© IJARW | ISSN (O) - 2582-1008
February 2022 | Vol. 3 Issue. 8
www.ijarw.com

A REVIEW OF BYCATCH REDUCTION DEVICES FOR SUSTAINABLE FISHING

Lantun Paradhita Dewanti[1], Izza Mahdiana Apriliani[2], Heti Herawati[3], Alexander Khan[4]

Fisheries Department, Faculty of Fisheries and Marine Research, Universitas Padjadjaran, Bandung, Indonesia
Corresponding author: lantun.paradhita@unpad.ac.id

ABSTRACT

Fishing activities are continuously carried out in line with the needs of the world market for fishery products. This high production and market share has become an economic potential but also has the potential for exploitation of fish resources and increased fishing activity. In addition to industrial-scale fishery production activities, small-scale fishery activities have a major contribution to the exploitation of coastal resources. Unsustainable capture fisheries activities are characterized by the use of fishing gear that is not environmentally friendly. An indication of this is the high bycatch and discards. Bycatch is a serious problem faced in capture fisheries, including crab fisheries because bycatch has the potential to reduce the abundance and diversity of aquatic biota species so it dangerous the sustainability of aquatic biota diversity. Several bycatch mitigation measures and technologies have been invented and applied to reduce bycatch. However, these measures often ignore the human dimension and fishers' involvement which play a crucial role in successful bycatch reduction. The importance of using fishing gear that can minimize bycatch should be a priority in developing sustainable capture fisheries activities. This review discusses the various types of bycatch reduction devices used for bycatch reduction efforts. One of the efforts to realize sustainable capture fisheries is to pay attention to the number of catches. Various technologies can be used to reduce the amount of bycatch by modifying the fishing gear. The use of a bycatch reduction device (BRD) is a wise choice to increase support for the sustainability of fish resource populations.

Keyword: bycatch reduction device, fishing activities, sustainable fisheries, fisheries resources, fishing gear

1. INTRODUCTION

The sustainable development goal has become the direction of all countries in carrying out development. Several governments, financial organizations, environmental groups, and scientific communities have declared support and commitment to the Sustainable Development Goals (SDGs) since their debut in 2015. For example, life Below the Surface (SDG 14) Water has been declared the worldwide aim for ocean, sea, and marine resource conservation and sustainable use [1]. The concepts of sustainable development are now widely recognized as the foundation for natural resource management, and community expectations are growing that they will be openly followed [2]. Tropical fisheries contribute significantly to the well-being of cultures in both the tropics and the extratropic, with the latter benefiting from 'telecoupling,' or links between distant human-natural systems. On the other hand, physical and biogeochemical oceanic changes connected to rising greenhouse gas levels are endangering tropical marine habitats and fish stocks. Fish population changes and their ramifications for fish productivity have major significance for the United Nations Sustainable Development Goals [3].

Fishing activities are continuously carried out in line with the needs of the world market for fishery products. Even according to Wijoyo [4] the demand for fishery products did not decrease during the Covid 19 pandemic, although fresh fish products experienced problems in the cargo process. This high production and market share has become an economic potential but also has the potential for exploitation of fish resources and increased fishing activity. In addition to industrial-scale fishery production activities, small-scale fishery activities have a major contribution to the exploitation of coastal resources. According to Yonviter [5], small-scale fisheries activities (artisanal fisheries) that are carried out continuously have the potential to cause stock changes and are at risk and are susceptible to disturbance, so that they can disrupt the sustainability of stocks. This can be a threat to the sustainability of fish resources in realizing sustainable capture fisheries [6] in line with the orientation of Indonesia's SDGs.

Furthermore, according to Yonvitner [5] in the perspective of sustainable stock management, it must be seen carefully (precautionary). Assurance of stock sustainability is influenced by internal and external factors of the population. External factors include management input components such as (number of fishermen, number of efforts, intensity of fishing, and economic driven). Meanwhile, the internal factor is the ability of the stock to sustain, due to the ability to reproduce, recover, withstand the impact of fishing from environmental changes (ecology change) and the availability of food and the completeness of the tropical structure of the ecosystem.

