

# Resilience and adaptability of small-scale tuna fisheries in Indonesia amid the COVID-19 outbreak

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**Abstract.** The COVID-19 pandemic caused significant disruptions to global fisheries, raising concerns about its impact on small-scale fisheries that are vital to livelihoods and food security. This study examines the resilience of small-scale tuna fisheries in Indonesian Fisheries Management Areas (FMAs) 713, 714, 715, 716, and 717, focusing on the operations of purse seine, pole-and-line, and handline vessels during the pandemic. By analyzing vessel landing data from 2019 (pre-pandemic) and 2020 (pandemic period), the study identifies trends in fishing activities, including the number of active boats, landings, days at sea (DAS), days of fishing (DOF), and catch per unit effort (CPUE). Results indicate no significant changes in these key metrics, suggesting that small-scale tuna fisheries maintained consistent operations despite the pandemic. This resilience is attributed to fishers' reliance on seasonal patterns, daily subsistence needs, and continued market demand, even amidst fluctuating fish prices. The sustainable stock status of skipjack, yellowfin, and bigeye tuna in the region, as reported by the Western and Central Pacific Fisheries Commission (WCPFC), further supported the stability of fishing activities. The study highlights the adaptability of small-scale fishers, who balanced traditional practices with socio-economic needs to navigate external shocks.

**Key Words:** COVID-19, CPUE, Indonesia's Archipelagic waters, seasonal pattern, small-scale fisheries, tuna.

**Introduction.** The COVID-19 pandemic has caused significant disruptions across various economic sectors, including the tuna fishing industry. In particular, the pandemic's impact on the tuna industry in the Pacific islands has been widely documented. Key challenges include port closures, extended quarantine periods that hindered access to regional ports, and interruptions in fish supply chains, which forced processing plants to shut down temporarily (Aqorau 2020). Additionally, reductions in market channels, fish prices, and overall revenue further compounded the economic strain on the tuna industry (Chumchuen et al 2022; Ogier et al 2022).

In Indonesia, research on the specific impact of COVID-19 on tuna fisheries, particularly small-scale tuna fisheries, remains limited. Except for SFP (2020), there has been minimal focus on understanding how the pandemic has affected this critical sector. The fishing industry encompasses various interconnected sectors, including fishing, processing, and distribution, collectively referred to as the fishery supply chain. The supply chain involves all processes and activities necessary to transform raw fish into final products delivered to consumers. These include production inputs, physical transformation, and distribution (Beamon 1998; Kaplinsky & Morris 2001; Bjørndal et al 2015).

A well-functioning fisheries supply chain requires the integration of various actors across all stages, from production to marketing (Gereffi et al 2005; Gibbon et al 2008; Bair 2009; Widodo et al 2021). Moreover, the supply chain's competitiveness is a critical determinant of the success of traceability frameworks, such as tuna catch documentation schemes (CDS) (Hosch 2016). For the tuna fishing industry, the supply chain involves activities at the harvesting stage, attributes of fishers, fish processing companies,

wholesalers, and traders, as well as the distribution of catches between domestic and export markets.

Despite its importance, previous studies on the impact of COVID-19 on fisheries have primarily focused on market sectors, neglecting the upstream production processes. Understanding the impact of the pandemic on each sector of the supply chain is crucial for a holistic assessment. Therefore, this study aims to identify the immediate impacts of the COVID-19 outbreak on tuna fishing activities, specifically focusing on the production sector within small-scale tuna fisheries in Indonesia's Archipelagic Waters (IAW).

**Material and Method.** This research was conducted in January-December 2021, focusing on IAW, specifically Indonesia Fisheries Management Areas (FMAs) 713, 714 and 715, and also FMAs 716 and 717 to capture the whole area of Western and Central Pacific Fisheries Commission (WCPFC). The study utilized a combination of methods, including (1) desk studies and literature reviews, (2) field data collection, and (3) expert consultative workshops. These approaches were employed to obtain both qualitative and quantitative data on small-scale tuna fisheries, which were then analyzed to assess the impacts of the COVID-19 outbreak on the harvesting sector of the tuna supply chain.

The study area encompasses FMAs 713, 714, 715, 716, and 717 which are significant fishing zones for small-scale tuna fisheries in Indonesia. The data collection was focused on two major fishing ports: Kendari Ocean Fishing Port (Kendari OFP) and Bitung Ocean Fishing Port (Bitung OFP), where small-scale fishing vessels primarily operate. These vessels include small purse seiners, pole-and-line, and hand-line vessels, which are representative of small-scale tuna fisheries in the region. Vessels based at these ports typically operate within FMA 713, 714, 715, 716, and 717, making them ideal for analyzing trends in tuna fisheries during the study period.

