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Fisheries Research Based on Experimental Fishing Methods in the Coastal Area of Rembang Regency, Central Java, Indonesia

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Authors' contributions

This work was carried out in collaboration between both authors. Author KEP designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author RZS manages literature searches and manuscript translations. Both authors read and approved the final manuscript.

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Systematic Review Article

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ABSTRACT

Rembang Regency coastal area is one of the central fishing production in Central Java Province. Various types of fishing gear are used by fishermen for fishing operations and are developed independently. Much research has been conducted in this area related to capture fisheries. This study aims to analyze the research development that uses experimental fishing methods. This study uses a systematic literature review method based on Published or Perish application tools. The results showed that 9 (nine) types of fishing gear were the object of research in the coastal area of Rembang Regency in 2013-2022. Experimental fishing methods have been carried out on 5 (five)

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types of fishing gear, namely small bottom trawl (arad), folding box traps (bubu lipat), longline (pancing rawai), squid jigging (pancing cumi), and gillnet (jaring insang). Experimental fishing research has been conducted on small bottom trawls, including towing speed and mesh size modification. Folding box traps were studied with escape gap and fishing time variables. Hooks and lines were studied with fish-hook materials and various bait variables. Gill net was studied with webbing modified. The results of this study provide knowledge of the potential for experimental fishing research that can be applied in the future, especially to understand fishing activities in the coastal areas of Rembang regency.

Keywords: Experimental; fish; fishing methods; marine resources.

1. INTRODUCTION

The coastal area of Rembang Regency has many potential fisheries and marine resources. The fishery and marine resources potential include mangroves (Indarsih & Masruri, 2019; Sibero et al., 2020; Sutanto et al., 2022), coral reefs (Handayani & Warsono, 2017; Kurniawati et al., 2019; Putri et al., 2019; Abdillah et al., 2021), pelagic fish (Zamroni et al., 2020) and demersal fish (Saputro et al., 2014; Tarigan et al., 2015). Several types of Pelagic fish groups that are target fish for fishermen in Rembang include Tembang (Sardinella spp.) (Nafthalya, 2021), Layang (Decapterus sp.) (Triharyuni et al., 2016; Dwiyanti et al., 2023), Teri (Stolephorus sp.) (Khairushubhi et al., 2017; Prihantoko & Boesono, 2018), Kembung lelaki (Rastrelliger kanagurta) (Utami et al., 2014), Layur (Trichiurus lepturus) (Pribadi et al., 2015), Selar (Selaroides sp.) (Purwasih et al., 2021), Cumi-cumi (Loligo sp.) (Triharyuni & Puspasari, 2012; Prakasa et al., 2014), and Rajungan (Portunus pelagicus) (Arios et al., 2013; Primadjati et al., 2014; Juliastuti et al., 2016; Principal et al., 2019). Meanwhile, the demersal fish groups that are target fish include Remang (*Congresox talabon*) (Pamuntjak et al., 2017), Kurisi (Nemipterus sp.) (Finayani et al., 2020; Yuniar, 2020), Kuniran (*Upeneus sp.*) (Zamroni & Widiyastuti, 2020; Hanafi et al., 2017), Pari (Dasyatis sp.) (Amir et al., 2018), Swanggi (*Priacanthus* sp.) (Finayani et al., 2020), Shrimp (*Penaeus sp*.) (Umam et al., 2021), and Kepiting (*Scylla spp.)* (Pambudi et al., 2019). Superior fisheries commodity in Rembang Regency are *Decapterus sp., Formio sp., Rastrelliger sp., Selaroides sp., Sardinella spp., Loligo sp., and Stolephorus sp*. (Ameriyani, 2014).

The potential for abundant fishery resources has an impact on the development of fisheries businesses. Fishing businesses in the coastal areas of Rembang Regency have developed with the use of various types of fishing gear. Some variety of fishing gear include; Gill net (Juliastuti et al., 2016; Fitri et al., 2019), Folding box-shape trap (Arios et al., 2013; Fitri et al., 2017; Jayanto et al., 2018), Folding dome-shape trap (Boesono et al., 2022), Small bottom mini trawl (Ayowa et al., 2014; Umam et al., 2021), Purse seine (Chodrijah & Pralampita, 2010; Nugraha et al., 2014; Wijayanto & Kurohman, 2018; Farida et al., 2019), Boat seine (Bayyinah et al., 2014; Nusantara et al., 2014; Wijayanto et al., 2019[b]), and Trammel net (Romadhani et al., 2016).