Unsustainable capture fisheries activities are characterized by the use of fishing gear that is not environmentally friendly. An indication of this is the high bycatch and discards. Bycatch is a serious problem faced in capture fisheries, including crab fisheries because bycatch has the potential to reduce the abundance and diversity of aquatic biota species so that it hurts the sustainability of aquatic biota diversity [7][8]. Several bycatch mitigation measures and technologies have been invented and applied to reduce bycatch. However, these measures often ignore the human dimension and fishers' involvement which play a crucial role in successful bycatch reduction [9][10]. The importance of using fishing gear that can minimize bycatch should be a priority in developing sustainable capture fisheries activities. This review discusses the various types of bycatch reduction devices used for bycatch reduction efforts.

2. FISHING GEAR GROUPS IN INDONESIA

According to Permen KP No. 18 of 2021 [11], there are 10 groups of fishing gear in Indonesia. The fishing gear is a group of surrounding nets, seine nets, trawls, dredges, lift nets, falling gear, gillnets, traps, hook and line, and not classified fishing gear. Furthermore, the types of fishing gear groups are divided into 2, namely permitted fishing gear and non-permitted fishing gear. According to the regulation, the types of fishing gear are prohibited. The prohibition is carried out because it can threaten the extinction of biota, cause habitat destruction, endanger the safety of users. Fishing gear that disrupts and destroys the sustainability of fish resources as intended includes, danish seine, pair seine, bottom trawl, beam trawl, bottom shrimp trawl, bottom pair trawl, midwater pair trawl, and muro ami.

The operation of this fishing gear must be by the fishing path as stipulated in the regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 59/Permen-KP/2020[12] concerning Fishing Paths and Fishing Equipment in the Fisheries Management Area of the Republic of Indonesia and the High Seas. Fishing activities are prohibited by destroying the sustainability of fish resources using explosives, poisons, electricity, and/or other dangerous tools or materials. Fishing is prohibited in areas such as spawning grounds and care areas for shipping lanes, core zones of marine conservation areas, marine biota migration routes, other fishing areas as determined by the Minister.

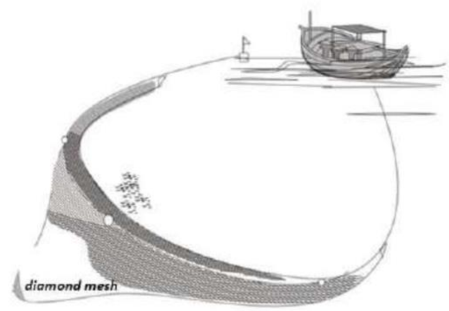

Fig- 1. Midwater trawl, one of the fishing gear that is prohibited from operating in Indonesia I[11]

3. MAIN-CATCH COMMODITY IN INDONESIA

The condition of Indonesia's territorial waters which has the characteristics of mega diversity makes the results of fish resources diverse. In general, fish resource groups in Indonesia are grouped into large pelagic, small pelagic, demersal fish, coral reef fish, crustaceans, and cephalopods. From the large pelagic group, Indonesia has groups of tuna, mackerel, and skipjack. From the small pelagic group, Indonesia's prima donna are sardines, scad fish, and anchovies, from the demersal fish group, for example, snapper from the crustacean group, such as crabs and penaeid.

From the cephalopod group, squid and cuttlefish are the main commodities. Below are the main commodities that become Indonesian fishery export products.

Table 1. Main commodities that become Indonesian fishery export products in 2017-2019 [13]

Commodity	**Year**					
	2017		**2018**		**2019**	
	Volume (Ton)	**Value (000 USD)**	**Volume (KG)**	**Value (USD)**	**Volume (KG)**	**Value (USD)**
Pomfret	6.692	13.749	5.925	12.685	6.708	16.045
Squid, octopus and cuttlefish	120.399	397.333	152.109	554.594	143.847	556.290
Egg and heart fish	3.658	27.796	3.628	40.838	4.426	51.545
Red Snapper	3.724	12.508	4.743	14.626	4.290	11.673
Shellfish	5.319	11.830	9.534	16.909	13.530	17.353
Grouper	7.112	39.630	6.794	41.457	7.692	42.370
Hairtail fish, Reeve S Croakers, Bigeye Croakers	22.919	35.341	21.378	33.647	23.488	43.098
Lobster	1.976	20.884	1.958	29.903	1.633	33.189
Crabs	27.067	409.816	27.792	472.962	25.943	393.497
Seaweed	191.853	204.871	212.962	291.837	209.241	324.849
Sarden-Sardinella	9.671	20.441	12.216	28.117	12.391	27.548
Sea cucumber	1.244	17.255	1.232	10.750	1.507	16.398
Tuna and Skipjack	198.152	660.154	168.434	713.919	184.130	747.538
Shrimp	180.592	1.748.135	197.434	1.742.119.	207.703	1.719