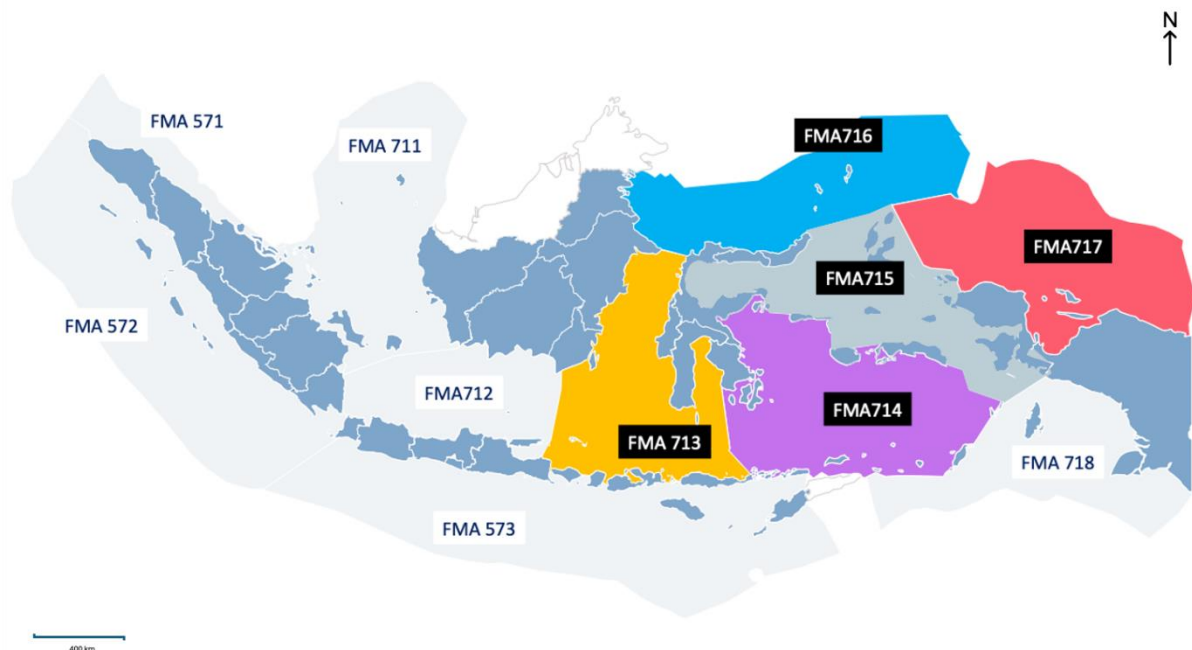


Figure 1. Map of Indonesia's Fisheries Management Areas (FMAs) 713-717 (highlighted).

The desk study and literature review were conducted in Jakarta and Bogor to gather secondary data and contextual information. These activities involved reviewing published and unpublished reports, journal articles, and other relevant documentation related to tuna fisheries and the impacts of COVID-19 on the fishing industry. Field data were collected at Kendari OFP and Bitung OFP. Data collection focused on small-scale tuna fishing operations, specifically small purse seiners, pole-and-line boats, and hand-line vessels. The primary data collected included daily landing data from January 2019 to December 2020. This timeframe was selected to analyze trends before and during the COVID-19 outbreak, officially declared in Indonesia in March 2020. The landing data included:

- vessel information: name, size (gross tonnage), and fishing gear used;
- fishing operation details: duration of fishing trips (days at sea, DAS) and days of fishing (DOF);
- catch information: catch volume (in kilograms) and species composition.

The following monthly trends were analyzed to assess the impact of COVID-19: number of active boats (vessels conducting fishing operations); number of fishing trips (landings); DAS and DOF; total catch volume (in kilograms); catch per unit effort (CPUE) for purse seine, pole-and-line, and hand-line. The CPUE or catch rate, was calculated using the equation provided by Petrere et al (2010), which standardizes fishing efforts to enable comparisons across different periods.

**Results.** Tropical tunas, including skipjack tuna (*Katsuwonus pelamis*, SKJ), yellowfin tuna (*Thunnus albacares*, YFT), and bigeye tuna (*Thunnus obesus*, BET), are commercially important species in Indonesian waters. These species are highly migratory, and their stocks are assessed by the Western and Central Pacific Fisheries Commission (WCPFC). Indonesia's Fisheries Management Areas (FMA) 713-717, located within the WCPFC's jurisdiction, are significant for tuna production (Figure 1). According to the National Tuna Catch Estimates (ANTCE) submitted to the WCPFC in 2020, the total tuna catch in Indonesia's Pacific Ocean waters (FMAs 713-717) reached 534.084 tonnes in 2019, with SKJ accounting for approximately 55% of the total catch (Table 1). The most productive fisheries in FMAs 713, 714 and 715 were dominated by handline and pole and line vessels, contributing around 45% of the total tuna catch in these areas (Table 2). In contrast, purse seine fisheries were the most productive gear type in FMAs 716 and 717 (Table 3).

