# Fishing strategies of troll line fisheries in Palabuhanratu Fishing Port, Indonesia

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**Abstract**. As a complex and dynamic activity, fishing is profoundly influenced by many factors, including rapid environmental changes and sociocultural shifts. Fishermen have developed intricate fishing operation patterns that stem from generational knowledge transfer and experiential learning. These patterns are adaptable responses that allow them to navigate evolving circumstances, influenced by their anticipation of profit or loss. Small-scale tuna fisheries, such as the troll line fishery at Palabuhanratu Fishing Port in Indonesia, exemplify the complexities of fisheries management. Issues involving fish aggregating device (FAD) ownership, overlapping fishing grounds, and interactions with other fisheries have led to fishermen's adaptations and shifts in fishing patterns. This study examined troll line operational strategies to understand these patterns and their implications for catch data comprehensively. In response to various changes encompassing environmental conditions, fish abundance, and the escalating economic needs of the community, troll line fishermen have implemented several adaptive strategies by employing diverse fishing operation patterns. These strategies include managing self-owned or group fish aggregating devices (FADs), extending their fishing durations through freezers and dedicated carrier vessels, and engaging in interactions and collaborative efforts with purse seine vessels.

**Key Words**: fishing pattern, fishing strategy, Palabuhanratu, troll line.

**Introduction**. Fishing is a complex and dynamic activity that is influenced by a variety of factors. Rapid environmental change and sociocultural displacement are likely to become a common feature in communities dependent on fish resources and natural resources in general (Young et al 2019). Fishermen have developed fishing operation patterns that have been passed down from generation to generation or from the experiences they have gained over time. In general, they have adapted in such a way that they can adjust to the situations and conditions they face and are influenced by whether they expect to make a profit or loss based on their expectations (Gelcich et al 2007; Wiyono 2022). These patterns are often based on a deep understanding of the local environment and the behavior of fish. Fishermen also learn from each other and share information about new fishing methods and technologies (Smith & Hanna 1993).

Fisheries management for small-scale fisheries is more complex due to its multi-gear and multispecies nature (Saldaña et al 2017). Therefore, it is important to consider fishermen's fishing patterns and strategies. One of the small-medium-scale tuna fisheries developing in Indonesia, especially in the Indian Ocean, is the troll line fishery in Palabuhanratu Fishing Port. Troll line in Palabuhanratu Fishing Port is a fishery that relies on fish aggregating devices (FADs), uses several types of fishing gear, such as troll line, handline, and kite fishing in one fishing unit, and uses vessels with an average size of less than 10 GT (Hargiyatno et al 2016; Ihsan 2017; Proctor et al 2019). Issues related to FAD ownership (Depari 2018; Hargiyatno 2018), overlapping fishing grounds with other fishing gear (Atmaja et al 2011, 2012; Jatmiko et al 2020), and interactions with other fisheries (Proctor et al 2019) are some of the factors that can influence fishermen's adaptation in developing fishing patterns.

Alterations in the fishing techniques employed by troll line fishermen can significantly impact the recorded catch data at fishing ports. Therefore, it is imperative to possess comprehensive knowledge regarding the strategies employed and the mapping of fishing patterns adopted by troll line fishermen. Such insights are crucial for the nuanced analysis of catch data corresponding to distinct fishing patterns. The primary objective of this study was to conduct an in-depth examination of the fishing patterns employed by troll liners and their subsequent influence on the recorded catch data. This research aims to provide valuable insights into the factors that influence fishing patterns, the impact of fishing patterns on catch data, and how these insights can be used to improve fisheries management.

## Material and Method

***Description of the study sites***. This study was conducted at Palabuhanratu National Fishing Port (PPN Palabuhanratu) from November 2021 to June 2022 (Figure 1). Palabuhanratu Fishing Port is a major tuna fishing center in southern Java, Indonesia. In 2021, the port produced around 3,012 tons of tuna and tuna-like species. Tuna fishing in Palabuhanratu is divided into two groups: medium-large scale, which uses tuna longline gear, and small-medium scale, which uses a variety of fishing gear on relatively small vessels. Before the introduction of fish aggregating devices (FADs), tuna fishermen in Palabuhanratu used longline, purse seine, and gillnet to catch tuna (tropical and neritic) and tuna-like species. Today, tuna fishing in Palabuhanratu is dominated by small-scale fishermen using troll lines (tonda) to operate on FADs. This type of fishing was introduced in the early 2000s by fishermen from Sulawesi.