4. BYCATCH OVERVIEW IN INDONESIAN CAPTURE FISHERIES

Traditionally, bycatch reduction practices have focused on command-and-control measures (time and area closures, effort reduction) or technology standards and associated legislative changes (mesh size, hook types, bycatch excluder devices, and mandated requirements that freeze technology in place). Incentives-based bycatch reduction practices such as user rights, taxes, credit schemes, or insurance may reduce bycatch more directly and cost-effectively. Inadequate attention has been paid to this approach [14].

Research conducted in Gorontalo, Sulawesi, cetaceans typically escaped or were released after being apprehended, resulting in minimal mortality. Sharks were taken in the greatest numbers, followed by sea turtles, and their meat was frequently sold. Fishers interviewed appeared to be very reliant on the fisheries, with large households (on average more than five persons) and few other sources of income. Bycatch was seen as a financial danger more than a benefit by many fishermen, thus they favored a reduction in it. It is critical to focus on fishers who are least reliant on the fisheries when adopting bycatch reduction measures, as these fishers are less likely to be negatively impacted by possible fishing limitations, and to include fishermen in the design and implementation of mitigation measures [15].

Bycatch of cetaceans and turtles was primarily influenced by fishing location, whereas bycatch of reef sharks, whale sharks (*Rhincodon typus*), and mobulids was primarily influenced by gear type. Cetaceans either escaped or were released after being captured. Reef sharks, which were frequently sold for their meat, were the most abundantly caught, followed by sea turtles [8].

Further reported from East Flores, Nusa Tenggara, the composition of sharks and mobula rays accounts for 16% of gillnet catches per year, where sharks (296 individuals) are the largest commodity in bycatch in gillnet fisheries, followed by mobula rays (253 individuals), and whale sharks (13 individuals). The operation of the gillnet fishing industry which covers 75% of the waters of East Flores is the cause of the high overlap of fishing gear with habitat which increases the probability of catching sharks and rays in the area [16].

From the Sulawesi fishing area, Hamid [17] stated, Ecosystem-based management and certification of *Portunus pelagicus* (Linnaeus, 1758) fisheries require bycatch biodiversity data. Bycatch biodiversity in crab fisheries in Kolono Bay, Sulawesi revealed 55 species, including 27 fish species, 20 crustacean species, 7 mollusk species, and 1 echinoderm species.

5. BYCATCH REDUCTION DEVICE (BRD)

Fyke Net

Many researchers have proposed the development of bycatch reduction devices (BRD) as an alternative to fisheries management to reduce bycatch in shrimp fisheries [17].

In Farias [18] bycatch (BC) was prevalent in both modalities, but the results showed that MG reduced BC catches by 66 percentage points, indicating that it was more selective than CG. Furthermore, the non-parametric test revealed no significant differences in shrimp catches between fishing gears (MG and CG). As a result, the tested bycatch reduction devices (BRD) reduced the acquisition of bony fishes while preserving the volume of the target catch.

In addition, other research conducted by Poirier [19] individual Fukui foldable traps caught roughly three times the number of green crabs caught by fyke nets. However, fyke nets caught nearly ten times as much bycatch and twice as many native species. Bycatch from fyke nets also included a higher proportion of endangered and commercially important species, such as American eel (*Anguilla rostrata*) and winter flounder (*Pleuronectes americanus*).

Square Net

The use of square nets on the seine net is widely used to reduce bycatch. According to Madhu [20], The incorporation of square mesh panels into traditional cod-end has also been found to improve selection properties while reducing bycatch in trawls. In the case of square mesh panels field-tested along the Cochin coast, an increase in L50 values of 5- 10% and a reduction in bycatch of 4-5% were observed. The technology's advantage is the minimal amount of change required to the existing cod end and the minimal investment required for installation.