Table 1  
Catch of tuna in FMA 713-717 reported by Indonesia to WCPFC in 2020

Waters	Catch (tonnes and %) by species of tuna (in 2019)			
	SKJ	YFT	BET	Total
FMA 713-715	263,177	188,512	14,421	466,110
%	57	40	3	100
FMA 716-717	33,566	30,666	4,742	68,974
%	49	44	7	100
Total I-FMA 713-717	296,743	219,178	19,163	534.084
%	55	41	4	100

SKJ = skipjack tuna; YFT = yellowfin tuna; BET = bigeye tuna.

Table 2  
Catch of tuna by type fishery in FMA 713, 714, and 715 reported by Indonesia to WCPFC in 2020

Fisheries	Catch (tonnes and %) of tuna in FMA 713, 714 and 715 (2019)				
	SKJ	YFT	BET	Total	%
Purse seine	85,621	16,372	712	102,705	22
Pole and line	79,795	14,060	963	94,818	20
Handline	6,163	94,881	4,112	105,156	23
Troll line	28,775	29,893	631	59,299	13
Longline	629	5,571	2,786	8,986	1.9
Gillnet	6,235	2,691	642	9,568	2.1
Others	55,959	25,044	4,575	85,578	18
Total	263,177	188,512	14,421	466,110	100
%	57	40	3	100	

SKJ = skipjack tuna; YFT = yellowfin tuna; BET = bigeye tuna.

Table 3

Catch of tuna by type fishery in FMA 716 &amp; 717 reported by Indonesia to WCPFC in 2020

Fisheries	Catch (tonnes and %) of tuna in FMA 713, 714 and 715 (2019)				
	SKJ	YFT	BET	Total	%
Purse seine	27,073	8,571	680	36,324	53
Pole and line	1,113	388	-	1,501	2.1
Handline	1,004	11,301	250	12,555	18
Troll line	1,405	3,797	11	5,213	8
Longline	495	4,382	2,191	7,068	10
Gillnet	935	199	-	1,134	1.6
Others	1,541	2,028	1,610	5,179	7.3
Total	33,566	30,666	4,742	68,974	100
%	49	44	7	100	

**Pole and line fishery.** In 2019, Kendari Fishing Port hosted 31 active carrier boats and 18 catcher boats operating pole and line gear. These vessels collectively conducted 273 transshipment events in 2019 and 230 in 2020, indicating fluctuations in total landings and fishing trips (Figure 2A). The estimated DAS and DOF for these boats were 1,955 DAS and 1,360 DOF in 2019 and 1,755 DAS and 1,233 DOF in 2020 (Figure 2B). Total estimated catches were 1,730 tonnes in 2019 and 1,402 tonnes in 2020, with average CPUEs of 1,184 and 869 kg day<sup>-1</sup>, respectively (Figures 2C and 2D).

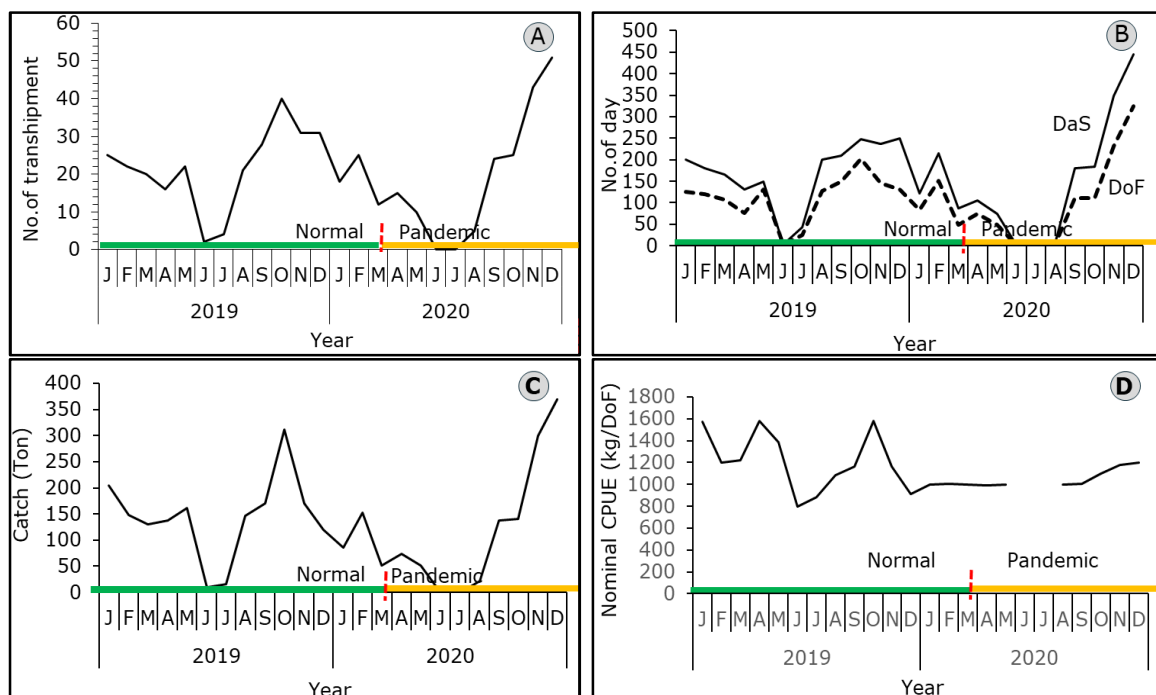


Figure 2. Fluctuations in pole and line fishery operations at Kendari Fishing Port (Southeast Sulawesi) during 2019 and 2020: (A) number of transshipment events from catcher boats to carrier boats; (B) estimated days at sea and days of fishing for catcher boats; (C) total tuna catch; and (D) catch per unit effort (CPUE). The red dashed line indicates the implementation of Indonesia's lockdown policy on March 20, 2020, marking the onset of COVID-19 restrictions.

