Review of Indonesian Tuna Purse Seine Fisheries in Indian Ocean

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Abstract:

The Indonesian tuna purse seine fishery has developed from small-scale operations in the late 1960s into one of the country's most significant fisheries in the Indian Ocean. Its growth was shaped by ecological conditions, government policy particularly the 1980–1981 trawl ban and technological advances, including the widespread adoption of anchored fish aggregating devices (aFADs). Currently, more than 330 purse seiners, dominated by 120–200 GT wooden boats, operate from major fishing ports in Sumatra, Java, and Bali. The fishery primarily targets skipjack tuna, which accounts for over two-thirds of total landings, while yellowfin and bigeye tunas are taken mostly as bycatch. However, catch data reveal that a high proportion of landed tunas, especially skipjack and yellowfin, are immature, raising sustainability concerns. Bycatch mainly consists of small pelagic species associated with aFADs, which add economic value, while ecologically related species (ERS) such as sharks, rays, turtles, and dolphins occur at low frequencies and are generally released alive. Management combines national measures licensing, logbooks, observer programs, FAD regulations, and shark finning prohibition with Indonesia's obligations to the Indian Ocean Tuna Commission (IOTC). Although these frameworks support responsible exploitation, persistent juvenile catches highlight the need for strengthened monitoring, enforcement, and selective fishing practices to ensure long-term sustainability.

Key words: indonesian tuna, purse seine, indian ocean.

Introduction

Purse seine fisheries in Indonesia were first introduced in 1968, evolving from traditional fishing practices and gradually expanding over subsequent decades (Semedi et al., 2006; Aprillia et al., 1993). As highlighted by Morgan et al. (2006), a broader regional historical perspective reveals that while simple purse seines had been employed as early as the 19th century for certain pelagic species, industrial-scale purse seine fisheries in Indonesia only developed later. The 1980s marked a period of rapid expansion, facilitated by the participation of foreign fleets and reinforced by government policies that encouraged the transition from shrimp trawl fisheries formally banned under Presidential Decree No. 39 of 1980 (Soeharto, 1980) to purse seine operations. Since the 1990s, purse seining has been firmly established as a principal fishing method in Indonesia's tuna fisheries, playing a central role in harvesting activities across the Indian Ocean.

Based on the target species, purse seining in Indonesia is classified into two types: small pelagic purse seine (called as PSPK) and large pelagic purse seine (called as PSPB) (Suwarso, et al., 2014; MMAF 2016; Jatmiko et al., 2020; Mardiah et al., 2023). The target of small pelagic purse seine are small pelagic fishes including sardine (*Sardinella spp.*), mackerel (*Rastrelliger* spp), scads, yellowstripe scads. In certain months, the small pelagic purse seine based at Prigi Fishing Port, with fishing grounds in Indonesia FMA 573 (Indian Ocean south of Java), targets neritic tuna, particularly frigate and bullet tuna (Suwarso, 2014). The targets of large pelagic purse seiners operate in Indonesian Indian Ocean (Indonesia FMA 572-573) are skipjack tuna with primary bycatch juvenile of yellowfin-bigeye tuna and neritic tuna, particularly frigate tuna as well (Jatmiko et al., 2020; Sulityaningsih et al., 2020). This review focuses on tuna purse seine fisheries, emphasizing their development, practices, ecological impacts, and management.

Large pelagic purse seine fisheries (PSPB) in Indonesia, which mainly target skipjack and other tunas, are heavily dependent on fish aggregating devices (FADs) to sustain catch efficiency (Proctor et al., 2019; Widodo et al., 2022). Free-schooling tuna are difficult to exploit because Indonesian purse seiners generally operate with small boats, limited cruising speeds of 6–8 knots, and relatively shallow nets, whereas tunas are fast-moving and form highly dynamic schools (Murua et al., 2018). Fishing trips typically extend from three to six months, reflecting the distant and prolonged nature of operations in offshore waters. Two main operational strategies are applied: direct landing of catches at the base port (non-transshipment) or transshipment at sea, which allows boats to maximize efficiency, prolong fishing duration, and maintain productivity across extended fishing ground.

According to Indonesia's 2024 National Report to the Indian Ocean Tuna Commission (IOTC), the nation's total tuna catches, consisting of albacore, bigeye, skipjack, and yellowfin, reached 274,601 metric tons (mt). Of this total, large pelagic purse seine fisheries, operating both within Indonesia's EEZ and in adjacent high seas target skipjack and other oceanic tunas, contributed 98,266 mt tuna, representing 36% of the total tuna catch. Meanwhile, small purse seines, which operate mainly only in Indonesia EEZ waters targeting small pelagic, but In certain months, however, these captured neritic and oceanic tunas, including frigate and bullet tuna accounted for 56,165 mt or about 20%. In certain months, however, these fisheries also capture neritic and oceanic tunas, including frigate and bullet tuna. Together, these figures demonstrate the central role of purse seine fisheries in sustaining Indonesia's tuna production.