As the meshes in the square mesh cod ends remain open under tension during trawling, the water flow will not be restricted and filtration will be efficient and resultant drag will be comparatively less which minimizes fuel consumption. As the mesh lumen remains open, it is easy for small fishes and juveniles to escape through the meshes which reduces the quantum of bycatch enabling the conservation of aquatic resources [21].

Fig- 2. Square net (left) and diamond net (right) [20]

Permanen Magnets (PMFs)

Standardized catch rates show that incorporating magnets into fish traps reduced elasmobranch bycatch by more than a third while increasing the amount of target fish caught by an equal amount. These findings indicate that magnets can be used as an effective bycatch reduction device, reducing elasmobranch bycatch while increasing the profitability of fish traps for fishermen. Future research should aim to replicate these findings in areas where different elasmobranch species are found [22].

The PMFs affected some of the sharks' behaviours, both close to (2 m) and far away (>2 m) from the source. The findings indicate that strong magnets are ineffective at deterring sand tiger sharks, whereas PMFs may be a promising alternative. This study confirms how factors such as the type of electrosensory stimuli, the species involved, and the context in which the interaction occurs can affect the efficacy of shark repellents [23].

Artificial Illumination

Fishing with artificial light has been practiced for years ago. It began with simple techniques like lighting a large fire on the beach to attract fish, but over time it has become increasingly technologically advanced. The use of light to increase catches but also an effort to reduce bycatch.

According to Nguyen [24] the use of illuminated gillnets to reduce the bycatch of sea turtles will necessitate effort and commitment from the government, international non-governmental organizations, and the fishing industry as a whole. Educating and increasing fishermen's awareness of environmentally safe and friendly artificial light use, including keeping broken lights aboard the vessel and returning them to recycling locations, will be an important step toward reducing negative environmental impacts.

The addition of artificial illumination along the trawl fishing line had a significant impact on average catch efficiency for eulachon, rockfish (*Sebastes* spp.), and flatfish, with the three LED configurations each catching significantly fewer individuals than the unilluminated trawl while not affecting ocean shrimp catches. The ten LED-configured trawls caught significantly more Pacific hake (Merluccius products) than the unilluminated trawl. Mean Pacific hake catches did not differ between the five and twenty LED configurations when compared to the unilluminated trawl. This study adds to the body of knowledge about how artificial lighting affects eulachon catches (and other fish) and helps to conserve them [25].

6.CONCLUSIONS

One of the efforts to realize sustainable capture fisheries is to pay attention to the number of catches. Various technologies can be used to reduce the amount of bycatch by modifying the fishing gear. The use of a bycatch reduction device (BRD) is a wise choice to increase support for the sustainability of fish resource populations.

REFERENCES

[1]. Said, Alicia, and Ratana Chuenpagdee. "Aligning the sustainable development goals to the small-scale fisheries guidelines: A case for EU fisheries governance." Marine Policy 107 (2019): 103599.
[2]. Fletcher, W. J., et al. "A flexible and practical framework for reporting on ecologically sustainable development for wild capture fisheries." Fisheries Research 71.2 (2005): 175-183.
[3]. Lam, Vicky WY, et al. "Climate change, tropical fisheries and prospects for sustainable development." Nature Reviews Earth & Environment 1.9 (2020): 440-454.
[4]. Wijoyo, Hadion. Keberlanjutan Pengelolaan Perikanan Era New Normal Pasca Pandemi Covid-19 Gagasan Inovasi Masa Depan. Insan Cendekia Mandiri, 2021.
[5]. Yonvitner, Yonvitner, et al. "Kerentanan intrinsik dan risiko pemanfaatan perikanan: Analisis berbasis data poor untuk pengelolaan berkelanjutan." Jurnal Pengelolaan Perikanan Tropis (Journal of

Tropical Fisheries Management) 2.2 (2018): 54-54.

[6]. Kusdiantoro, Kusdiantoro, et al. "Perikanan Tangkap Di Indonesia: Potret Dan Tantangan Keberlanjutannya." Jurnal Sosial Ekonomi Kelautan Dan Perikanan 14.2 (2019): 145-162.

[7]. Hamid, Abdul, and Syamsul Kamri. "KEANEKARAGAMAN JENIS IKAN HASIL TANGKAPAN SAMPINGAN (BYCATCH) PERIKANAN RAJUNGAN DI TELUK LASONGKO DAN KENDARI SULAWESI TENGGARA." Marine Fisheries: Journal of Marine Fisheries Technology and Management 10.2 (2019): 215-224.