At Bitung Fishing Port, pole and line vessels ranged from 19 to 94 GT (average 79 GT). There were 18 active vessels in 2019, with 360 and 378 landings in 2019 and 2020, respectively. The estimated DAS increased from 2,530 in 2019 to 3,232 in 2020, while DOF rose from 1,743 to 2,349 over the same period (Figures 3A and 3B). The total estimated catches were 4,601.4 tonnes in 2019 and 4,888.8 tonnes in 2020, with CPUEs averaging

2,479 and 2,031 kg day<sup>-1</sup>, respectively (Figures 3C and 3D). Fishing efforts were concentrated in FMAs 714, 715, and 716. In 2019, 26% of operations targeted FMA 714, 55% FMA 715, and 19% FMA 716. By 2020, these shifted to 2%, 70%, and 28%, respectively. Catch estimates followed similar trends, with higher landings in FMA 715 in 2020.

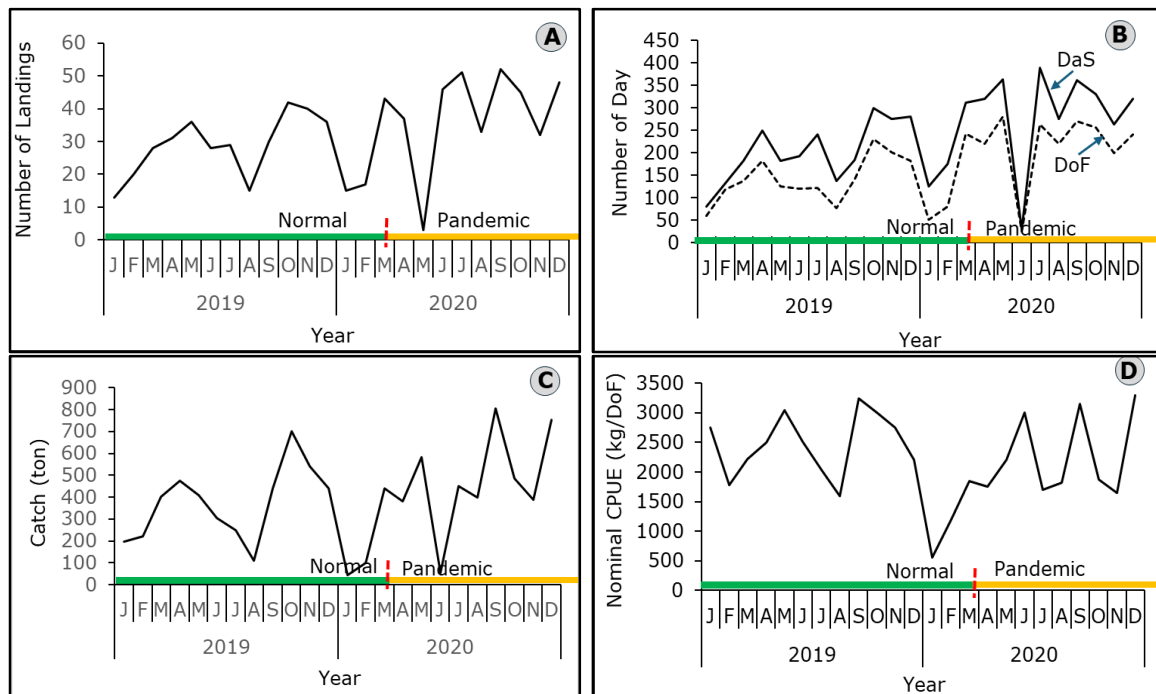


Figure 3. Fluctuations in pole and line fishery operations at Bitung Fishing Port (North Sulawesi) during 2019 and 2020: (A) number of transshipment events from catcher boats to carrier boats; (B) estimated days at sea and days of fishing for catcher boats; (C) total tuna catch; and (D) catch per unit effort (CPUE). The red dashed line indicates the implementation of Indonesia's lockdown policy on March 20, 2020, marking the onset of COVID-19 restrictions.