Methods

This paper employed a literature review approach to synthesize existing knowledge on purse seine fisheries targeting tuna in Indonesia. The review was applied to characterize the Indonesian tuna purse seine fishery in the Indian Ocean, focusing on its historical development, fishing operation , catch (tuna and bycatch-ERS), and management under national and regional frameworks. The review included peer-reviewed journal articles, books, and technical reports. References were identified through targeted searches in academic databases (Scopus, Google Scholar) and institutional repositories (University, MMAF, FAO, IOTC), using keywords such as purse seine, tuna, skipjack, yellowfin, Indonesia, and Indian Ocean. Documents were screened based on their relevance and inclusion criteria, requiring empirical data, case studies, or policy analyses directly related to Indonesia tuna purse seine fisheries. The review results are presented as a thematic narrative to provide a structured synthesis of diverse sources. Findings are organized into five themes: (1) history and development of purse seine fisheries in Indonesia, (2) fishing operation, (3) catch including tuna and bycatch-ERS, and (4) management aspect.

Results and Discussion

1. Fleet History and Development

The development of purse seine fisheries in Indonesia began in 1968 and progressed rapidly, especially in the Java Sea, marked by continuous improvements in boat size and fishing technology. Potier et al. (1995) highlighted that around 1975, Central Java adopted a new boat type derived from trawlers previously operating in the region. By 1980, the fleet consisted of approximately 250 units, with fishing activity largely limited to the traditional fishing grounds around Java Sea. However, the 1980–1981 trawl ban triggered a major transition, as numerous trawlers were converted into purse seiners. This conversion spurred both numerical growth of the fleet and geographic expansion of fishing grounds. By 1985–1986, the fleet had extended operations beyond the Java Sea into the new fishing grounds include Makassar Strait where includes as Indonesian Pacific Ocean, the southern sector of the South China Sea, and in part, the Indian Ocean, particularly in the waters of the Indonesian Exclusive Economic Zone (I-EEZ).

The movement of part of the purse seine fleets from the Java Sea to the new fishing grounds was mainly driven by two factors. The decline of fish stocks in the Java Sea (Squires, D., **et al., 2003,** Sriwiyono et al., 2014a; Sriwiyono et al., 2014b) acted as a push factor. While the greater availability of fish resources in the new fishing grounds served as a pull factor, for example, the tuna resources in the Indian Ocean in the 1980s were healthy (Stequert & Marsac, 1989). Purse seine boats that initially targeted small pelagic resources in the Java Sea, upon shifting their fishing grounds particularly to the Indian Ocean began to consider changing their target species to large pelagic, primarily tuna, with skipjack being the focus. The development is estimated to have begun in the 1990s, accompanied by the expansion of anchored FAD use in the same waters (Proctor et al., 2019; Nugroho, et al., 2013).

Due to skipjack movements are more dynamic the purse seine fleet also adjusted their gear configuration by increasing the net dimensions in both length and depth, and by enlarging the mesh size. Current regulations (MMAF, for large pelagic purse seines (tuna) require a minimum mesh size of 3 inches and a maximum length of 1,500 meters for the float line. Before the mid-1990s, purse seine boats were generally equipped only with a compass and radio communication to support fishing operations. However, afterward many began to be fitted with GPS and fish finders, making fishing operations more efficient. Since the 2000s, many purse seine boats have begun using powerblocks as net haulers, whereas previously they used capstans. Figures 1a-1b present photos of boats using capstans and those using power blocks. Currently, total of Indonesian purse seiners registered in IOTC year 2025 are 334 boats (IOTC, 2025), dominated by in general the fleet are wooden hull boats, ranging in size from 60 to 400 GT and dominated by vessels of 120–200 GT, which account for 83%. The main bases of Indonesian tuna purse seine boats operating in the Indian Ocean include Lampulo Fishing Port (Aceh), Sibolga Fishing Port (North Sumatera), Nizam Zachman Fishing Port (Jakarta) and Benoa Port (Bali).

Source : Murua et al. (2018)

Figure 1a. Illustration a typical purse seine boat (A), equipped with a simple auxiliary fishing device, the horizontal capstan (locally known as gardan) (B), which is used to haul the purse line during net hauling process. The capstan is powered by an electro-hydraulic system, and the nets employed on this type of boat generally range from 600 to 800 meters in length.

Photos courtesy A. Anung Widodo, NRIA (2022).