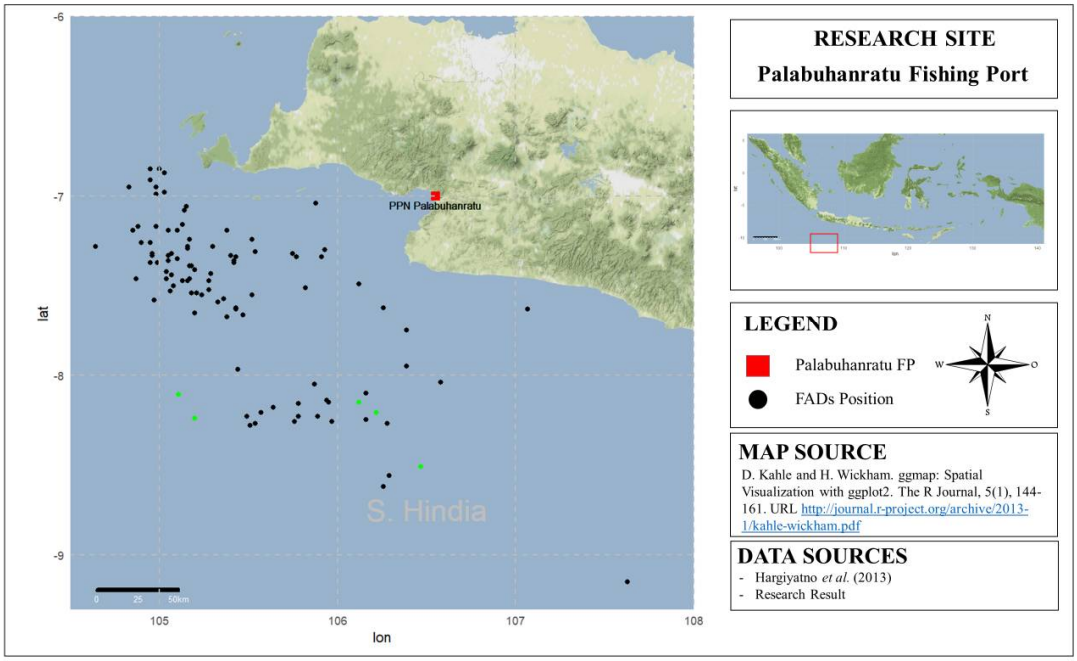


Figure 1. Research location.

***Data collection***. Data was collected through interviews with fishermen and direct observations during fishing operations. Sampling was conducted on 30 fishermen/ captains of troll line vessels with a minimum experience of 5 years. The interview method used was semi-structured, using a list of questions and question guidelines, but still flexible regarding how and when to ask questions and how the interviewee can respond to the questions (Edwards & Holland 2013). In addition, a logbook form was given to troll line fishing vessels, which contains detailed information on fishing activities, catch data, and other data needed for further analysis, including FAD locations, unreported catches, and interactions with other fishing units. To verify the data gathered from interviews and

logbooks, two direct observations during fishing operations at sea were conducted by experienced observers.

The fish landing data at Palabuhanratu Fishing Port for 2012-2021 were obtained from the Palabuhanratu Fishing Port Authority. This dataset comprises comprehensive catch information, including species-specific data, from each fishing vessel recorded at the time they offloaded their catches at Palabuhanratu Fishing Port. Several previous research findings in scientific papers, project reports, and information provided by data collection personnel at Palabuhanratu Fishing Port were utilized to supplement the ongoing study.

***Data analysis***. A descriptive analysis was conducted by capturing the operational patterns of troll line vessels based at Palabuhanratu Fishing Port. This entailed examining the operational patterns of both FAD-equipped and non-equipped purse seine fleets to discern disparities and their consequent impacts on catch outcomes and data collection. Previous research has suggested the possibility of collaboration between purse seine and troll line vessels (Hargiyatno 2018; Proctor et al 2019), although the specifics of this cooperative arrangement were not extensively elucidated. The analysis outcomes will be presented descriptively alongside diagrams illustrating the operational patterns of purse seine vessels and potential interactions that may occur between purse seine and troll line vessels. These insights will be derived from interviews and direct onboard observations.