**Purse seine fishery.** Purse seine vessels at Kendari Fishing Port were wooden vessels ranging from 10 to 60 GT (average 29 GT). Active boats totaled 281 in 2019 and 244 in 2020. These boats conducted 3,637 landings in 2019 and 3,718 in 2020, with transshipment events making up 3.5% (127 events) in 2019 and 2.2% (82 events) in 2020 (Figure 4A). Estimated DAS and DOF declined from 22,486 DAS and 14,856 DOF in 2019 to 16,557 DAS and 10,435 DOF in 2020 (Figure 4B). Total catches were 4,784.5 tonnes in 2019 and 4,161.3 tonnes in 2020, while CPUEs were 312.8 kg day<sup>-1</sup> in 2019 and 474.5 kg day<sup>-1</sup> in 2020 (Figures 4C and 4D). Purse seine vessels based at Bitung Fishing Port, ranging from 5 to 198 GT (average 44 GT), conducted 3,120 landings in 2020. Total DAS and DOF for purse seine were 28,863 and 9,654 days, respectively (Figures 5A and 5B). Total tuna landings were 25,081 tonnes, with an average CPUE of 1.02 tonnes/DOF (Figures 5C and 5D).

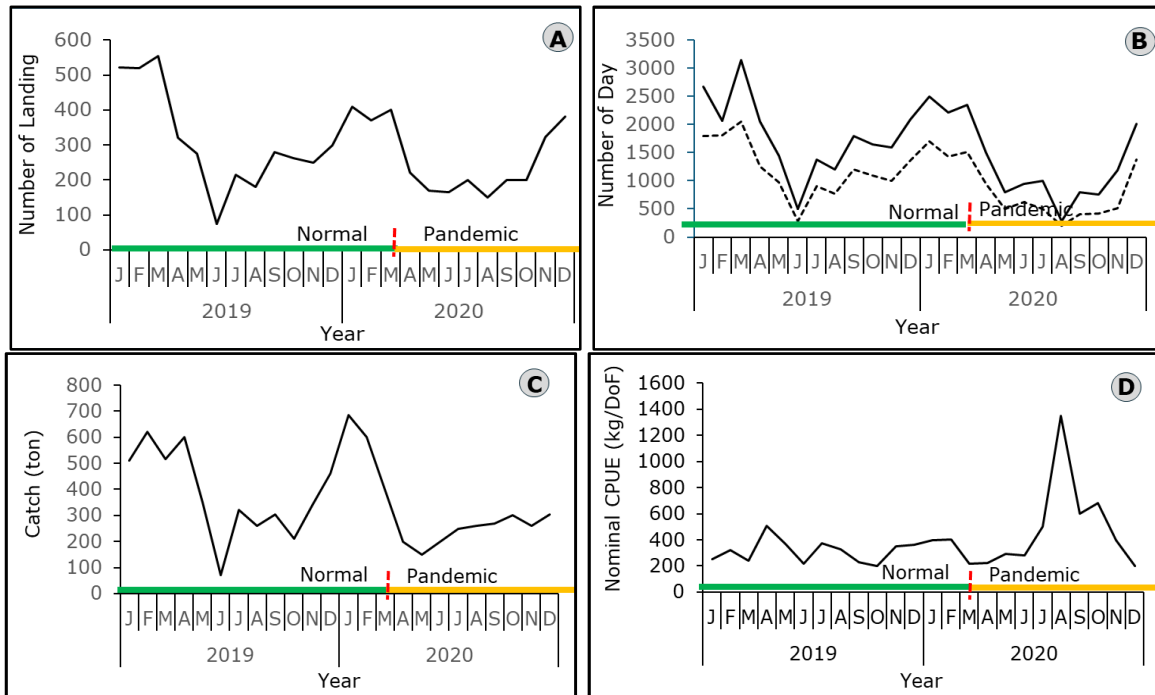


Figure 4. Fluctuations in purse seine catcher vessels activities at Kendari Fishing Port (Southeast Sulawesi) during 2019 and 2020: (A) number of landings (trips); (B) estimated days at sea and days of fishing; (C) total tuna catch; and (D) catch per unit effort (CPUE). The red dashed line marks the implementation of Indonesia's lockdown policy on March 20, 2020, highlighting the onset of COVID-19-related restrictions.