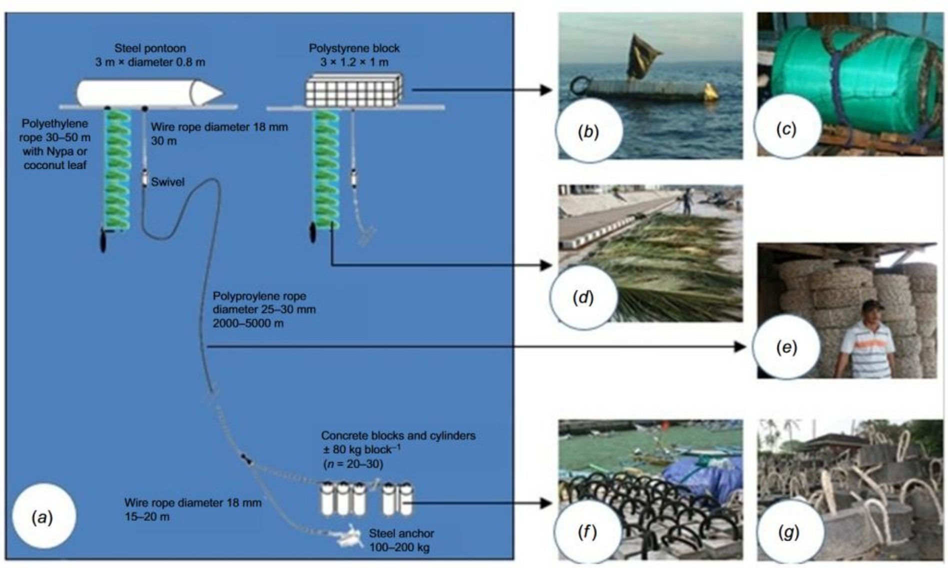
Figure 1b. A typical Indonesian purse seine boat equipped with an advanced auxiliary fishing device, namely a power block, which functions to haul the purse line during net hauling process. The machine is powered by a hydraulic system, and the net length is greater than 1,000 meters.

The evolution of Indonesian purse seine fisheries reflects a dynamic response to resource availability, regulatory interventions, and technological progress. The trawl ban of 1980–1981 was a critical turning point, prompting the conversion of trawlers into purse seiners and driving both fleet expansion and the extension of fishing grounds beyond the Java Sea. This transition was largely influenced by the depletion of small pelagic resources in traditional areas and the comparatively abundant tuna stocks in the Indian Ocean during the 1980s. By the 1990s, the fishery increasingly targeted large pelagic, particularly skipjack, facilitated by the adoption of anchored FADs and modern fishing technologies. At present, the sector is characterized by medium-sized wooden boats, predominantly 120–200 GT, operating from major fishing ports such as Lampulo Fishing Port (Aceh), Sibolga Fishing Port (North Sumatera), Nizam Zachman Fishing Port (Jakarta), and Benoa Port (Bali).

2. Fishing Operation

In brief, the purse seine fishing process, particularly those employing advanced technology, can be described as follows: once a tuna aggregation is detected, the skipper evaluates its size and composition, often using sonar or echosounders, especially at FADs before daylight. If suitable, the skiff is released with one end of the net, while the boat encircles the fish school. The purse line is then hauled, closing the net beneath the fish in a process called "pursing." Net hauling follows, using a power-block to concentrate the catch until "sacking up". Fish are removed with brails and either sorted in a hopper or directly loaded into wells. Storage is usually in refrigerated brine tanks or iced seawater (FAO, 2001, ISSF, 2016).

In general, purse seine skippers are not professionals with higher formal education backgrounds; instead, their skill is traditionally inherited and passed down through generations of skippers. Fishing strategies and tactics are closely linked to the skipper's knowledge of the environment and fish behavior, which are key factors influencing fisheries performance. This knowledge is applied both at the strategic level, including the selection of time scales for fishing trips, for example, 30 days or more per fishing trip and at the tactical level, which concerns the specific methods used during fishing including fishing in free schooling or associated with FADs. Interviews conducted in 2022 with 34 purse seine skippers based at Nizam Zachman Fishing Port (Muara Baru), Jakarta, revealed that purse seine operations are generally carried out around fish aggregating devices (FADs) or other floating objects. The type of FADs used are anchored FADs, with designs and constructions as illustrated in Figure 2.



Photos courtesy Craig Proctor, CSIRO (2015).

Figure 2. Construction of aFADs. (a) general FAD construction; (b, c) pontoon types; (d) fish attractor; (e) ropes used in construction; (f, g) blocks used to anchor FAD in place (Widodo et al., 2023).

The fishing trip (day at sea) of Indonesian purse seine fishery of the Indian Ocean, typically range from 30 to 120 days in duration, of which 18 to 80 days are effective fishing days (effective days about 60-67% of day at sea), on each effective day, boats usually perform a single net set. About 33–40% of the remaining days are primarily allocated for (1) steaming from the fishing port to the position of the first FADs and returning from the position of the last FADs, (2) steaming between FADs, (3) unfavorable weather conditions that do not allow fishing operations, and (4) repair of nets, engines, hulls, and other equipment.

The fishing grounds of the Indonesian purse seine fishery in the Indian Ocean encompass three main areas: (1) Indonesian Fisheries Management Area (I-FMA) 572 (Indonesian EEZ west of Sumatra), (2) I-FMA 573 (Indonesian EEZ south of Java, Bali and Nusa Tenggara Timur), and (3) the high seas. Tuna purse seine boats generally operate in the Indonesian EEZ and the high seas, while small purse seine boats typically operate in territorial waters and the I-EEZ. Based on fishing logbooks managed by the Directorate General of Capture Fisheries (DGCF) in 2022 and 2023, the distribution of fishing grounds and the composition of species caught are presented in Figures 3 - 5.