Fishing is an activity to obtain fish in waters that are not in a state of being cultivated by any means or methods, including activities that use ships to load, transport, store, cool, handle, process, or preserve them (MMFA regulation No. 45 of 2009). Fishing equipment is necessary for fishing operations, consisting of fishing vessels, fishing gear, and fishing aids (SNI 7277.1:2008). Fishing technology is required to optimize catch. The problem is that fisheries' technology development could not be done faster. Therefore, research based on experimental fishing methods needs to be conducted. The latest data and information regarding the development of existing experimental fishing methods are required. Research is an organized investigation. Therefore, it is very important to know and understand previous research that has been done. Thus, the quality of research will be improved and help accelerate the development of fisheries technology. According to Natsir (2003), research is conducted to change the conclusions that have been accepted or change the postulates with the new applications of the postulates. Therefore, research experiments need to be carried out carefully and critically. However, research efforts are often constrained by the basic questions "What will be studied?" and "What is the purpose of the research?". Through this article, researchers can find alternative solutions to conduct experimental-based research on fishing. The scope of this article is based on the administrative area,

namely the Rembang Regency area, Central Java Province, Indonesia. The research question in this article is about experimental research on fishing that has been studied in the coastal regions of Rembang Regency. The next question is what capture fisheries and fishing gear topics have been widely studied in 2013 - 2022. This information will be useful to find out what types of fishing gear have been studied. This study aims to analyze research articles with location coverage in the coastal areas of Rembang Regency. The period that is the limitation of this study is 2013-2022.

2. METHODOLOGY

This study uses the Systematic Literature Review (SLR) method. The analysis database is limited to the period 2013-2022. Data search uses the Publish or Perish (PoP) application (Harzing, 2007). The scope of data search is limited to the Google Scholar database. The stages of implementing this research include the data search, selection, and analysis.

2.1 Stage of Data Search

Data search was conducted using Publish or Perish (PoP) software. The keyword used is the location of the object study, namely "Rembang." The keyword is used only in one aspect of the search, namely the title (Title of words). Data search is only carried out on the Google Scholar database. A data search was conducted for the period 2013-2022. Article searches are performed annually, not simultaneously. The search method in PoP is done by filling in keywords in the Title column. The results of searching for article data with PoP consist of two main pieces of information, namely citation metrics and results paper.

2.2 Stage of Article Data Selection

The next stage in this research process is the data selection stage. Data selection is carried out in stages to obtain several articles according to the criteria set to achieve the objectives. The following are the stages of data selection carried out and the criteria used in the data articles obtained from PoP:

1. **Stage 1: data year selection**

At this stage, data selection is carried out by creating two data categories: articles with year data availability (Available) and articles that do not have year data (Not Available). The selection results found 2934 articles with Available status and 179 with Not Available status. In the first stage, article data was produced to be processed in Stage 2, amounting to 2934 articles.

2. **Stage 2: data cites selection**

At this stage, data selection is done by creating two data categories, na: articles with several citations ≥ 1 and articles with several citations 0. The selection process is based on article data from 2934 articles, which are the results of the Stage 1 selection. Stage 2 selection produced 1041 articles with citations ≥ 1 and 1893 with 0 citations. In Stage 2, article data was created to be processed in Stage 3, amounting to 1041 articles.

3. **Stage 3: selection of relevant topics**

Data selection is done at this stage by creating two topic categories: articles on Fisheries and Marine topics (Relevance) and articles not on Fisheries and Marine topics (Not Relevance). The selection process is carried out based on the data from the selection results of Stage 2. The selection results show that 216 articles have relevant status and 825 have no relevance status. In Stage 3, article data was produced to be processed in Stage 4, totaling 216 articles.

4. **Stage 4: selection of article type**

At this stage, data selection is done by creating two categories of data article types: Journal articles and Non-Journal articles. The Non-Journal category includes Books, Proceedings, and Repositories. The selection process is based on data from the selection results of Stage 3. The selection results show that 159 articles are journal articles, and 57 are Non-journal articles. In Stage 4, article data was produced to be processed in Stage 5, summing 159 articles.

5. **Stage 5: Selection of duplicate articles**

At this stage, data selection is carried out by creating two categories: single articles and duplicate articles. The category of duplicate articles includes the same article but is detected as two-article data. The selection process is carried out based on the data from the selection results of Stage 4. The selection results show that 149 articles are single, and 10 articles are duplicate articles. In Stage 5, article data was

produced to be processed in Stage 6, totaling 149 articles.

6. Stage 6: Fisheries topic selection

Data selection is carried out by creating two categories: capture fisheries topics and Other Fisheries topics. The selection process is carried out based on the data from the selection results of Stage 5. The selection results show that 54 articles are Capture Fisheries topic articles, and 95 articles are Other Fisheries topics. In Stage 6, article data was produced to be processed in Stage 7, totaling 54 articles.

