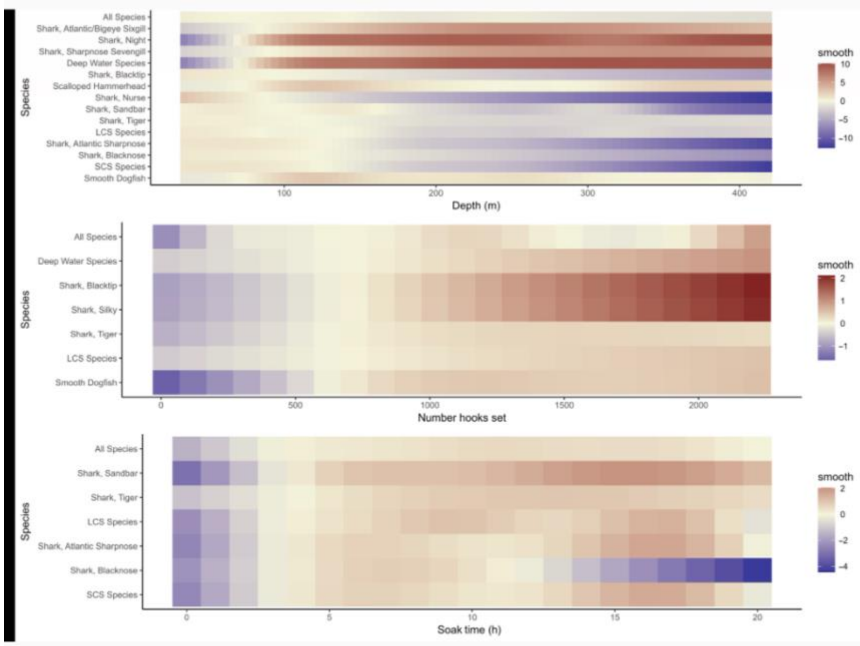


California, unlike Peru or the Baltic Sea, chose to introduce bycatch and fishing policies rather than experiment with or implement the use of pingers or LED. The California Department of Fish and Wildlife has conducted multiple surveys and reports highlighting the crisis of bycatch in the coastal waters. Policies, including gear marking and electronic technology, are communicated to fishermen and, in many situations, are enforced heavily. But some believe more measures should be actively implemented to combat the bycatch in California.
Some solutions include limiting nets, replacing gillnet fishing, and even outright prohibition. California, as part of a First World country, can enforce implemented policies and laws.

Unlike Peru, where laws have been implemented and are continuously ignored. California fishing isn't as vital as Peruvian fishing is. To implement policies to mitigate bycatch in Peru, governmental enforcement and cooperation with artisanal fisheries would be required, which, as mentioned previously, would need to outweigh the financial and job security challenges faced in Peru.

Gulf of Mexico Analysis

The Gulf of Mexico is one of the most significant, most economically valuable, and most participant-rich shrimp trawling regions. (Smith et al., 2023) A 64% discarded rate of shrimp trawling fisheries is estimated in the Gulf of Mexico region. (Keledjian et al., 2014) Making the Gulf of Mexico the fifth-highest bycatch region in the world, with a discard-landing ratio of 4:6:1 (Parsons & Foster, 2015). Figure 12 highlights the bycatch number for 2014 in the Gulf of Mexico. (NOAA, 2018)



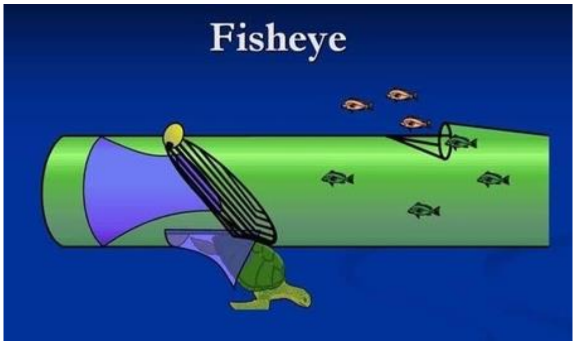
Shrimp Trawling is a fishing method where vessels drag nets across the ocean floor, catching many species and reportedly discarding more pounds of fish than the shrimp they catch. (Keledjian et al., 2014) Species such as “sea turtles, sharks, and marine mammals, are characterized by slow population growth, low fecundity, and diminished survival rates. (Millán & Gamboa, 2025)