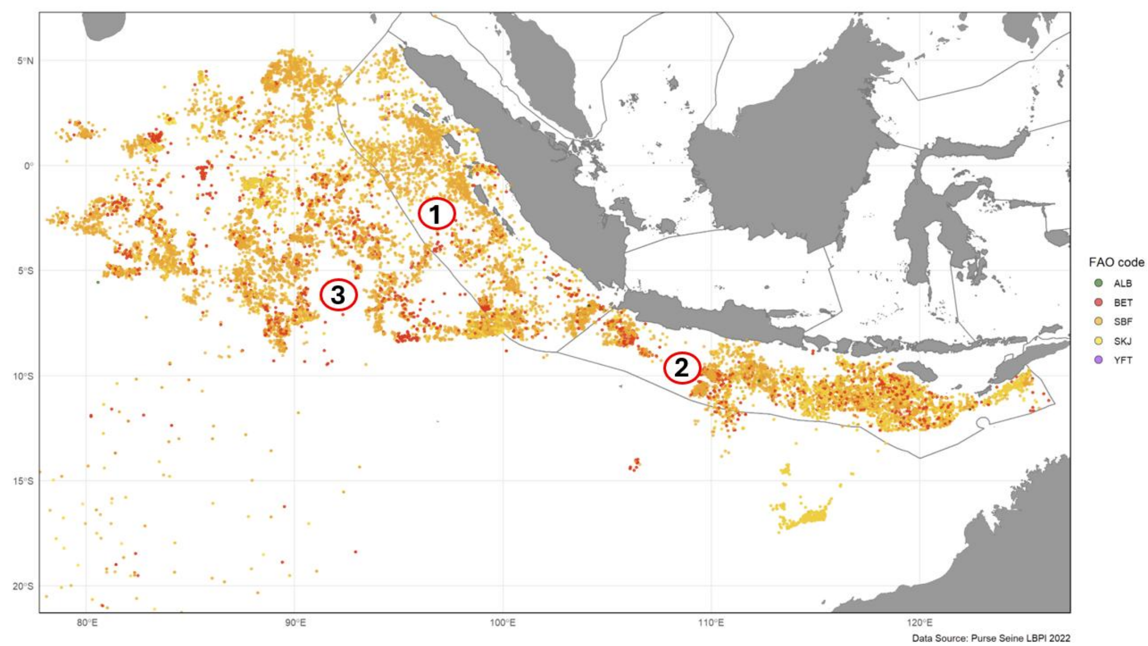


Figure 3. Fishing positions and species composition of purse seine catches based on 2022 fishing logbook records. (1) I-FMA 572, (2) I-FMA 573, and (3) high seas.

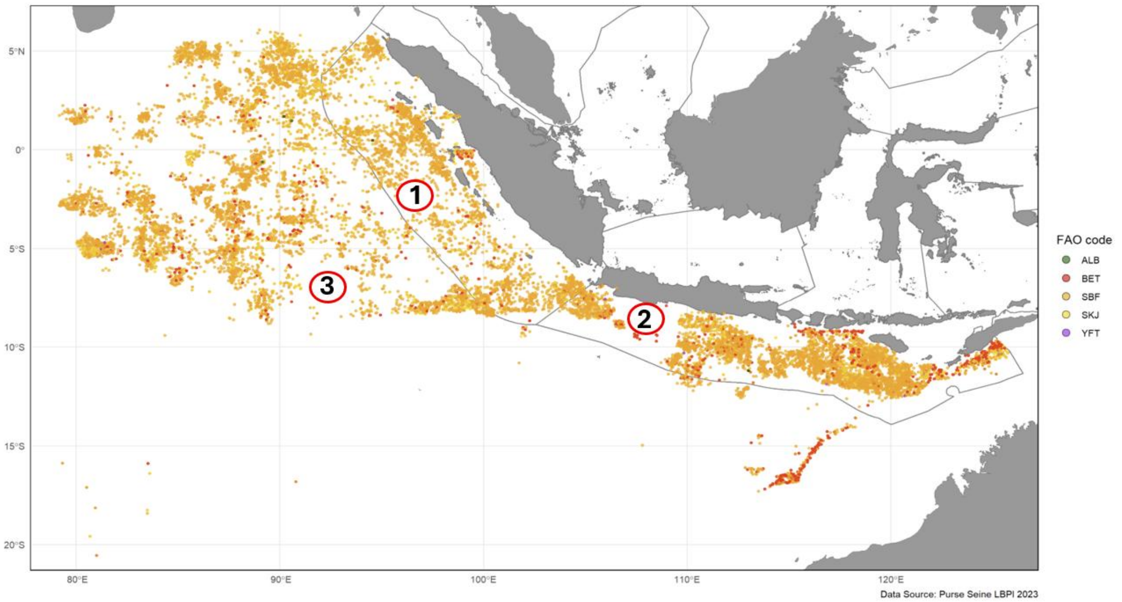


Figure 4. Fishing positions and species composition of purse seine catches based on 2023 fishing logbook records. (1) I-FMA 572, (2) I-FMA 573, and (3) high seas.