7. Stage 7: Fishing Gear sub-topic selection

At this stage, data selection is carried out by creating two categories: the subtopic of Fishing Gears and the subtopic of Others. The selection process is carried out based on the data from the selection results of Stage 6. The selection results show that 31 articles are articles with the subtopic of Fishing Gears, and 23 articles are subtopics of Others. In Stage 7, article data was generated for analysis of 31 articles.

2.3 Stage of Data Analysis

Data analysis was conducted on 31 articles resulting from the selection process. Furthermore, a descriptive analysis was conducted on the article data. The results of the analysis were then presented in the form of tables and graphs as needed, thus facilitating the distribution of information. In addition, this study also conducted a PRISMA analysis (Haddaway et al., 2022). Fig. 1 presents the Prisma Diagram of the results of the data selection process carried out. Following the established criteria, 31 articles were found. A number of these articles are articles that are relevant to the criteria set to answer the research objectives.

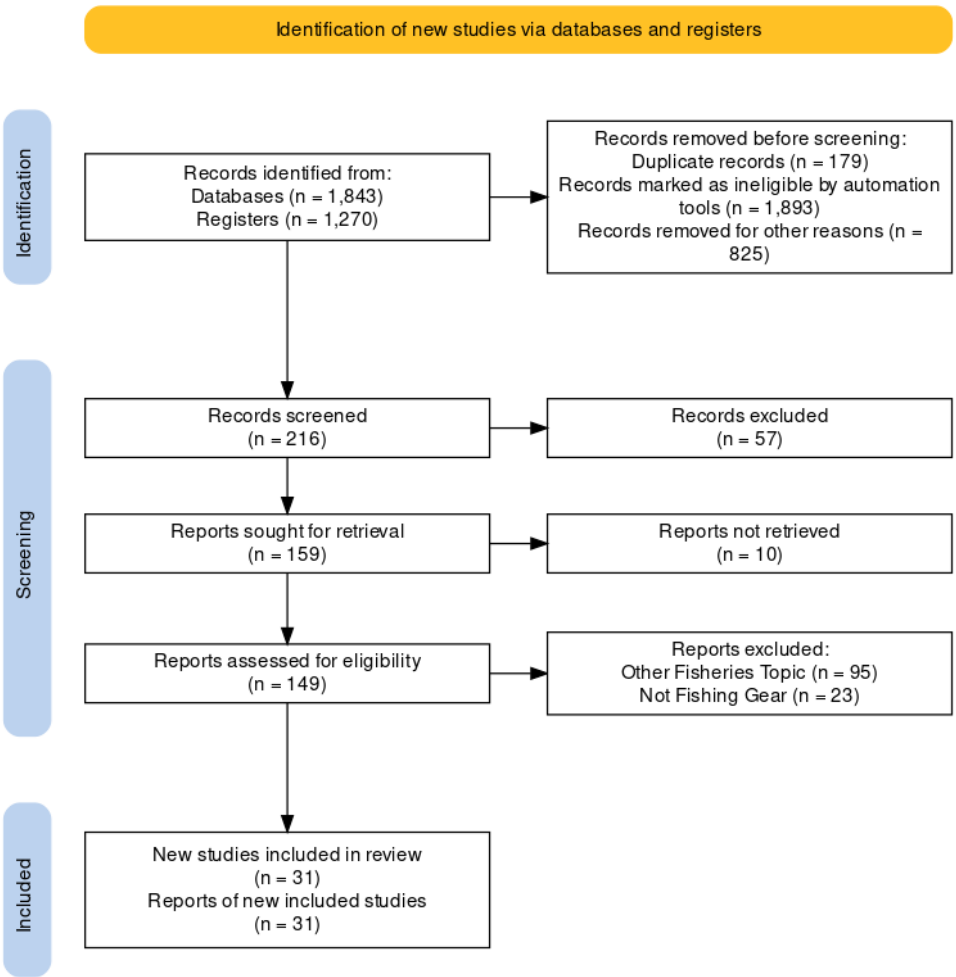

Fig. 1. Prisma diagram

3. RESULTS AND DISCUSSION

3.1 Distribution of Articles, Citations and Authors

The search results using PoP found 3113 papers from 2013-2022. The number of articles found with PoP was between 181 and 406 papers per year (an average of 311 papers/year) during the period 2013-2022. The largest number of articles was found in 2021, 406 articles (13.04%). The lowest number of articles was found in 2013, 181 articles (5.81%). The number of articles found related to the topic of fishing gear varies each year. The highest number of articles relevant to the objectives of this study was found in 2017, which was eight articles (Fig. 2.A). In 2021, only 1 (one) article was found relevant to the objectives of this study. The article with the highest number of citations, with 13 citations (Fig. 2.B), was known to be written by Wijayanto et al. (2020) on the topic of fisheries bioeconomics on the use of boat seine and purse seine. The article with the second highest number of citations, with 12 citations, was occupied by the article by Sari et al. (2016) on the topic of marketing distribution of *Portunus sp.*, and the third highest, with 11 citations, was occupied by Fitriyashari et al. (2014) on the topic of fishing vessel supplies.