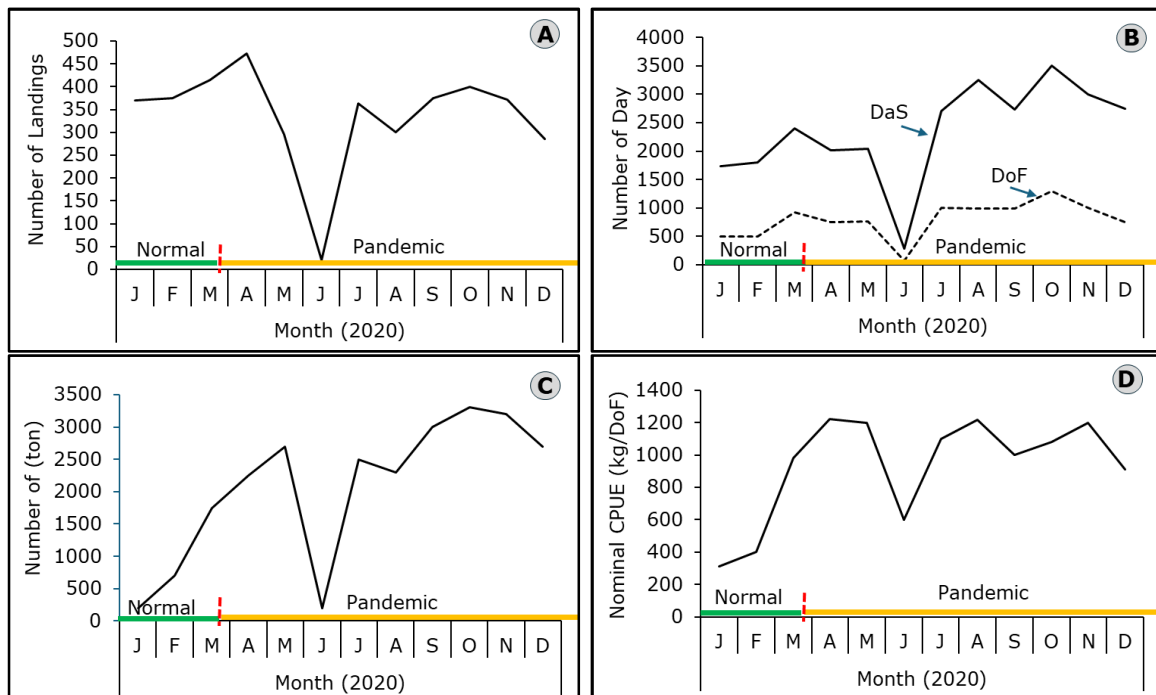


Figure 5. Fluctuations in purse seine catcher and carrier vessels activities at Bitung Fishing Port (North Sulawesi) during 2020: (A) number of landings (trips); (B) estimated days at sea and days of fishing for catcher boats; (C) total tuna catch; and (D) catch per unit effort (CPUE). The red dashed line marks the implementation of Indonesia's lockdown policy on March 20, 2020, indicating the onset of COVID-19-related restrictions.

**Handline fishery.** Handline boats at Kendari Fishing Port averaged 21 GT and conducted 616 landings in 2019 and 365 in 2020. Total DAS and DOF decreased from 6,672 DAS and 4,347 DOF in 2019 to 2,290 DAS and 2,208 DOF in 2020 (Figures 6A and 6B). Estimated catches were 787 tonnes in 2019 and 931 tonnes in 2020, with CPUEs averaging 185 kg day<sup>-1</sup> and 568 kg day<sup>-1</sup>, respectively (Figures 6C and 6D). In 2020, Bitung Fishing Port hosted 749 active handline boats (average 17 GT), conducting 4,964 landings. Total DAS and DOF were 110,755 and 49,917 days, respectively (Figures 7A and 7B). Estimated total tuna catches reached 7,663 tonnes, with an average CPUE of 154 kg day<sup>-1</sup> (Figures 7C and 7D).

Figures 2 to 7 indicate that small-scale tuna fisheries showed no significant immediate response to the COVID-19 outbreak. Seasonal fishing patterns and the fishers' need to meet daily livelihood requirements appeared to outweigh short-term market disruptions. This resilience highlights the adaptability of small-scale fishers in maintaining routine activities despite external challenges such as the COVID-19 pandemic.