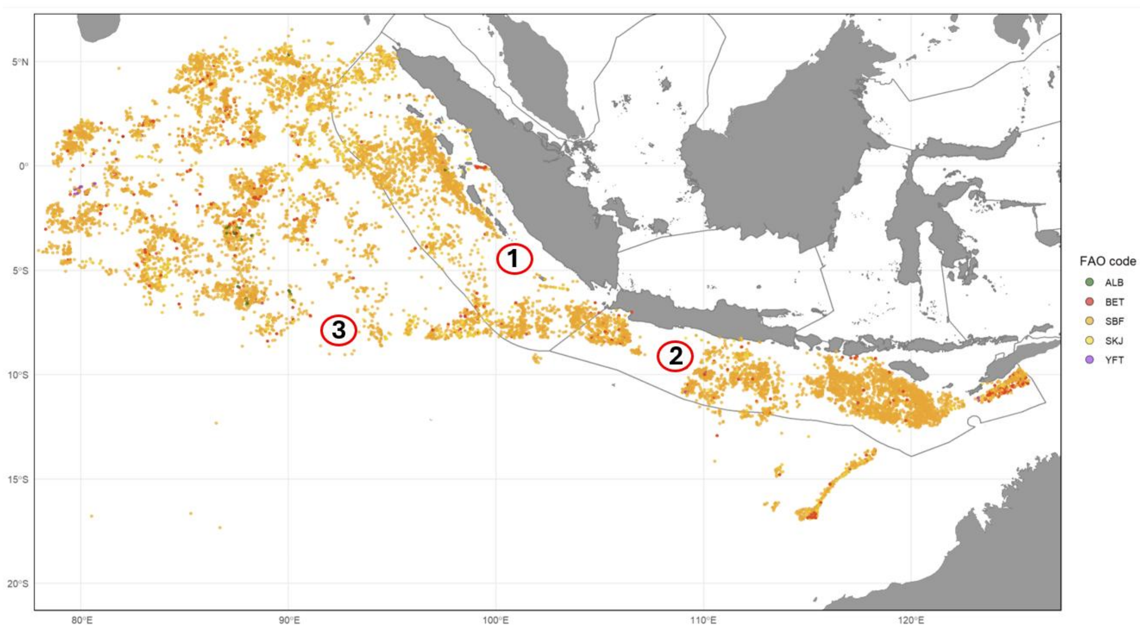


Figure 5. Fishing positions and species composition of purse seine catches based on 2024 fishing logbook records. (1) I-FMA 572, (2) I-FMA 573, and (3) high seas.

Chumchuen et al. (2016) said that generally in the fishing industry, each skipper applies specific strategies, combining different operation types to maximize or stabilize revenue. Decisions on which fish schools to pursue depend largely on skipper skills, fish prices, and species size categories. While vessel equipment and gear modifications influence fishing performance, these factors were considered part of the skipper's overall skill set. In Indonesia, the operation of tuna purse seine fisheries in the Indian Ocean reflects a combination of traditional skipper knowledge and modern fishing technologies. While sonar, echosounders, and power-blocks enhance efficiency, fishing performance still relies heavily on the skipper's environmental knowledge and decision-making, particularly in relation to FAD-associated fishing.

The Fish Aggregating Devices (FADs) employed by Indonesian purse seine fishers are anchored FADs, which regarded as environmentally friendly. The FAD attractors are made of coconut or other palm leaves that are biodegradable, while the main ropes are constructed from non-plastic materials, allowing them to degrade more readily once they are no longer utilized. This situation differs somewhat from tuna purse seine fleets of other countries, which make extensive use of drifting FADs (dFADs) with attractors made of entangling material. Such practices often lead to ghost fishing (ALDFG), with significant consequences for the abundance and ecological impacts on both target species and ecologically related species or ERS (Heile et al., 2024).

Fishing trips typically last 30–120 days, with 60–67% of days spent effectively fishing, while the remainder are used for steaming, maintenance, or weather-related delays. The main fishing grounds include I-FMA 572, I-FMA 573, and adjacent high seas. This operational pattern illustrates the adaptive strategies employed to optimize tuna catch efficiency, including through transhipment practices such as Satria et al. (2018) said that transhipment was a common practice in tuna longline and purse seine fisheries in Indonesia until it was banned by the Indonesian government in 2014.

3. Catch

a. Tuna

As previously mentioned, the fishing grounds of Indonesian purse seine fisheries consist of four areas: territorial waters, the Indonesian Exclusive Economic Zone (IEEZ) in Fisheries Management Area (FMA) 572, the IEEZ in FMA 573, and the high seas. The overlapping fishing grounds, particularly within the I-EEZ where both tuna purse seiners and small purse seiners operate, allow for the possibility that purse seine fisheries capture a relatively similar number and composition of tuna species between the two fleet types (Table 1). The total tuna catch of Indonesian purse seine including tuna purse seine and small purse seine recorded from 2017 to 2023 showed substantial fluctuations, ranging from 54,171 MT in 2018 to a peak of 154,431 MT in 2023, with an average of 97,893 MT. Table 1 further indicates that skipjack tuna constitutes the predominant species in the catch of both tuna purse seine and small purse seine fisheries, contributing 71.9% and 76.0% of the total catch, respectively.