Fisheries bioeconomics, fish marketing distribution, and fishing store supplies are part of the research topics of fisheries economics. Fisheries bioeconomics is the application of bioeconomic concepts in the field of fisheries. Fisheries bioeconomics is the use of economic concepts with the aim of optimizing the use of fisheries resources based on economic reviews (Wijayanto et al., 2007). According to Clucas (1997), fisheries marketing is a series of activities that include planning, organizing, implementing, and controlling the flow of goods and services related to the production, distribution, promotion, and sale of fishery products. Supplies are all goods needed to support the implementation of tasks. These goods can be movable or immovable (Dinita et al., 2015).

Meanwhile, fishing vessel supplies are needed to support fishing operations. These supplies include fuel, oil, ice, freshwater, salt, and food ingredients (Bagaskara et al., 2024). These supplies are needed by fishing vessels to provide fishermen or fishing vessel crews during fishing operations at sea (Fitriyashari et al., 2014).

The results of grouping scientific article data based on journal type status obtained 5 (five) group categories, namely International Journal Index DOAJ (3.23%), International Journal index scopus Q1 (3.23%), International Journal index scopus Q3 (6.45%), Indonesian Journal index Sinta 2 (6.45%), and Indonesian Journal (80.65%). The dominant articles found and relevant to the focus of this study are the Indonesian Journal category. This study has limiting factors that have been described in the method section. It makes the articles found in the search process and data filtering stages more specific according to the focus of the study.

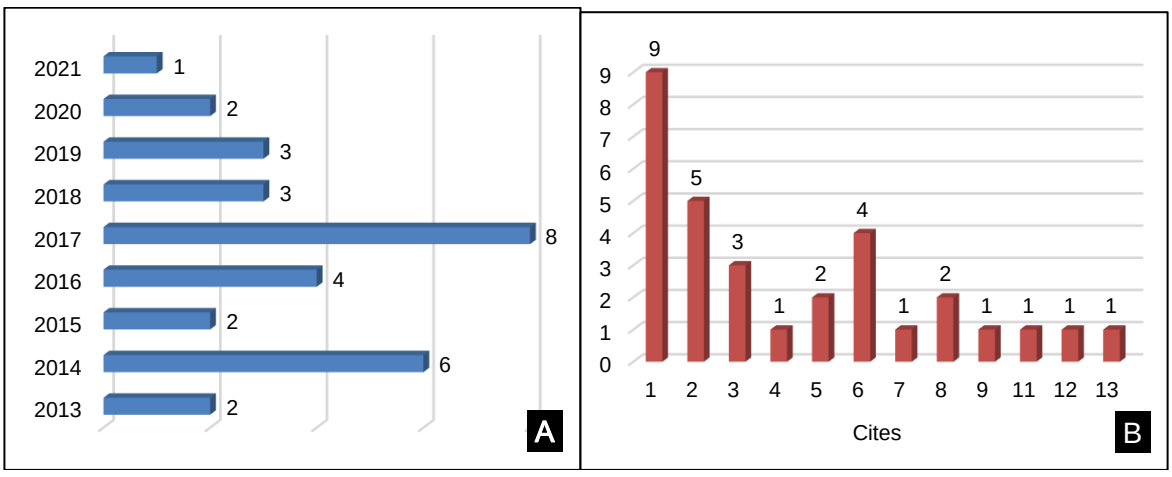

Fig. 2. (A) Number of Selected Articles by Year; (B) Articles Distribution based on Citations number

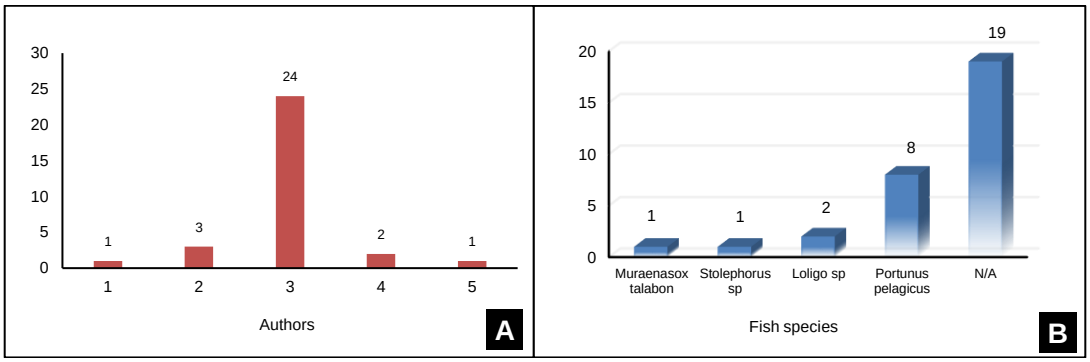

Fig. 3. (A) Articles Distribution based on Authors number; (B) Articles Distribution based on Fish species