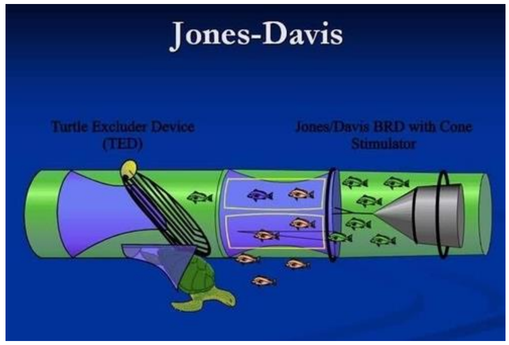
Similar to California policies, mitigation strategies have been implemented, such as fishing closer during shark reproductive seasons. (Cruz et al., 2021) More importantly, the Gulf of Mexico has been a certain testing ground for bycatch innovation.

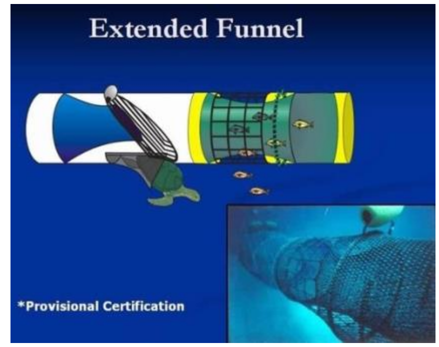
An extensive study has been conducted in the Gulf of Mexico, focusing on identifying bycatch statistical variables, such as hook, depth, number of hooks, and soak times. In Farrell (2024), the exploration of these variables was studied on the shark population. Figure 13 shows these findings.

This application of extensive research and experimentation is required to mitigate bycatch in Peru. Other than the pinger and LED experiments in Peru, not many extensive findings like those identified by Creuz et al. (2021) have been identified. Moreso, the Gulf of Mexico has been the site of innovations being tested, and it has voluntarily adopted new devices with improved fish bycatch reduction capabilities. (Gulf Spill Restoration, 2022) Here, new bycatch reduction devices (BRDs) have been showcased as sustainable bycatch mitigation applications. Figures 14-

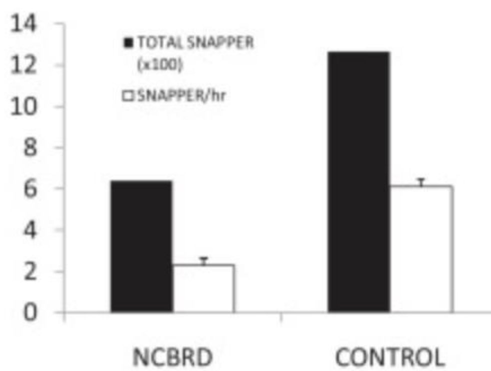
16 show shrimp trolling BRDs, which sources like NOAA have identified as viable mitigation devices.







A modified BRD based on the devises pictured in figures 14-16 has been found to provide effective bycatch mitigation. NCBRD was studied in the Gulf of Mexico, primarily observing the bycatch of Red Snappers. (Parsons & Foster, 2015) Figure 17 shows the bycatch rate of red snappers in shrimp trawling.



There is potential for innovation and application of BRDs in Peru. While Peruvian artisanal fisheries primarily use gillnets and longlines, trawling is similar to gillnets. Adapting and modifying the trawling BRDs used in the Gulf of Mexico for the Peru gillnet is a viable bycatch mitigation strategy.

Discussion

Peru is a giant within the fishing industry; artisanal fisheries play significant roles in Peruvian exports and local economies. However, these same artisanal fisheries are informal, as they lack the contractual, financial, and security that other countries provide for fisheries.

Examining regions in the Baltic Sea, California, and the Gulf of Mexico provides an extensive understanding of bycatch that is applicable to adapting and mitigating Peruvian bycatch. In contrast, these same regions and bycatch mitigation strategies lack evidence and solutions that reach the root of Peru's bycatch crisis, artisanal fisheries.

This article began highlighting the economic and cultural importance of fishing in Peru, as well as exploring how informal artisanal fisheries bycatch activities come from these informal challenges.