Table 1. Tuna catches of Indonesian tuna purse seine and small purse seine as reported to IOTC 2024 (NIRA-MMAF, 2024).

Type of Gear	Species	Catch (MT) by Year 2017	2018	2019	2020	2021	2022	2023	Average (MT)	%
Tuna Purse seine	ALB	30	13	-	-	131	286	38	71	0.1
	BET	9,488	5,116	897	4	1,096	9,819	10,473	5,270	7.3
	SKJ	43,613	14,203	53,612	6,181	44,888	51,425	72,524	40,921	71.9
	YFT	11,595	5,430	14,719	733	14,349	13,760	15,231	10,831	20.7
	Sub-Total	64,726	24,762	69,228	6,918	60,464	75,290	98,266	57,093	100.0
Small Purse seine	ALB	0.0	12	0,0	0,0	81	278	627	200	0.1
	BET	0.0	803	507	4,550	880	7,197	803	2,106	4.2
	SKJ	0.0	21,682	9,422	59,606	29,820	48,815	44,770	30,588	76.0
	YFT	0.0	6,912	1,669	15,133	7,554	14,513	9,965	7,964	19.7
	Sub-Total	0.0	29,409	11,598	79,289	38,335	70,803	56,165	40,800	100.0
	Total	64,726	54,171	80,826	86,207	98,799	146,093	154,431	97,893	

The catch trends of Indonesian purse seine fisheries highlight the importance of this sector in tuna exploitation within both national and international waters. The overlap of fishing grounds between tuna purse seiners and small purse seiners, particularly in the Indonesian EEZ, results in comparable catch composition across fleets. Skipjack tuna consistently dominates the catch, accounting for over 70% of total landings, which underscores its role as the primary target species. Annual catches between 2017 and 2023 fluctuated markedly, reflecting variability in resource availability and fishing effort. The recent peak in 2023 suggests both expanding effort and favorable stock conditions.

b. Bycatch-ERS

The bycatch of Indonesian tuna purse seine fisheries consists mainly of finfish species aggregated around aFADs, such as rainbow runner, mahi-mahi, and others, which are generally retained on board due to their considerable economic value. In contrast, ecologically related species (ERS), including sharks, rays, sea turtles, and dolphins, although occasionally caught at low frequency, are typically released back into the sea in accordance with national and regional regulations (Murua et al., 2018). Jatmiko et al. (2020) reported, based on port sampling conducted at Sibolga Fishing Port and Nizam Zachman Fishing Port, that the economically valuable bycatch of tuna purse seine fisheries consisted of scads (26.89%), rainbow runner (0.54%), Spanish mackerel (0.20%), dolphinfish (0.08%), kawakawa (0.05%), barracuda (0.02%), bigeye scads (0.01%), oceanic triggerfish (0.04%) and sharks (0.01%), from a total sampled catch of 69.5 metric tons.

Triggerfish is usually discarded back into the sea (due to low market value), particularly when no storage space remains in the fish hold. Sharks and other ERS, when present, are returned to the sea in live condition, following recommended best-practice protocols for bycatch and ERS handling. In relation to bycatch and ERS mitigation and handling, the International Seafood Sustainability Foundation (ISSF), in collaboration with the Research Center for Fisheries of the Ministry of Marine Affairs and Fisheries (MMAF), has conducted skipper workshops for purse seine fisheries operating in the Indian Ocean. These workshops involved more than 200 participants, including skippers, crew members, and managers, and were held at several major fishing ports, namely Lampulo, Sibolga, Nizam Zachman, Pekalongan (Central Java), Prigi Fishing Port (Eastern Java), and Benoa Fishing Port.

The bycatch composition of Indonesian tuna purse seine fisheries indicates that most non-tuna species aggregated around anchored FADs, such as scads, rainbow runner, and mahi-mahi, contribute additional economic value and are therefore retained. However, the incidental capture of ecologically related species (ERS), including sharks, rays, sea turtles, and dolphins, remains infrequent and is generally released alive in accordance with national and regional regulations. Port sampling confirmed that bycatch volumes are relatively low, with scads dominating the retained component. Ongoing mitigation efforts, including ISSF–MMAF skipper workshops, have strengthened awareness and adoption of best practices for bycatch and ERS handling.

c. Fish Size

There is limited information available on the size of tunas, particularly skipjack, yellowfin, and bigeye caught by Indonesian tuna purse seine in the Indian Ocean. To provide an overview of the size, reference can be made to the findings of Jatmiko et al. (2020), as presented in Figures 6 - 9.