Articles written by multiple authors indicate collaborative work. Articles produced by multi-authors indicate multispectrum discussions. Collaboration has a positive influence on research impact. The more authors collaborate in compiling an article, the higher the number of citations to the article (Rahmaida & Amelia, 2018). Collaborating authors will produce higher-quality articles (Rahayu & Tarwan, 2020). Fig. 3. A shows that 3 (three) authors wrote 75.00% of the articles found, and only 3.13% were written by 5 (five) authors. Based on observations of selected articles, it shows that most articles are written by 3 (three) authors. As a result of further observations, most of the articles were written by authors from the same institution.

3.2 Types of Fish species Research Objects

Fig. 3.B shows the types of fish that are the objects of study. It is known that 4 (four) fish species are the objects of research in the articles found, namely rajungan (*Portunus pelagicus*) (Arios et al., 2013; Juliastuti et al., 2016; Parahita et al., 2016; Sari et al., 2016; Ferdiansyah et al., 2017; Ummaiyah et al., 2017; Jayanto et al., 2018; Principal et al., 2019), cumi-cumi (*Loligo* sp) (Widiatmoko et al., 2015; Surachmat, 2018), ikan teri (Stolephorus sp) (Khairushubhi et al., 2017) and ikan remang (*Congresox talabon*) (Pamuntjak et al., 2017). During the period 2013-2022, *Portunus pelagicus* was the dominant type of fish as the object of research, namely 25.81% of articles discussing *Portunus pelagicus*. Loligo sp. was found in 6.45% of articles, and 3.23% discussed Stolephorus sp and Congresox talabon. As many as 61.29% of the articles found were known not to discuss specific fish species in their research (Not Available = N/A). These data show that research based on specific fish species in the coastal area of Rembang has a high potential to be carried out. Ameriyani (2014) revealed that there were 7 (seven) superior fish commodities in the Rembang regency. Based on the superior fishery commodities produced in Rembang, only *Stolephorus sp and Loligo sp* were the objects of research in scientific articles for the 2013-2022 period. Thus, there is an opportunity for research based on specific fish species, which are superior fish commodities in the coastal area of Rembang Regency. Some of these fish are Decapterus sp., Formio sp., Rastrelliger sp., Selaroides sp., and Sardinella sp.

The 2023 Marine and Fisheries statistics of the Ministry of Marine and Fisheries Affairs (https://portaldata.kkp.go.id) recorded 26 (twenty-six) fish species landed in the coastal areas of Rembang regency. The types of fish species are mackerel scad, other fish, starry triggerfish, priacanthus, longspine silverbiddy, ponyfish, snapper fish, threadfin bream, stingray, giant trevally, ariid catfish, dusky sleeper, yellow tail fish, grouper fish, sardinella fish, mackerel tuna, yellow stripe shad, long-jawed mackerel, blue swimming crab, black/white pomfret, squid, beltfish, spanish mackerel fish, anchovy, shrimp, and barracuda. Based on 26 (twenty-six) fish species, only 11.54% were the object of research, and 88.46% were not found in the article.

3.3 Types of Fishing Gears Research Objects

The Marine and Fisheries statistics data 2023 from the Ministry of Marine and Fisheries Affairs (https://portaldata.kkp.go.id) recorded 12 (twelve) types of fishing gear operating in the coastal areas of Rembang regency. The groups of

fishing gear types are One-boat-operated purse seines for small pelagic fish (40.63%), Traps (16.35%), Driftnets/oceanic gillnets (16.01%), Boat seine (cantrang) (9.55%), Set gillnets/liong bun (4.38%), Boat seine (payang) (3.55%), Combined gillnets-trammel nets (2.68%), Trammel nets (2.38%), Bottom trawl (2.15%), Small bottom trawl (1.25%), Danish seine (dogol) (0.91%), and other Trawls (0.15%). The number of fishing gear in the coastal areas of Rembang regency is 2648 unit. One-boat-operated purse seines for small pelagic fish are the type of fishing gear predominantly used by fishermen in Rembang Regency. Fig. 4 shows the composition of the number of types of fishing gear in Rembang regency.