Regions like the Baltic Sea, California, and the Gulf of Mexico are subject to extensive study, funding, and enforcement, unlike Peru. California bycatch mitigation can be sustainable by using policies because fishermen don't face the same struggles or fear of enforcement as Peru artisanal fisheries. Baltic fishermen are educated about the statistics and findings of how to better mitigate the bycatch of grey seals and harbor porpoise. The Gulf of Mexico is a central point of worldwide ocean and fishing research that supports innovation for better mitigation.

In order to fully identify Peru's bycatch mitigation, examinations and studies such as the ones conducted in the other mentioned regions must be conducted in Peruvian waters. This is highlighted in the differences in mitigation strategies between the regions. While yes, pingers and LED BRDs have been implemented and studied in some of these regions, the majority of studies have been aimed at the specifications of the bycatch in the region.

The overarching similarity between the regions examined is that bycatch is a global crisis, not specifically in Peru. But the situations are all different, which means the mitigation strategies must reflect the differences. The Baltic Sea, California, and the Gulf of Mexico are examples of mitigation progress because those regions don't face the same struggles or lack the funding that Peruvian artisanal fisheries do.

Conclusion

Coexistence begins with rescuing, restoring, and reinforcing bycatch mitigations. In Peru, bycatch is one of the globe's top representatives. Bycatch, similar to most human-wildlife conflicts, is situational; the differences between bycatch in the Gulf of Mexico and Peru have different factors pertaining to them. However, studies and innovations have the ability to be adaptable to each situation.

Baltic Sea mitigation strategies, such as pingers, highlight the potential for similar pinger experiments conducted in Peru. California bycatch policies are enforced and are viable options that can help artisanal fisheries comply with bycatch mitigation efforts, and the BRDs innovated and tested in the Gulf of Mexico have the potential to be adapted to gillnet fishing in Peru.

Peruvian bycatch is riddled with more than just ignorance; it's rooted in economic struggle, global export expectations, and lack of funding. In order to apply bycatch mitigation strategies, it's important to begin with understanding these principles.

References

\r\n \n CCB Save The Baltic Porpoise\n \r\n. (2024). Www.ccb.se. https://www.ccb.se/save-the-baltic-porpoise

A biodiverse marine paradise in Peru is now protected! (2024, April 25). Nature and Culture International» Bringing People Together to Save Wild Places. https://www.natureandculture.org/directory/a-biodiverse-marine-paradise-in-peru-is-now-protected/

ACTION – HELCOM. (2024). Helcom.fi. https://helcom.fi/helcom-at-work/projects/action/

Akre, K. (2023, September 1). *Bycatch | Description, Statistics, Solutions, & Facts | Britannica*. Www.britannica.com. https://www.britannica.com/topic/bycatch

Baltic Sea. (n.d.). WorldAtlas. https://www.worldatlas.com/seas/baltic-sea.html

Baltic Sea | Countries, Location, Map, & Facts | Britannica. (2020). In *Encyclopædia Britannica*. https://www.britannica.com/place/Baltic-Sea

Best practices to reduce ETP bycatch in fisheries. (n.d.). SFP Bycatch Hub. https://bycatchsolutions.org/

Bielli, A., Alfaro-Shigueto, J., Doherty, P. D., Godley, B. J., Ortiz, C., Pasara, A., Wang, J. H., & Mangel, J. C. (2019). An illuminating idea to reduce bycatch in the Peruvian small-scale gillnet fishery. *Biological Conservation*, *241*, 108277. https://doi.org/10.1016/j.biocon.2019.108277

Brennecke, D., Wahlberg, M., Gilles, A., & Siebert, U. (2021). Age and lunar cycle predict harbor porpoise bycatch in the south-western Baltic Sea. *PeerJ*, *9*, e12284. https://doi.org/10.7717/peerj.12284

Bycatch. (2022). Iwc.int. https://iwc.int/management-and-conservation/bycatch-and-entanglement-of-cetaceans-in-fishing/bycatch

BYCATCH MITIGATION FOR THE BALTIC PROPER HARBOUR PORPOISE What To Do If Pingers Are Not An Option? (2023). https://seas-at-risk.org/wp-content/uploads/2023/05/Alternative-measures_HP-bycatch_English_May.pdf

Bycatch of critically endangered Baltic Sea harbour porpoise must stop. (n.d.). WWF Protecting Whales & Dolphins Initiative. https://wwfwhales.org/news-stories/bycatch-of-critically-endangered-baltic-sea-harbour-porpoise-must-stop

California Bycatch. (2025, May 13). Oceana USA. https://usa.oceana.org/our-campaigns/california-bycatch/