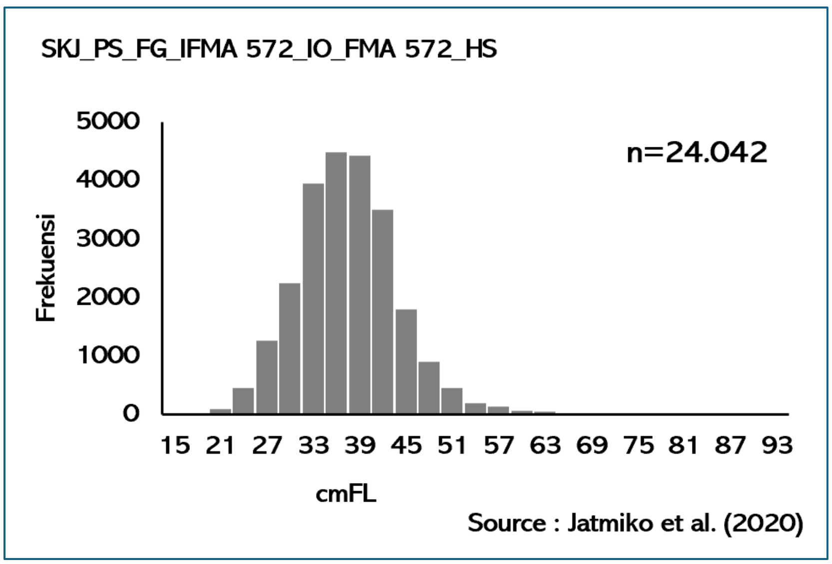


Figure 6. Size (cmFL) distribution of skipjack caught by Indonesian tuna purse seine in Indian Ocean I-EEZ FMA 572 and high seas.

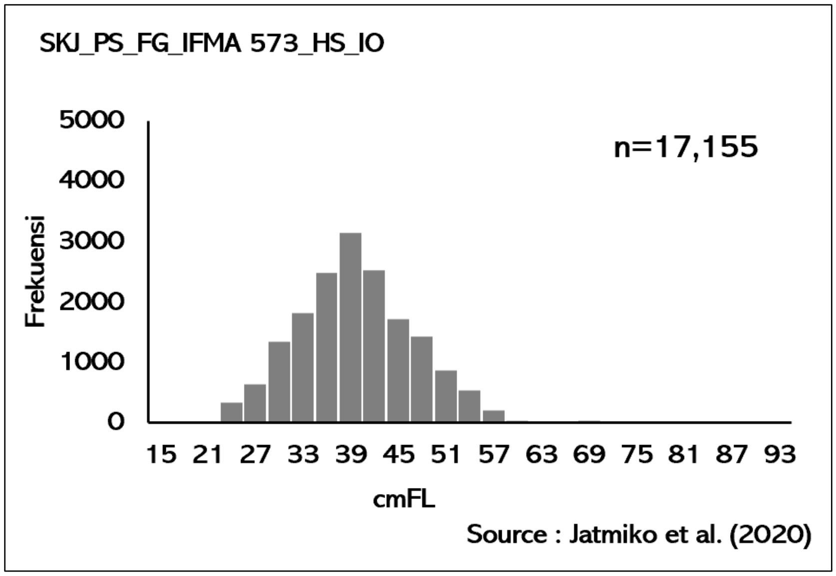


Figure 7. Size (cmFL) distribution of skipjack caught by Indonesian tuna purse seine in Indian Ocean I-EEZ FMA 573 and high seas.

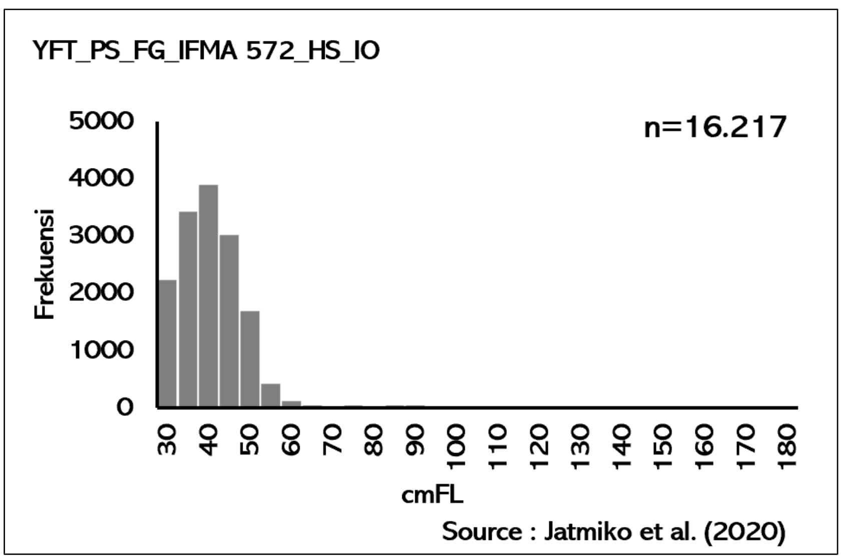


Figure 8. Size (cmFL) distribution of yellowfin tuna caught by Indonesian tuna purse seine in Indian Ocean I-EEZ FMA 573 and high seas.