Daily landing data was analyzed to identify anomalies in the catch of troll line vessels, which in practice do not constitute the targeted or incidental catches of troll lines. These catch results are suspected to be the product of interactions or collaboration with other fisheries. Examining the temporal composition of catch results allows us to discern patterns of abnormal catches and to infer periods when troll line interactions with other fishery may have occurred.

**Results**. In response to various changes encompassing environmental conditions, fish abundance, and the escalating economic needs of the community, troll line fishermen have implemented several adaptive strategies by employing diverse fishing operation patterns. Based on field investigations, there are generally three predominant fishing operation patterns carried out by troll line fleets at Palabuhanratu Fishing Port (Figure 6), namely:

***Operating on self-owned/group FADs***. Since the introduction of troll line fishing in Palabuhanratu Fishing Port in late 2003, FADs have become essential for this fishing method. As the troll line fishing industry in Palabuhanratu Fishing Port has grown, the number of FADs deployed in the waters off the southern coast of West Java and Banten has steadily increased. However, the high cost of constructing, deploying, and maintaining FADs has limited their deployment compared to the number of troll line vessels operating in the area. As a result, some vessels with common ownership have formed groups to share FADs. Typically, each group consists of 2 to 8 vessels, each having 1 to 5 FADs. Based on sample data, troll line fishing vessels can visit 1 to 5 FADs and spend up to 15 days at one FAD during a single trip.

In general, troll line fishermen use a variety of fishing gear to catch fish around FADs, including troll lines, kite fishing, handline, and float fishing. Additionally, each crew member, known as Anak Buah Kapal (ABK), typically carries their squid fishing line, which they use during nighttime breaks. The squid catch obtained by ABKs is considered their personal property and is not included in the vessel owner's catch calculations.

During the late 2015 to early 2017 period, there was an increased demand and price for hairtail fish (*Trichiurus* sp.), particularly along the southern coast of Java. This led many troll line vessels from the West Java region, especially Sukabumi, to switch to hairtail fishing in the waters off southern Java, ranging from Pangandaran, Cilacap, Sadeng, and Pacitan, to Sendang Biru. Consequently, some troll line vessels adjusted their operations to target hairtail using hairtail fishing lines and driftnets. Fishermen also often shifted their target to hairtail during hairtail seasons and when obtaining tuna catches became challenging.

In recent years, some troll line vessels in Palabuhanratu Fishing Port have begun to adopt a technique known as "drop-stone fishing", which involves lowering fishing lines with bait attached and small stones tied to coconut leaves. When reaching a certain depth, the lines are "jerked", causing the stones to detach and the lines to be pulled vertically upward. While using stones in troll line fishing has long been practiced in other locations such as Sendang Biru and Prigi, it has only been implemented by Palabuhanratu fishermen in the past 2-3 years. In addition to employing various types of fishing gear, some troll line vessels in Palabuhanratu also use surface gillnets to capture fish. These gillnets are operated both during the day and at night with the assistance of lights. While gillnets are common on troll line vessels in other locations, only a few vessels in Palabuhanratu employ this method (Table 1).

Table 1

A variety of fishing gear is used by troll line fishers

| *Type of fishing gear* | *Remarks* |
|---|---|
| Pancing tonda/troll line | Operated by attaching fishing lines to a vessel that operates around a fish aggregating device (FAD). |
| Pancing tomba/float line | Using live small tuna or skipjack as bait attached to a 20 L buoy/oil drum to target large tuna/billfish. |
| Pancing taber/surface handline | Using artificial bait made of plastic/CD scraps to target fish that are swimming near the surface. |
| Pancing layang-layang/kite line | Using kites and artificial squid bait to target large tuna and billfish. |
| Pancing batu/drop stone - line | Using rocks to sink a fishing line to a certain depth and then releasing the rock. |
| Pancing cumi/squid line | Used by fishermen at night to target squid. |
| Gillnet permukaan/surface gillnet | Using 2-3 sets of gillnets to target surface fish. |
| Pancing layur/hairtail line | Only used during the hairtail fish season. |

Source: research results and Anggawangsa et al (2021).