Carlén, I., & Cosentino, M. (2023). High-frequency pingers do not increase catch loss owing to seals in the Baltic Sea. *Aquatic Conservation*, *33*(4), 389–396. https://doi.org/10.1002/aqc.3932

Castrejón, M., & Defeo, O. (2025). Correction: Addressing illegal longlining and ghost fishing in the Galapagos marine reserve: an overview of challenges and potential solutions. *Frontiers in Marine Science*, *12*. https://doi.org/10.3389/fmars.2025.1692750

Countries Act to Better Protect Whales and Dolphins from Bycatch, Chemicals and Underwater Munitions | ASCOBANS. (2016). Ascobans.org. https://www.ascobans.org/en/news/countries-act-better-protect-whales-and-dolphins-bycatch-chemicals-and-underwater-munitions-0

Cruz, Tovar-Ávila, J., César Meiners-Mandujano, Jiménez-Badillo, L., & Oviedo-Pérez, J. L. (2021). Determining potential management strategies for the elasmobranchs bycatch of the Mexican shrimp trawl fishery of the Gulf of Mexico through a vulnerability analysis. *Regional Studies in Marine Science*, *42*, 101626–101626. https://doi.org/10.1016/j.rsma.2021.101626

Data.gov. (2025). Data.gov. https://catalog.data.gov/dataset/peruvian-bycatch-in-ssf-and-bycatch-reduction-technology-testing1

Deutsch, S. (2020). "Who doesn't like dolphins?!" Neoliberalization, variegated environmentalities, and value alterations in a cross-national comparison of Irrawaddy dolphin conservation. *Geoforum*, *114*, 159–171. https://doi.org/10.1016/j.geoforum.2020.05.010

Díaz, D., & García-Cegarra, A. M. (2025). Pingers as a potential deterrent tool to mitigate Burmeister's porpoise (Phocoena spinipinnis) bycatch while foraging nocturnally in the Humboldt Current System: a pilot study. *Frontiers in Marine Science*, *12*. https://doi.org/10.3389/fmars.2025.1582414

Dolphin Conservation: Protecting Our Marine Ecosystems | GVI. (n.d.). Www.gviusa.com. https://www.gviusa.com/blog/smb-dolphin-conservation-protecting-our-marine-ecosystems/

Dolphin hunt in Peru – TAF – The Animal Fund. (2025). Theanimalfund.net. https://theanimalfund.net/en/dolphin-hunt-in-peru/

Dolphin Research Center. (n.d.). Dolphin Research Center. https://dolphins.org/

Dolphins. (2019). Defenders of Wildlife. https://defenders.org/wildlife/dolphins

Dolphins Killed for Shark Bait in Peru. (2025). Pulitzer Center. https://pulitzercenter.org/stories/dolphins-killed-shark-bait-peru

Donovan, P., & Springborn, M. (2022). Balancing conservation and commerce: A shadow value viability approach for governing bycatch. *Journal of Environmental Economics and Management*, *114*, 102689. https://doi.org/10.1016/j.jeem.2022.102689

Duque Londono, C., Cones, S. F., Deng, J., Wu, J., Yuk, H., Guza, D. E., Mooney, T. A., & Zhao, X. (2024). Bioadhesive interface for marine sensors on diverse soft fragile species. *Nature Communications*, *15*(1), 2958. https://doi.org/10.1038/s41467-024-46833-4

Durant, M., Shackell, N. L., Keith, D., Tittensor, D. P., & Worm, B. (2025). Addressing bycatch of depleted species through a marine conservation network in the Canadian Atlantic. *Canadian Journal of Fisheries and Aquatic Sciences*. https://doi.org/10.1139/cjfas-2024-0301

Effect of lure and bait type on catch, size, hooking location, injury and bycatch in the western Baltic Sea recreational cod fishery. (2019). *Fisheries Research*, *210*, 121–130. https://doi.org/10.1016/j.fishres.2018.10.002

Erickson-Davis, M. (2025, June 18). *Peru's new bycatch training aims to help save hooked sea turtles: Q&A with fisher Gustavo Rosales*. Mongabay Environmental News. https://news.mongabay.com/2025/06/perus-new-bycatch-training-aims-to-help-save-hooked-sea-turtles-qa-with-fisher-gustavo-rosales/