Based on the articles analyzed in 2013-2022, it is known that 9 (nine) types of fishing gear have been studied in Rembang Regency. The nine types of fishing gear are (1) one boat operated purse seines for small pelagic fish (Fitriyashari et al., 2014; Nugraha et al., 2014; Mutmainnah et al., 2017; Wijayanto & Kurohman 2018; Farida et al., 2019; Wijayanto et al., 2020; Zamroni et al., 2020), (2) boat seine (cantrang) (Sasmita et al., 2013; Bayyinah et al., 2014; Fitriyashari et al., 2014; Nusantara et al., 2014; Tarigan et al., 2015; Pahlefi & Hidayat 2017; Sari & Brata 2017; Sari et al., 2017; Wijayanto et al., 2019[a]; Wijayanto et al., 2020), (3) folding box-shape trap (Arios et al., 2013; Parahita et al., 2016; Ferdiansyah et al., 2017; Ummaiyah et al., 2017; Jayanto et al., 2018; Principal et al., 2019), (4) gillnets (Juliastuti et al., 2016; Nazda et al., 2016; Parahita et al., 2016; Sari et al., 2016; Sari et al., 2017; Fitri et al., 2021), (5) trammel nets (Tarigan et al., 2015), (6) small bottom trawl (arad) (Ayowa et al., 2014; Saputro et al., 2014; Widiatmoko et al., 2015), (7) danish seine (dogol) (Khairushubhi et al., 2017), (8) squid jigging (Surachmat, 2018), and (9) longline (Pamuntjak et al., 2017).

The results of the article's identification show that there are two research patterns based on fishing gear. The research patterns are combined fishing gear (multi-gears) and single fishing gear (Fig. 5). The types of fishing gear studied in combination are PCPK and boat seine (cantrang) (Fitriyashari et al., 2014; Wijayanto et al., 2020). However, the number of research is only 2 (two) articles that discuss both types of fishing gear simultaneously. Other types of fishing gear that have been studied simultaneously include folding box-shape traps and gillnet (Parahita et al., 2016), gillnet and boat seine (cantrang) (Sari et al., 2017), and boat seine (cantrang) and trammel net (Tarigan et al., 2015). The types of fishing gear studied using single fishing gear are small bottom trawl (arad) (Ayowa et al., 2014; Saputro et al., 2014; Widiatmoko et al., 2015), danish seine (dogol) (Khairushubhi et al., 2017), squid jigging (Surachmat, 2018) and longline (Pamuntjak et al., 2017).

From 2013 through 2022, the types of fishing gear widely studied were one-boat small pelagic purse seine, boat seine (cantrang), and traps (folding traps). The three types of fishing gear were discussed in 6 articles for each type of fishing gear. Boat seine (cantrang) is the type of fishing gear that was most widely discussed in the ten articles found, both combined and single. Fig. 5 shows the results of the identification of research patterns based on the types of fishing gear that have been studied from 2013 to 2022 in the Rembang Regency. Based on the articles studied, it is known that the Trammel net type was not found to be studied as a single fishing gear.

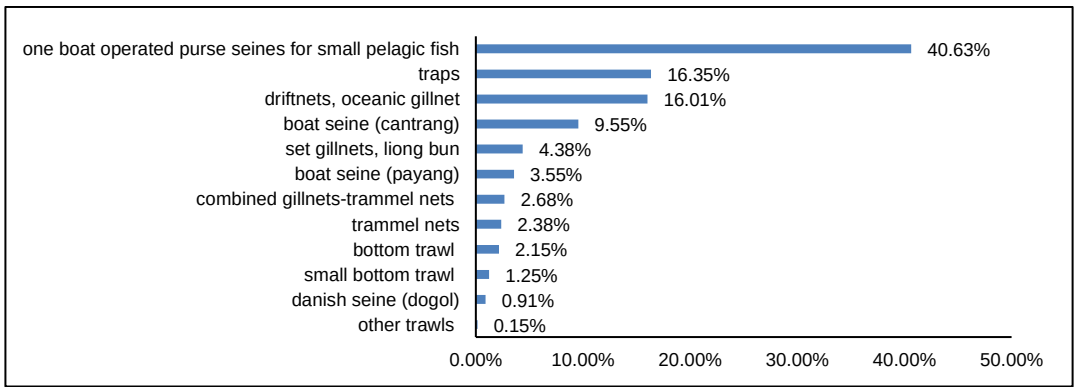

Fig. 4. Proportion of Fishing gear based on government statistical data
Source: https://portaldata.kkp.go.id (2023)