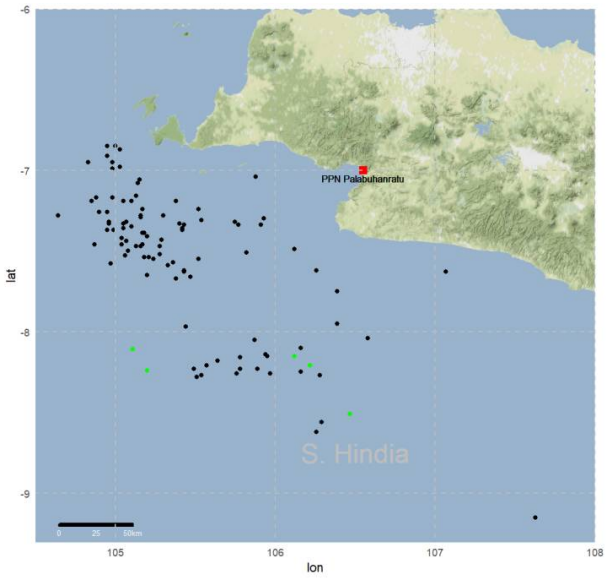
***Operating for longer periods using freezers and carrier vessels***. The development of technology and the pressure to improve efficiency in fishing have led to the adaptation of businesses in the troll line fishing industry. Fishermen typically carry a variable amount of ice, ranging from 35 to 80 blocks to store fish catches in the hold of the vessel each time they fishing according to the capacity and length of time they spend at sea. However, data from 30 sampled vessels found that two vessels have adopted freezer technology as a replacement for ice blocks (see Figure 2). According to port officials, in the past 2 to 3 years, about 15 vessels that are part of a group or have the same owner have switched to using freezers as the cooling system in their troll line fishing vessels.

The operating patterns of troll fishing vessels that have switched to freezer technology differ from conventional tonda vessels operating at PPN Palabuhanratu. These vessels focus on the FADs owned by their group, and they carefully coordinate their operating schedules to ensure that no FADs are left unattended. The group also provides a larger tuna longline vessel as a cargo vessel for their catch. Tonda fishing vessels equipped with freezers can operate for longer periods of time, even up to more than one month at sea. The catch they successfully obtain is then stored in the longline vessel with a larger capacity and then transported to the port more efficiently.

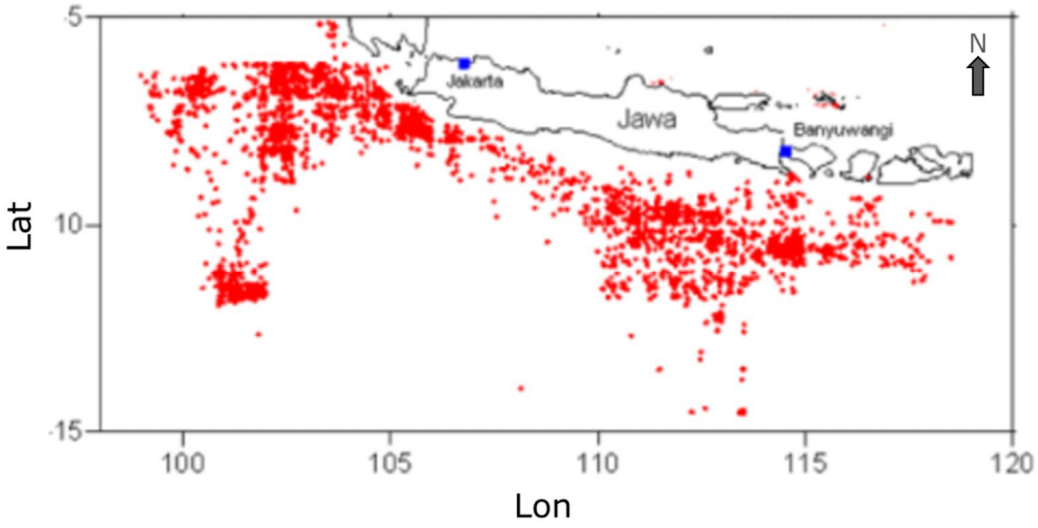
This change reflects the commitment of troll line fishing businesses to adopt the latest technology to improve the efficiency of their operations, maintain the quality of their catches, and minimize the waste of resources, such as ice blocks. With the existence of troll vessels using freezers and more coordinated operating patterns, it is hoped that it can help the troll fishing industry at Palabuhanratu Fishing Port to remain competitive and sustainable in the future.

Figure 2. Some troll line vessels already use freezers in their hold/fish storage.