Facts about dolphins - Whale & Dolphin Conservation USA. (2018). Whale & Dolphin Conservation USA. https://us.whales.org/whales-dolphins/facts-about-dolphins/

Fang, Y., Carretta, J. V., & Free, C. M. (2025). Estimates and potential drivers of protected species bycatch in the California set gillnet fishery. *Fisheries Research*, *291*, 107560. https://doi.org/10.1016/j.fishres.2025.107560

Federated Identity Service | University of Colorado Boulder - Loading Session Information. (2025). Ebsco.com. https://research.ebsco.com/c/3czfwv/search/details/bfp74uzusj?limiters=FT1%3AY%2CRV%3AY&q=marine%20mammal%20conservation&searchMode=all

Ferguson-Cradler, G. (2024). Coping with crisis: The Peruvian state-owned fishing enterprise Pesca Perú, 1973–1998. *Business History*, 1–24. https://doi.org/10.1080/00076791.2023.2292751

Fisheries, N. (2020, May 21). *National Bycatch Reduction Strategy | NOAA Fisheries*. NOAA. https://www.fisheries.noaa.gov/international/bycatch/national-bycatch-reduction-strategy

Fisheries, N. (2022, June 8). *National Bycatch Report | NOAA Fisheries*. NOAA. https://www.fisheries.noaa.gov/resource/document/national-bycatch-report

Fisheries, N. (2025, March 6). *| NOAA Fisheries*. Www.fisheries.noaa.gov. https://www.fisheries.noaa.gov/species/common-bottlenose-dolphin/conservation-management

Foster, D. G., Pulver, J. R., Scott-Denton, E., & Bergmann, C. (2017). Minimizing bycatch and improving efficiency in the commercial bottom longline fishery in the Eastern Gulf of Mexico. *Fisheries Research*, *196*, 117–125. https://doi.org/10.1016/j.fishres.2017.08.007

Galán, A. S., Chiara Guidino, Francia-Quiroz, J. C., Alfaro-Shigueto, J., & Mangel, J. C. (2025). Evaluating humpback whale (Megaptera novaeangliae) behavioral responses to whale pingers in breeding grounds of northern Peru. *Latin American Journal of Aquatic Research*, *53*(3), 439–449. https://doi.org/10.3856/vol53-issue3-fulltext-3379

Gallaway, B. J., Raborn, S. W., Picariello, L., & Putman, N. F. (2020). Changes in Shrimping Effort in the Gulf of Mexico and the Impacts to Red Snapper. *IScience*, *23*(5), 101111. https://doi.org/10.1016/j.isci.2020.101111

Garcés-García, K. C., Tovar-Ávila, J., Vargas-Trejo, B., Chávez-Arrenquín, D. A., Walker, T. I., & Day, R. W. (2020). Elasmobranch bycatch by prawn trawls in the Gulf of California: First comprehensive analysis and the effect of fish escape devices. *Fisheries Research*, *230*, 105639. https://doi.org/10.1016/j.fishres.2020.105639

General Science and Conservation Studies | Dolphin Quest. (2019). Dolphin Quest. https://dolphinquest.com/scientific-studies-overview/general-science-and-conservation-studies/

Guidino, C., Bielli, A., Groenendijk, S., Campbell, E., Alfaro-Shigueto, J., & Mangel, Jeffrey C. (2025). Assessing the Effectiveness of Whale Pingers in Mitigating Large Whale Entanglements in Gillnet Fisheries in Northern Peru. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *35*(7). https://doi.org/10.1002/aqc.70195

Guidino, C., Cortez-Casamayor, S., Campbell, E., Cajaleón, M., Peña-Cutimbo, N., Delgado, M., Moran-Valverde, J., Arbulu-Vercauteren, Y., & Pacheco, A. S. (2023). Public knowledge and awareness of the conservation of the common bottlenose dolphin (*Tursiops truncatus*) along the central coast of Peru. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *33*(4), 397–408. https://doi.org/10.1002/aqc.3925

Importance of Dolphins in the Ecosystem - Sunshine Scenic Tours. (2022, January 7). Pirate Ship Johns Pass Boat Tours & Dolphin Tour. https://boattoursjohnspass.com/importance-of-dolphins-in-the-ecosystem/

Incentivizing Sustainable Fishing on the High Seas | Projects | WWF. (n.d.). World Wildlife Fund. https://www.worldwildlife.org/projects/incentivizing-sustainable-fishing-on-the-high-seas