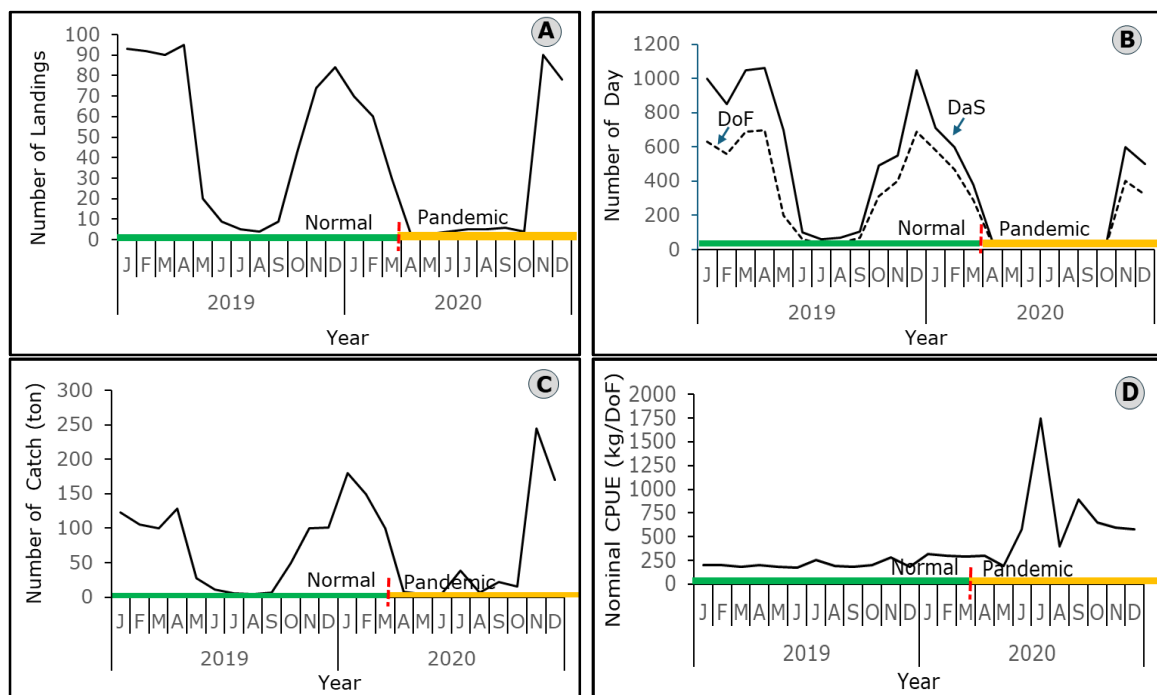
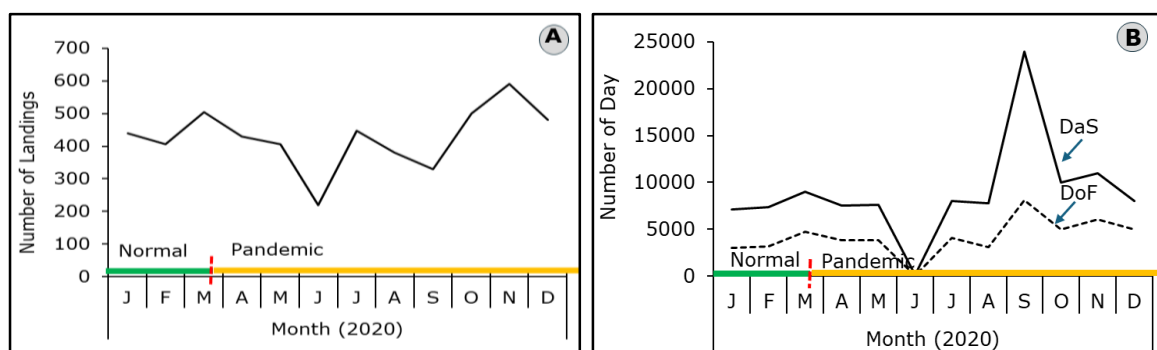


Figure 6. Fluctuations in handline catcher vessels activities at Kendari Ocean Fishing Port (Southeast Sulawesi) during 2019-2020: (A) number of landings (trips); (B) estimated days at sea and days of fishing; (C) total tuna catch; and (D) catch per unit effort (CPUE). The red dashed line indicates the implementation of Indonesia's lockdown policy on March 20, 2020, marking the onset of COVID-19-related restrictions.



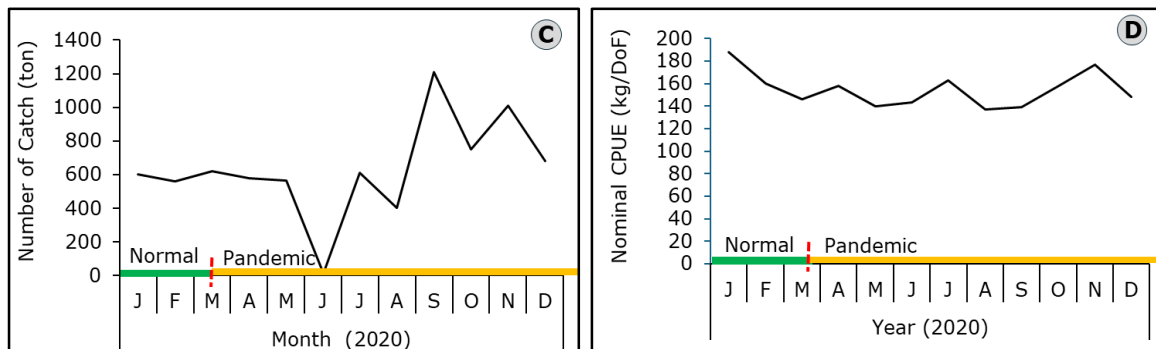


Figure 7. Fluctuations in handline catcher vessels activities at Kendari Ocean Fishing Port (Southeast Sulawesi) during 2019-2020: (A) number of landings (trips); (B) estimated days at sea and days of fishing; (C) total tuna catch; and (D) catch per unit effort (CPUE). The red dashed line indicates the implementation of Indonesia's lockdown policy on March 20, 2020, marking the onset of COVID-19-related restrictions.

**Discussion.** The findings of this study highlight several important aspects of small-scale tuna fisheries in Indonesia, particularly the operations of purse seine, pole and line, and hand-line vessels in key Fisheries Management Areas (FMAs) 713-717 during the COVID-19 pandemic. Despite the challenges introduced by the pandemic, small-scale tuna fisheries exhibited a remarkable degree of resilience, largely attributed to the socio-economic and operational characteristics of these fisheries.