***Interactions/collaboration with purse seine vessels***. The growing tuna fishery, especially those that use FADs in the Indian Ocean, has the potential for overlap in fishing areas, both for the same fishing gear and with other fisheries. The shift in the fishing grounds of purse seine vessels from northern Java operating in southern Java waters has the potential to create friction with small vessels from southern Java, one of which is the troll line vessels from Palabuhanratu Fishing Port. Purse seine vessels deploy FADs close to the location of FADs owned by troll line vessels (Figure 3). In fact, according to the testimony of some fishermen, there are several FADs owned by purse seine vessels that are deployed closer to land than FADs owned by troll line fishing vessels.




(a) Source: Hargiyatno et al (2015) and research results




(b) Source: Atmaja et al (2012)

Figure 3. Fishing ground of troll line (a) and purse seine (b) in Indian Ocean - Southern Java.

Although there was a conflict in the early days of the arrival of purse seine vessels in the waters off southern Sukabumi-Banten, some troll line vessels have taken advantage of the opportunity to cooperate with these vessels. Indications of cooperation between troll line vessels from Palabuhanratu and purse seine vessels in fishing in the waters off southern West Java and Banten can be seen from the catches landed at Palabuhanratu Fishing Port in the past ten years. Based on daily landing data, several types of fish are not commonly caught by troll lines but are recorded as their catches. Several species of small pelagic fish, such as Indian scad (*Decapterus ruselli*), redtail scad (*Decapterus kurroides*) and shortfin scad (*Decapterus macrosoma*) that are generally caught by purse seine are recorded as catches of troll line vessels (Figure 4). Indian scads have a higher production than other scads species, reaching 8,720 kg in 2013. These three species appeared in the landing data in the period 2012-2016, then there was no production in 2017-2020, and it was recorded that around 51 kg of redtail scad were landed in 2021.

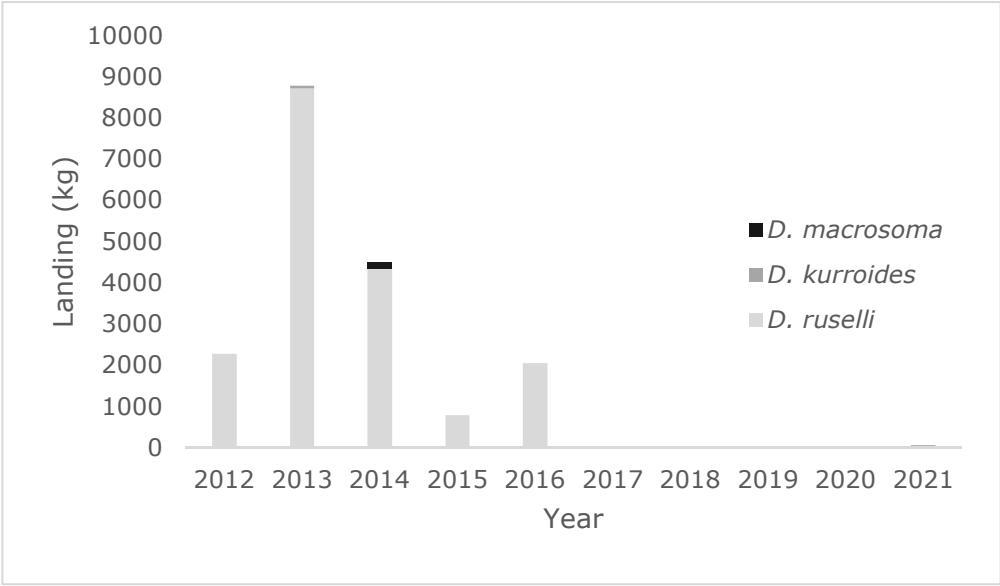



Figure 4. Some small pelagic species caught by troll line.

In addition to small pelagic fish, there are also neritic tuna species that were landed by troll line vessels in the period 2012-2014, namely kawakawa (*Euthynnus affinis*) and bullet tuna (*Auxis rochei*) (Figure 5). The catch of bullet tuna was higher than kawakawa,

with 4,981 kg in 2013 and 1,796 kg in 2014. Meanwhile, the catch of kawakawa was 1,320 kg in 2012, decreasing to 15 kg in 2013 and 232 kg in 2014.