Indirectly Subsidized by the Government, Industrial Fishing Companies in Peru Continue to Reap Profits. (2021, December 27). Earth Journalism Network. https://earthjournalism.net/stories/indirectly-subsidized-by-the-government-industrial-fishing-companies-in-peru-continue-to

Kendall-Bar, J., Kendall-Bar, N., Forbes, A. G., McDonald, G., Ponganis, P. J., Williams, C., Horning, M., Hindle, A., Klinck, H., Beltran, R. S., Friedlaender, A. S., Wiley, D., Costa, D. P., & Williams, T. M. (2021).

Visualizing Life in the Deep: A Creative Pipeline for Data-Driven Animations to Facilitate Marine Mammal Research, Outreach, and Conservation. *EScholarship (California Digital Library)*, 1–10. https://doi.org/10.1109/visap52981.2021.00007

Kessler, R. (2024, May 31). *Peru approves the creation of long-awaited marine protected area*. Mongabay Environmental News. https://news.mongabay.com/2024/05/peru-approves-the-creation-of-long-awaited-marine-protected-area/

Li, L., Tang, Y., Dong, H., Zhao, L., & Liu, C. (2025). Planning conservation priority areas for marine mammals accounting for human impact, climate change and multidimensionality of biodiversity. *Journal of Environmental Management*, *381*, 125193. https://doi.org/10.1016/j.jenvman.2025.125193

Mammal, M. (2016, July 6). *Peruvian Government Prosecutes Dolphin Killers*. International Marine Mammal Project. https://savedolphins.eii.org/news/peruvian-government-prosecutes-dolphin-killers

Mangel, J. C., Alfaro-Shigueto, J., Witt, M. J., Hodgson, D. J., & Godley, B. J. (2013). Using pingers to reduce bycatch of small cetaceans in Peru's small-scale driftnet fishery. *Oryx*, *47*(4), 595–606. https://doi.org/10.1017/s0030605312000658

MARCHOWSKI, D., JANKOWIAK, Ł., ŁAWICKI, Ł., WYSOCKI, D., & CHYLARECKI, P. (2020). Fishery bycatch is among the most important threats to the European population of Greater Scaup *Aythya marila*. *Bird Conservation International*, *30*(2), 176–193. https://doi.org/10.1017/s0959270919000492

Marine Stewardship Council . (n.d.). *What is bycatch and how can it be managed | Marine Stewardship Council*. Www.msc.org. https://www.msc.org/what-we-are-doing/oceans-at-risk/what-is-bycatch-and-how-can-it-be-managed

Matthews, K. E., Mohay, J. L., Todd, J. W., & Starr, R. M. (2022). Bycatch in the California halibut (Paralichthys californicus) Trawl Fishery. *Bulletin Southern California Academy of Sciences*, *121*(2). https://doi.org/10.3160/0038-3872-121.2.88

MLMA Master Plan - Appendix M. Bycatch Mitigation Measures and Considerations. (2015). Ca.gov. https://wildlife.ca.gov/Conservation/Marine/MLMA/Master-Plan/Bycatch-Mitigation#gsc.tab=0

Mura, J. P. M., Ferreira, G. A., Zerbini, A. N., & Andriolo, A. (2025). Spatiotemporal group definition of franciscana dolphins from passive acoustic data. *JASA Express Letters*, *5*(8). https://doi.org/10.1121/10.0038646

Need to address bycatch risks? The Bycatch Solutions Hub is here to help! (2024, September 19). Sustainable Fisheries Partnership. https://sustainablefish.org/advisory-blog/need-to-address-bycatch-risks-the-bycatch-solutions-hub-is-here-to-help/

NOAA Fisheries. (2017). *Understanding Bycatch*. Noaa.gov. https://www.fisheries.noaa.gov/insight/understanding-bycatch

NOAA Fisheries. (2018). *Dolphins & Porpoises | NOAA Fisheries*. Noaa.gov. https://www.fisheries.noaa.gov/dolphins-porpoises

NOAA Fisheries. (2022, September 15). *Common Bottlenose Dolphin*. Noaa.gov. https://www.fisheries.noaa.gov/species/common-bottlenose-dolphin

NOAA Fisheries. (2025a). *Bycatch Data Reporting from Observer Programs Database*. NOAA. https://www.fisheries.noaa.gov/national/fisheries-observers/bycatch-data-reporting-observer-programs-database