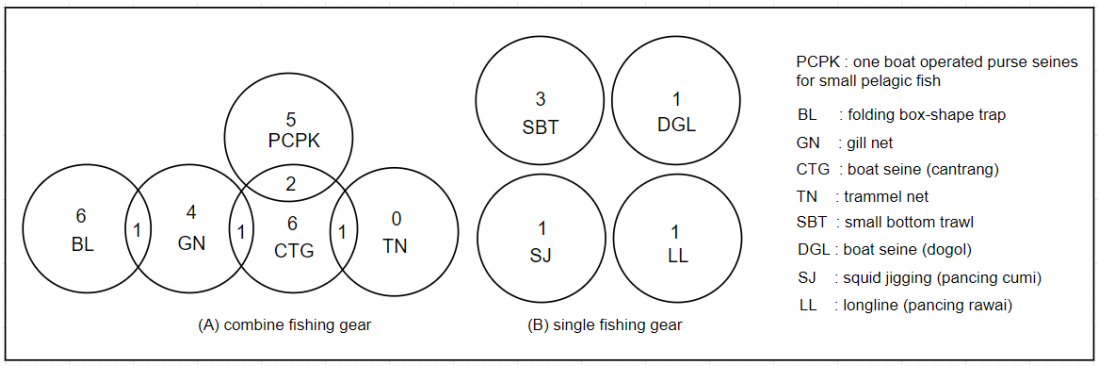

Fig. 5. Fishing gear research objects and number of article

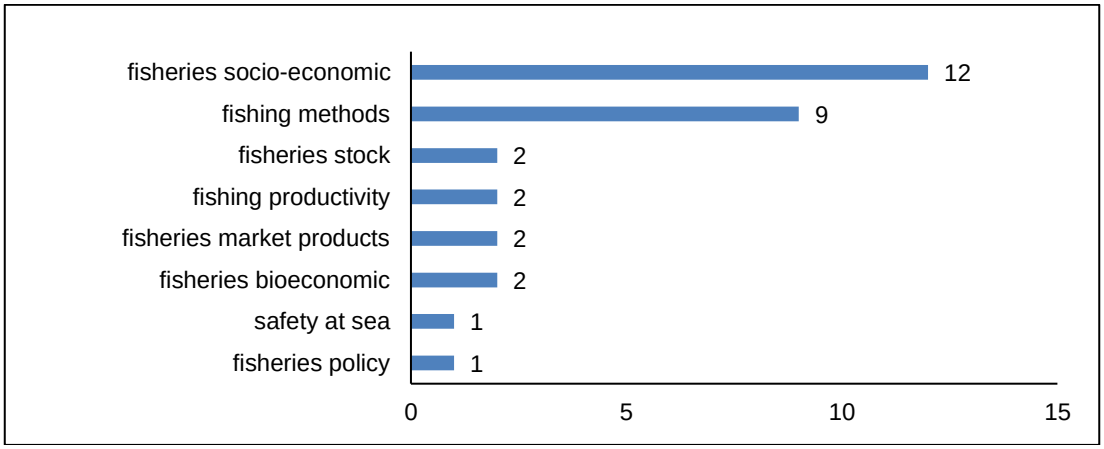

Fig. 6. Main topics of research studies

3.4 Main Topics of Research Studies

Fig. 6 presents the results of grouping articles based on the main research topic. The identification results show that there are 8 (eight) main topics. The main topic that is widely studied is the socio-economics of fisheries (Bayyinah et al., 2014; Fitriyashari et al., 2014; Nugraha et al., 2014; Juliastuti et al., 2016; Nazda et al., 2016; Parahita et al., 2016; Mutmainnah et al., 2017; Sari & Brata, 2017; Wijayanto & Kurohman, 2018; Farida et al., 2019; Principal et al., 2019; Wijayanto et al., 2019[a]), while the main topic related to fishing methods (Ayowa et al., 2014; Nusantara et al., 2014; Widiatmoko et al., 2015; Ferdiansyah et al., 2017; Pamuntjak et al., 2017; Sari et al., 2017; Ummaiyah et al., 2017; Jayanto et al., 2018; Surachmat, 2018) is in second place. The results of this identification indicate that fishing gear at the research location is widely reviewed from the perspective of the socio-economics of fisheries and fishing methods. Other seven topics are included in the category of research that has yet to be widely conducted. The potential main research topics to be conducted include fisheries stock (Saputro et al., 2014; Zamroni et al., 2020), fishing productivity (Arios et al., 2013; Fitri et al., 2021), fisheries market products (Sari et al., 2016; Khairushubhi et al., 2017), fisheries bioeconomic (Tarigan et al., 2015; Wijayanto et al., 2020), safety at sea (Sasmita et al., 2013), and fisheries policy (Pahlefi & Hidayat, 2017).