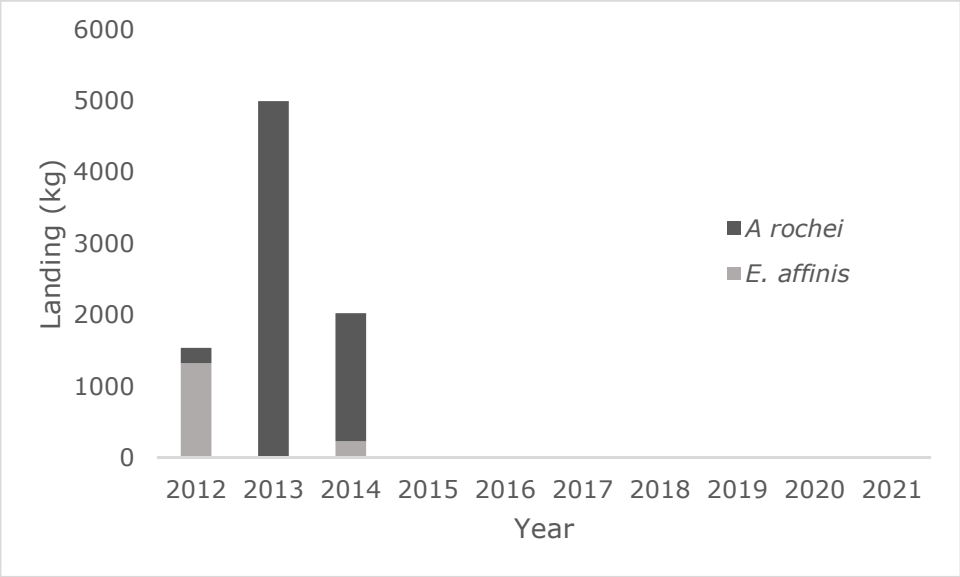



Figure 5. Some neritic tuna species caught by troll line.

Based on information from troll line vessel respondents who had cooperated with purse seine vessels from northern Java, there were about 5-10 troll line vessels from Palabuhanratu that cooperated with purse seine vessels from the early 2010s to 2021. Currently, no troll line vessels still cooperate with purse seine vessels at FADs in the waters off southern West Java - Banten. The interaction patterns between troll line fleets and purse seine vessels can be seen in Table 2.

Table 1

The pattern of interaction between troll line and purse seine vessels

| *Indicators* | *Remarks* |
|---|---|
| Actors | - Troll line vessels from Palabuhanratu Fishing Port;<br>- Purse seine vessels from northern Java. |
| Motive | - Fishing vessels using troll line: to obtain catches easily;<br>- Fishing vessels using purse seine: to obtain additional supplies. |
| Goods exchanged | - The catch of purse seine vessel gear is exchanged for supplies/logistics brought by troll line vessels. |
| Consequences | - The traceability of catch data;<br>- Inaccuracy in the reporting of catches from troll line and purse seine. |
| Benefits/Losses | *Benefits:*<br>- Efficiency in the operation of fishing vessels;<br>- Avoiding conflict.<br>*Losses:*<br>- There is a need to review the reporting system for fishing vessels using troll line and purse seine. |
| Legality | - Does not meet the requirements for transshipment based on PERMEN KP NO.58/2020 |

The interaction pattern is to exchange supplies/logistics intentionally brought by troll line vessels for fish caught by purse seine vessels. The agreement is made based on prior communication, depending on the logistical needs requested by the purse seine vessel. The purse seine vessel will contact the troll line vessel that has previously collaborated to order logistics when they operate at FADs in waters that are not too far from Palabuhanratu. There is no profit-sharing system during purse seine fishing operations.

Troll line fishermen assist in operations and are given a portion of the catch. Troll line fishermen are allowed to fish at the FAD owned by the purse seine vessel, provided they have first requested permission and helped with the hauling process. The amount of logistics exchanged for fish caught is around Rp. 2,000,000-5,000,000 in food supplies, depending on the order requested. These supplies are exchanged for 2-3 tons of fish caught by purse seine vessels, with species of small pelagic and skipjack.