NOAA Fisheries. (2025b). *Bycatch Reduction Devices - Gulf of America and South Atlantic*. NOAA. https://www.fisheries.noaa.gov/southeast/bycatch/bycatch-reduction-devices-gulf-america-and-south-atlantic

NOAA Fisheries amends red snapper bycatch rule for Gulf of Mexico shrimpers. (2025). Seafoodsource.com. https://www.seafoodsource.com/news/supply-trade/noaa-fisheries-amends-red-snapper-bycatch-rule-for-gulf-of-mexico-shrimpers

O'Farrell, H. B., Babcock, E. A., & McCarthy, K. J. (2024). Bycatch mitigation for commonly caught shark species in the Gulf of Mexico reef bottom longline fishery. *Marine and Coastal Fisheries*, *16*(5). https://doi.org/10.1002/mcf2.10310

Örjan Östman, Sundblad, G., Ljungberg, P., Levin, S., Blass, M., Marju Kaljuste, Dahlin, I., Svensson, R., & Olsson, J. (2023). Catches, bycatches and stock indicators of fisheries targeting cyprinids along the Swedish Baltic Sea coast. *Fisheries Research*, *268*, 106829–106829. https://doi.org/10.1016/j.fishres.2023.106829

Ortiz Alvarez, C., Ortes, R., Mangel, J., Alfaro-Shigueto, J., & Heinrich, S. (n.d.). *Estimating bycatch rates and abundance of small cetaceans in Pucusana, Peru to guide management and conservation initiatives Final Report for the Consortium of Wildlife Bycatch Reduction Project: NA20NMF0080322_6 Prepared by*. https://www.bycatch.org/sites/default/files/2025-06/ProDelphinus%20Final%20report%202024_1.pdf

Ortiz-Alvarez, C., Alfaro-Cordova, E., Bielli, A., Mangel, J. C., & Alfaro-Shigueto, J. (2022). Solid waste assessment in a coastal fishing community in Peru. *Marine Pollution Bulletin*, *178*, 113632. https://doi.org/10.1016/j.marpolbul.2022.113632

Ortiz-Alvarez, C., Ortés-Villauriz, R., Mangel, J. C., Alfaro-Shigueto, J., & Heinrich, S. (2025). Concurrent bycatch and population assessments of Burmeister's porpoises in northern Peru reveal unsustainable levels of mortality. *ICES Journal of Marine Science*, *82*(8). https://doi.org/10.1093/icesjms/fsaf144

Parsons, G. R., & Foster, D. G. (2015). Reducing bycatch in the United States Gulf of Mexico shrimp trawl fishery with an emphasis on red snapper bycatch reduction. *Fisheries Research*, *167*, 210–215. https://doi.org/10.1016/j.fishres.2015.02.009

Pérez-Burgos, J. L., López-Martínez, J., Rábago-Quiroz, C. H., Martínez-Rincón, R. O., García-Morales, R., & Marín-Enríquez, E. (2025). Interannual variability in the distribution and biomass of five demersal fish species from shrimp bycatch and their relationship with environment in the Gulf of California. *Regional Studies in Marine Science*, *87*, 104245. https://doi.org/10.1016/j.rsma.2025.104245

Peru "pinger" trial deters dolphins but not whales · GreenFutures. (2022). GreenFutures. https://greenfutures.exeter.ac.uk/article/peru-pinger-trial-deters-dolphins-but-not-whales/

Peru.info. (2024, October). *Peruvian superfishing takes the world by storm*. Perú Info. https://peru.info/en-us/foreign-trade/blogperu/7/30/peruvian-superfishing-takes-the-world-by-storm

Piskuła, P., & Astel, A. M. (2025). Well-Being of the Baltic Herring and Bycatch Fish Species from FAO Major Fishing Areas 27 According to Microplastic Pollution. *Animals*, *15*(16), 2381. https://doi.org/10.3390/ani15162381

Ramey, K., Barilotti, A., Coates, J., Haggerty, M., Gliniak, H., Lesyna, K., Reilly, P., Tanaka, T., & Valle, C. (2023). *Evaluating Bycatch in the California Halibut Set Gill Net Fishery*. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=213366