[8]. Mustika, Putu Liza Kusuma, et al. "Marine megafauna bycatch in artisanal fisheries in Gorontalo, northern Sulawesi (Indonesia): An assessment based on fisher interviews." Ocean & Coastal Management 208 (2021): 105606.

[9]. Campbell, L.M. & Cornwell, M.L. (2008). Human dimensions of bycatch reduction technology: current assumptions and directions for future research. Endangered Species Research 5:325-334.

[10]. Cox, T.M., Lewison, R.L, Zydelis, R., Crowder, L.B., Safina, C. & Read, A.J. (2007). Comparing effectiveness of experimental and implemented bycatch reduction measures: the ideal and the real. Conservation Biology 21:1155-1164

[11]. Minister of Marine Affairs and Fisheries Regulation of the Republic of Indonesia Regulation No. 18 of 2021.

[12]. Minister of Marine Affairs and Fisheries of the Republic of Indonesia Regulation Number 59/Permen-KP/2020

[13]. Ministry of Marine Affair and Fisheries. 2022. Fisheries and Marine Affair in Figure 2021.

[14]. Squires, Dale, and Serge M. Garcia. "Ecosystem-level impacts of fisheries bycatch on marine megafauna: Biodiversity conservation through mitigation, policy, economic instruments, and technical change." Report of an IUCN-CEM-FEG Scientific Workshop October. 2013.

[15]. Wonneberger, Elena. "MARINE MEGAFAUNA BYCATCH IN ARTISANAL FISHERIES IN GORONTALO, NORTHERN SULAWESI: AN ASSESSMENT BASED ON FISHER INTERVIEWS." (2018).

[16]. Salim, Muhammad Ghozaly, Mochamad Iqbal Herwata Putra, and Erfian Raditiaz Davinto. " BYCATCH RISK ASSESSMENT IN SMALL-SCALE GILLNET FISHERIES: SHARK FISHERIES DAN PARI MOBULA DI FLORES TIMUR." PROSIDING PUSAT RISET PERIKANAN 1.1 (2019): 145-152.

[17]. Hamid, Abdul, and Syamsul Kamri. "Bycatch biodiversity of blue swimming crab (Portunus pelagicus) fisheries in Kolono Bay, Southeast Sulawesi, Indonesia." AACL Bioflux 14.3 (2021).

[18]. Farias, Eduardo GG, et al. "Proposed bycatch-reduction modifications of shrimp fyke nets used in South American lagoons." Acta Ichthyologica et Piscatoria 49.1 (2019): 1-7.

[19]. Poirier, Luke A., et al. "Fukui foldable traps versus fyke nets as options for fishing European green crabs (Carcinus maenas) in soft-bottom habitats: Exploring efficiency and limiting bycatch." Fisheries Research 230 (2020): 105637.

[20]. Madhu, V. R. "Bycatch reduction devices for trawls." ICAR:: Central Institute of Fisheries Technology, 2019.

[21]. Edwin, Leela, and Saly N. Thomas. "Responsible fishing and sustainability." (2020).

[22]. Richards, R. J., V. Raoult, D. M. Powter, and T. F. Gaston. "Permanent magnets reduce bycatch of benthic sharks in an ocean trap fishery." Fisheries Research 208 (2018): 16-21.

[23]. Polpetta, Maila, Francesco Piva, Stefano Gridelli, and Filippo Bargnesi. "Behavioural responses in the sand tiger shark (Carcharias taurus) to permanent magnets and pulsed magnetic fields." Marine Biology Research 17, no. 1 (2021): 41-56.

[24]. Nguyen, Khanh Q., and Paul D. Winger. "Artificial light in commercial industrialized fishing applications: a review." Reviews in Fisheries Science & Aquaculture 27, no. 1 (2019): 106-126.

[25]. Mark J M Lomeli, Scott D Groth, Matthew T O Blume, Bent Herrmann, W Waldo Wakefield, Effects on the bycatch of eulachon and juvenile groundfish by altering the level of artificial illumination along an ocean shrimp trawl fishing line, ICES Journal of Marine Science, Volume 75, Issue 6, November-December 2018, Pages 2224–2234,