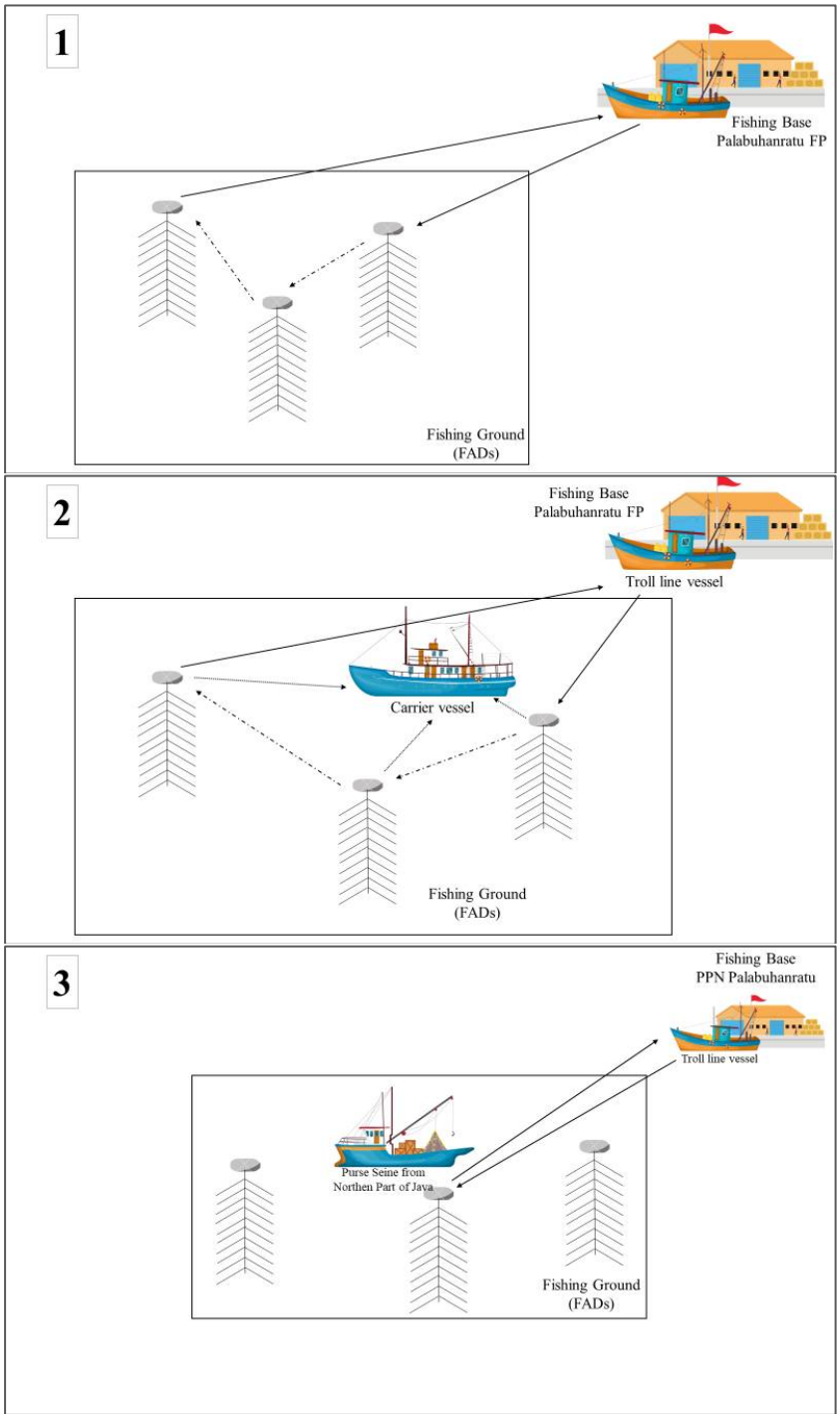



Figure 6. Illustration of troll line fishing operation patterns at Palabuhanratu Fishing Port: (1) operating on self-owned/group FADs; (2) operating for longer periods using freezers and carrier vessels; (3) interactions/collaboration with purse seine vessels.

**Discussion**. Fishing operation management is a key component in ensuring fishery resources' sustainability. The main objectives of this management include improving cost efficiency, time efficiency, and human resource efficiency to increase the fisheries sector's income (Wiyono 2022). In this context, fishing strategies are central to achieving these objectives. However, it is important to remember that fishing not only involves technical aspects, but is also influenced by various factors, including social interactions among fishing communities (Smith & Hanna 1993).

There are several operating patterns that troll line fishermen apply at Palabuhanratu Fishing Port in response to environmental changes, fish resource dynamics, technological developments, and interactions with other fisheries. Using multiple fishing gears in one troll line fishing unit requires further study, both legally and in terms of calculating its fishing capacity. The strategy of utilizing rumpon by using a shared rumpon within a group is a response to the high cost of tuna pole fishing production.