Reducing bycatch to save marine life. (2025). World Wildlife Fund. https://www.worldwildlife.org/our-work/oceans/sustainable-seafood/wild-caught-seafood/bycatch/

Segura-Cobeña, E., Alfaro-Shigueto, J., Colodro, V., Gutiérrez-Guzmán, H., Arrese-Dávila, V., Torrejón-Zegarra, R., Vega, L., Custodio-Uribe, A., Peña-Cutimbo, N., Rodríguez-Salazar, J., Messutto, D., Ugalde, V., Araya, E., Andersen Muñoz, I. T., Alfaro-Cordova, E., & Mangel, J. C. (2025). Use of rapid assessments of fishery bycatch of Humboldt penguins *Spheniscus humboldti* in Peru and Chile to help identify conservation priorities. *Royal Society Open Science*, *12*(8). https://doi.org/10.1098/rsos.250319

Skerry, B., Keledjian, A., Brogan, G., Lowell, B., Warrenchuk, J., Enticknap, B., Shester, G., Hirshfield, M., & Cano-Stocco, D. (2014). *WASTED CATCH: UNSOLVED PROBLEMS IN U.S. FISHERIES*. https://oceana.org/wp-content/uploads/sites/18/Bycatch_Report_FINAL.pdf

Smith, S. G., Atkinson, S., Peterson, C., Williams, J. A., & Lowther, A. (n.d.). *Improving Estimation of Bycatch from Shrimp Trawls in the Gulf of Mexico*. https://sedarweb.org/documents/sedar-98-rd01-improving-estimation-of-bycatch-from-shrimp-trawls-in-the-gulf-of-mexico/

so. (2024). *What is bycatch & why is it so harmful? | IFAW*. IFAW. https://www.ifaw.org/international/journal/bycatch

Tamayo-Millán, C., Villegas-Hernández, H., Guillén-Hernández, S., & Díaz-Gamboa, R. E. (2025). Innovative Machine Learning and Stakeholder Method to Assess Bycatch of Tursiops truncatus in the Southern Gulf of Mexico. *Aquatic Mammals*, *51*(3), 281–296. https://doi.org/10.1578/am.51.3.2025.281

Tamayo-Millán, C., & Díaz-Gamboa, R. E. (2025). Tracking the Geographical Origins of the Bycatch of Marine Mammals Stranded in the Southern Gulf of Mexico: Spatial and Temporal Patterns. *Marine Mammal Science*. https://doi.org/10.1111/mms.70013

The Baltic. (n.d.). WWF Baltic. https://www.wwfbaltic.org/about/the-baltic

Using acoustic deterrents to safeguard dolphins from bycatch in Peru. (n.d.). WWF Protecting Whales & Dolphins Initiative. https://wwfwhales.org/news-stories/using-acoustic-deterrents-to-safeguard-dolphins-from-bycatch-in-peru

Villar, D. A., Gutiérrez Tito, E. R., Velásquez-Noriega, P., Anahi Cosky Paca-Condori, Moreno Terrazas, E. G., Balcón Cuno, A., Hinojosa Cárdenas, R., Villanueva, C., Chapman, P., Chiaverini, L., Marino, J., & Gosler, A. G. (2024). Problems with combining modelling and social science approaches to understand artisanal fisheries bycatch. *Diversity and Distributions*. https://doi.org/10.1111/ddi.13918

Westphal, L., von Vietinghoff, V., Moritz, T., von Nordheim, H., Schaarschmidt, T., Teifke, J., Wohlsein, P., Piroch, I., Harder, T., König, P., Höper, D., Benke, H., & Dähne, M. (2025). By-Catch of Grey Seals in Fish Traps in the German Baltic Sea—From Incidents to Mitigation and Fisheries Regulation. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *35*(5). https://doi.org/10.1002/aqc.70147

What is bycatch? | Bycatch Management Information System (BMIS). (2014). Bmis-Bycatch.org. https://www.bmis-bycatch.org/about-bmis/what-is-bycatch

What is Bycatch? | Consortium for Wildlife Bycatch Reduction. (n.d.). Www.bycatch.org. https://www.bycatch.org/what-bycatch

Wood, J. (2021, July 16). *This is how to reduce bycatch for healthier oceans*. World Economic Forum. https://www.weforum.org/stories/2021/07/oceans-fishing-industry-marine-mammals-bycatch/

(2019). https://www.scienceforconservation.org/science-in-action/reducing-bycatch