Purse seine boats based at Kendari Fishing Port primarily fish in FMA 714, while those at Bitung Fishing Port operate in FMAs 715, 716, and 717. These vessels are classified into small pelagic purse seine ("pajeko") and large pelagic purse seine categories. Pajeko vessels target small pelagic fish, such as scads, with tuna often caught as by-catch, whereas large pelagic purse seine vessels primarily target tuna, with small pelagic fish as secondary catches (Anggawangsa et al 2014; Sunarto et al 2017). Purse seine fishing operations in Indonesia employ two primary strategies: single and group fishing. Group fishing, commonly practiced at both Kendari and Bitung, typically involves multiple vessels, including 1-2 catcher boats, several light boats, and 2-4 carrier boats. Light boats enhance catch efficiency by attracting fish at night, particularly around fish aggregating devices (FADs). While some catcher boats are equipped with fish holds, others rely on direct transshipment to carrier boats (Widodo et al 2016).

Regulatory changes have significantly influenced PS operations. The issuance of Ministerial Regulation 57/2014, prohibiting at-sea transshipment in Indonesian exclusive economic zones (EEZs), disrupted group fishing strategies and led to operational challenges for many purse seine companies. Subsequent amendments in 2016 permitted transshipment under strict conditions, allowing for recovery in the sector while ensuring catch accountability and landings at designated fishing ports.

Handline vessels, operated as single units, are versatile multi-gear vessels that adjust fishing methods based on seasonal availability, sea conditions, and target species. These wooden-hull boats, known locally as "penongkol" in Sulawesi and "sekoci" in Bali and East Java, target tuna species such as skipjack tuna, yellowfin tuna, and bigeye tuna, often operating near FADs. Originating from Bugis fishers in southern Sulawesi, the handline fishing tradition has spread across Indonesia, maintaining its cultural and operational significance (Proctor et al 2019).

According to the Western and Central Pacific Fisheries Commission (WCPFC) stock assessments, the tuna stocks in the region are in sustainable condition (WCPFC 2023). Skipjack tuna stocks remain above the limit reference point (LRP) and are fished below  $F_{msy}$  (fishing mortality at  $M_{sy}$  level) with 100% probability, indicating no overfishing or overfished status. Similarly, yellowfin tuna stocks are not overfished and are fished below  $F_{msy}$ . Bigeye tuna stocks also show sustainable conditions, with biomass above LRP and a low likelihood of overfishing (87.5% probability  $F < F_{msy}$ ). These favorable stock conditions have ensured continued availability for small-scale fishers.

To assess the impact of the COVID-19 outbreak, data from 2019 (pre-pandemic) and 2020 (pandemic period) were analyzed. Results showed no significant changes in key

operational metrics, including the number of active boats, landings or fishing trips, DAS, DOF, and CPUE. This lack of significant impact underscores the resilience of small-scale tuna fisheries, which continued their regular operations despite the pandemic-induced disruptions.

Several factors contributed to this resilience:

- dependence on daily needs: small-scale fishers prioritize daily subsistence and income generation, driving them to maintain consistent fishing activity even during external economic shocks;
- seasonal fishing patterns: fishing operations are strongly tied to the availability and migration patterns of target species, as dictated by seasonal marine environmental conditions. These cycles take precedence over short-term market fluctuations;
- continued market demand: although fish prices declined during the pandemic (Anna et al 2021), the continued purchase of fish by buyers ensured market access for fishers.

Small-scale fishers demonstrated adaptability by maintaining traditional fishing methods and focusing on meeting community needs. While market prices fluctuated, their reliance on seasonal patterns and the need to fulfill immediate household requirements enabled them to sustain fishing operations. This adaptability reflects the intricate balance between traditional practices, socio-economic drivers, and external economic influences. While this study highlights the resilience of small-scale tuna fisheries, further research is needed to explore the socio-economic dimensions of their operations, particularly their reliance on daily subsistence fishing. Understanding these dynamics can inform policies aimed at enhancing the sustainability and resilience of small-scale fisheries against future disruptions.

**Conclusions.** The findings of this study demonstrate the remarkable resilience of small-scale tuna fisheries in Indonesia's FMAs 713-717 during the COVID-19 pandemic. Despite disruptions caused by the pandemic, the operations of purse seine, pole-and-line, and hand-line vessels were largely unaffected, with no significant changes observed in key metrics such as active boats, landings, days at sea, and CPUE. This resilience is primarily attributed to the socio-economic and operational characteristics of small-scale fisheries, including their dependence on daily subsistence needs, adherence to seasonal fishing patterns, and sustained market demand despite declining fish prices. The sustainable stock conditions of skipjack, yellowfin, and bigeye tuna, as reported by the WCPFC, also contributed to the stability of fishing activities. The adaptability of small-scale fishers, rooted in traditional practices and community needs, underscores their ability to navigate external shocks while maintaining essential operations.

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**Conflicts of interest.** The authors declare that there is no conflict of interest.

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