Establishing a pattern for fishing operations, involving extending operational days to several weeks and utilizing cooling systems in freezers and fish carrier vessels, represents the efforts made by the industry to enhance efficiency and increase productivity. Nevertheless, further investigation is warranted regarding the traceability of catch data and the legal aspects involved. The adaptation patterns adopted in response to changes vary among industry participants, including both fishermen and entrepreneurs, depending on their respective needs and objectives (Salas & Gaertner 2004; Wiyono 2008).

Interactions with other fisheries can lead to conflicts or mutually beneficial interactions. The proximity of the deployment of FADs by troll line vessels to FADs deployed by purse seine vessels initially resulted in friction during the early stages of FAD-based fisheries development in the southern waters of West Java - Banten (Hargiyatno 2018). Conflict arose due to competition in capturing the same fishery resources, particularly tuna (Apriliani et al 2021). However, conflicts have subsided over time, and some troll line vessels have chosen to collaborate with purse seine vessels. According to Proctor et al (2019), several troll line vessels, especially those without their FADs, utilize the FADs owned by purse seine vessels through a system commonly referred to as "tuyul", which involves maintaining these FADs and exchanging supplies in return for a share of the purse seine catch. Collaborative systems involving the exchange of supplies for catch require special consideration as they relate to transshipment activities, catch traceability, and FAD management. According to Regulation of the Minister of Marine Affairs and Fisheries Number 58/PERMEN-KP/2020, catch transshipment activities in the Fisheries Management Area of the Republic of Indonesia can be conducted from fishing vessels to fish transport vessels, subject to certain conditions, including having the same port of landing and creating a transshipment report. Troll line vessels operating their fishing gear around FADs belonging to other vessels or FADs belonging to other fishery will have a different operational pattern than those operating around their own FADs. This variation arises from interactions with other fishing gear in utilizing FADs. Such interactions represent a form of adaptation fishermen undertake to optimize their capture activities for maximum profit (Samsuddin et al 2021).

The catch data recording in logbooks is mandatory to minimize the potential for misreporting resulting from interactions among fishing units. It must be carried out by the vessel captain/fishermen following the regulations specified in Minister of Marine Affairs and Fisheries Regulation Number 33 of 2021. According to this regulation, vessels with a gross tonnage (GT) above five must use an *e-logbook*, which is a smartphone-based logbook application. However, the data format for recorded catch information in this *e-logbook* system does not accommodate the fisheries using more than one type of fishing gear, as well as the origin and distribution of the catch. At the very least, several minimum data elements required as inputs in the e-logbook system include:

- location and time of capture;
- species of caught fish;
- quantity and/or weight of the captured fish;

- type of fishing gear used;
- origin of the captured fish, whether from the reporting unit or obtained from other fishing units;
- distribution of the captured fish if provided to other fishing units.

Changes in fishing operation patterns undertaken by fishermen in response to dynamics in the industry should be a consideration for government authorities in fisheries management. According to Salas & Gaertner (2004), the often-overlooked complexity of fishing dynamics has contributed to the failure of management initiatives in many parts of the world. Fishermen are typically treated as a fixed entity without taking into account individual attitudes based on their operational scale and personal objectives. Several studies have demonstrated that fishermen are more likely to employ varying fishing strategies depending on whether they perceive potential gains or losses from their fishing endeavors (Gelcich et al 2007). Furthermore, several research, such as that conducted by Abbott et al (2023) have highlighted that diversification in fisheries operations can serve as a crucial form of self-protection against natural risks, regulations, and market risks affecting fishermen's livelihoods. However, the success of fisheries management relies not only on technical aspects but also on the capacity to comprehend and respond to changes in fishermen's behavior and the dynamic ecological conditions in which they operate (Yletyinen et al 2018).

**Conclusions**. Troll line fishermen at Palabuhanratu Fishing Port implement diverse fishing operational strategies in response to fluctuations in the natural environment, variations in fishery dynamics, technological advancements, and interaction with other fisheries. These strategies include the management of self-owned or group fish aggregating devices, extending their fishing durations through the use of freezers and dedicated carrier vessels, as well as engaging in interactions and collaborative efforts with purse seine vessels.

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

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