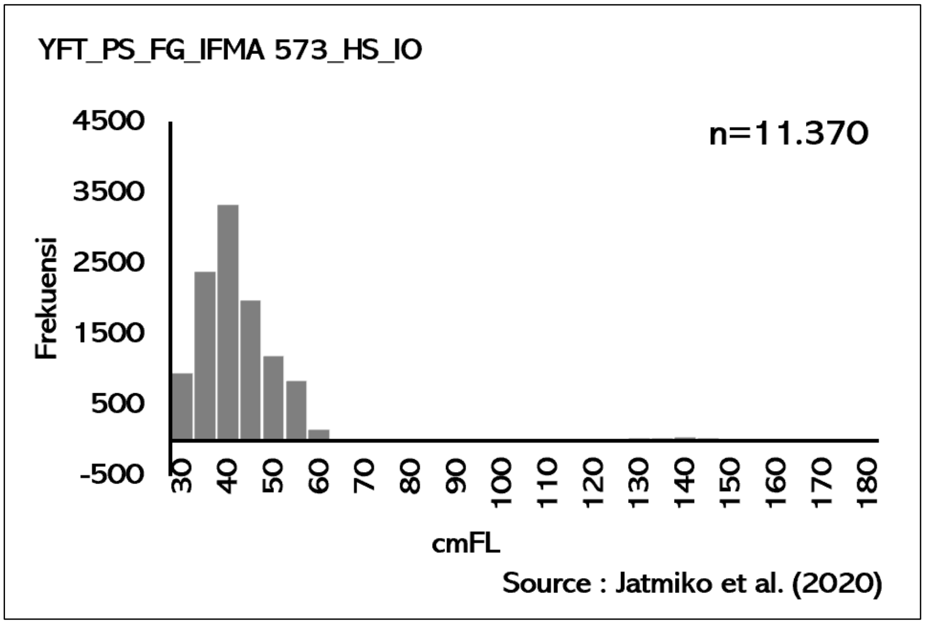


Figure 8. Size (cmFL) distribution of yellowfin tuna caught by Indonesian tuna purse seine in Indian Ocean I-EEZ FMA 573 and high seas.

The size composition of tuna caught by Indonesian purse seine fisheries in the Indian Ocean indicates a predominance of immature individuals, raising concerns for stock sustainability. Skipjack catches show that approximately 70.9% in FMA 572–high seas and 56.8% in FMA 573–high seas are below the maturity length (L50 ≈ 38–40 cm FL; Gande et al., 2010; Grande et al., 2014). For yellowfin, Zudaire (2013) reported L50 at 75 cm FL (cortical alveolar stage) and 102 cm FL (vitellogenic stage), yet 100% of yellowfin landed were immature. These findings highlight the need for improved size-selective measures and strengthened management to protect juvenile tunas. Referring to the IOTC stock assessment results, which state that based on the weight-of-evidence available in 2023 the skipjack tuna stock is determined to be not overfished and not subject to overfishing (IOTC, 2024), the skipjack tuna caught should therefore be of larger sizes. It is plausible that the relatively small size of skipjack tuna caught is influenced by fishing on FADs, where individuals are generally smaller. Several studies have documented that skipjack captured around FADs are typically smaller than those caught outside FADs or from free schools (Mallawa, 2020; Hidayat, 2021; Widodo et al., 2023). Further research is required to better understand the underlying factors contributing to this issue.

4. Management

The management framework of Indonesian tuna purse seine fisheries reflects a multi-layered approach that integrates national and regional measures to ensure sustainability. At the national level, the Directorate General of Capture Fisheries (DGCF–MMAF) enforces licensing requirements, mandatory logbooks, and observer programs, which serve as essential tools for monitoring and compliance. Conservation-oriented measures, such as the prohibition of shark finning and the regulation of fish aggregating devices (FADs) further strengthen domestic management. At the regional level, Indonesia's adherence to the Indian Ocean Tuna

Commission (IOTC) mandates aligns national practices with international standards, promoting responsible fishing across shared stocks. Collectively, these instruments aim to balance economic benefits with long-term stock sustainability while advancing ecosystem-based fisheries management. National regulations related to purse seine management in Indonesia include, among others:

- Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 36 of 2023 concerning The Placement of Fishing Gears and Fishing Aids in Measured Fishing Zones and Fisheries Management Areas of the Republic of Indonesia in Inland Waters The regulation stipulates that the length of the float line of tuna purse seine shall not exceed 1,500 meters and the minimum mesh size shall not be less than 2 inches maximum of 3 units of AFADs), for those operating in the IFMA and the minimum distance between AFADs shall be 10 nautical miles.
- Ministerial Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia No. 18/KEPMEN-KP/2013 (2013) on the Establishment of Full Protection Status for Whale Shark (*Rhincodon typus*). As is well known, whale sharks are frequently caught as ecosystem-related species (ERS) in tuna purse seine fisheries.

Conclusion

The Indonesian tuna purse seine fishery in the Indian Ocean is dominated by medium-sized wooden vboats (120–200 GT) with relatively modest technology compared to industrial fleets. While the fishery contributes substantially to national tuna production, catches are characterized by high proportions of juvenile tunas, and skipjack sizes are relatively small, likely influenced by FAD-based fishing. Anchored FADs reduce some ecological risks but still raise sustainability concerns. Strengthened monitoring, enforcement, and selective fishing strategies remain crucial to secure long-term sustainability.

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