3.5 Experimental Fishing Research Studies

In this study, there are 9 (nine) types of fishing gear found in the selected articles (Fig. 5). Based on the nine types of fishing gear found, there are two groups of research methods used, namely experimental fishing methods and non-experimental fishing methods. The types of fishing gear studied using non-experimental fishing methods were: (1) boat seine (cantrang) (Sasmita et al., 2013; Bayyinah et al., 2014; Nusantara et al., 2014; Tarigan et al., 2015; Pahlefi & Hidayat, 2017; Wijayanto et al., 2019[a]), (2) one boat operating a purse seine for small pelagic fish (Fitriyashari et al., 2014; Nugraha et

al., 2014; Mutmainnah et al., 2017; Wijayanto & Kurohman, 2018; Farida et al., 2019), (3) trammel net (Tarigan et al., 2015), and (4) boat seine (dogol) (Khairushubhi et al., 2017). The types of fishing gear studied using experimental fishing methods are (1) small bottom trawl (Widiatmoko et al., 2015), (2) squid jigging (Surachmat, 2018), (3) long line (Pamuntjak et al., 2017), (4) folding box-shape trap (Ferdiansyah et al., 2017; Ummaiyah et al., 2017; Jayanto et al., 2018), and (5) gillnet (Fitri et al., 2021).

Research-based on boat seine (cantrang) fishing gear is predominantly conducted based on interviews with respondents, namely with the research topic of the feasibility study of fishing businesses (Bayyinah et al., 2014; Wijayanto et al., 2019[a]), the level of environmental friendliness of fishing gear (Sari et al., 2017), fisheries policy (Pahlefi & Hidayat, 2017; Sari & Brata, 2017), and fisheries bioeconomics (Tarigan et al., 2015). Meanwhile, other topics use observation methods, namely safety at sea (Sasmita et al., 2013) and data collection of fish catches (Nusantara et al., 2014). Research based on one-boat-operated fishing gear for small pelagic purse seine is also predominantly carried out using interview-based research methods with respondents, namely with research topics consisting of the feasibility study of fishing business (Nugraha et al., 2014; Mutmainnah et al., 2017; Wijayanto & Kurohman, 2018; Farida et al., 2019), fisheries bioeconomics (Wijayanto et al., 2020), fisheries resource stocks (Zamroni et al., 2020), and fishing supplies (Fitriyashari et al., 2014). The types of boat seine (dogol) and trammel net fishing gear were also studied using respondent-based interview methods. The main topic discussed in the boat seine (dogol) fishing gear is related to the marketing of fisheries products (Khairushubhi et al., 2017), while the trammel net fishing gear is the bioeconomics of fisheries (Tarigan et al., 2015). Based on the main focus of this study in the form of experimental fishing methods, the types of fishing gear that will be described in this study are small bottom trawls, hook and line (squid jigging and longline), folding box-shape traps, and gill net.

Table 1 presents the types of treatments carried out in experimental fishing research. Folding traps are one type of fishing gear that is widely studied using experimental fishing methods. What is interesting about experimental research conducted on folding traps is that all of these studies examine the escape gap and do not use variations in the type of bait. The second most widely studied type of fishing gear using experimental fishing methods is the hooks and lines. Two types of fishing gear were used in the articles studied, namely longline and squid jigging. Both types of fishing gear are included in the hook and line category in the classification of fishing gear. The difference between the two lies in their construction. The construction of a longline is a series of several hooks that are operated lengthwise in seawater. The construction of squid fishing gear is a single fishing line, which is often referred to as a hand line. Based on Table 1, it is known that the variables studied in the type of fishing line are the variables of the type of bait and the material of the fishing hook. The types of bait studied include sardines, fresh pelagic fish, and salted pelagic fish. The materials for the fishing hooks studied are plastic and wood. Potential studies for line fishing research use other types of bait. Gill net and small bottom trawl are other types of fishing gear that are studied using experimental fishing methods. Small bottom trawls are studied using experimental fishing methods with different mesh sizes and towing speeds. Gill nets are studied using experimental fishing methods with modified gillnet (using mono-multifilament material, adding swivel component and essens bait).

3.6 Small Bottom Trawl

Towing speed is one of the variables used to determine the ability of small bottom trawls in fishing operations. According to Triharyuni and Hargiyatno (2016), the variable of ship engine power affects fish catch. The power of the ship's engine is related to the ship's ability to reach fishing areas and pull nets (towing). Prisantoso et al. (2017) state that towing speed in small bottom trawls has significant effects on fish catches. To maintain the optimal position of the net mouth opening and otter board in small bottom trawl operations, the ship's speed during towing is 1.5-2.5 knots (Nababan et al., 2018). Widiatmoko et al. (2015) studied the ability of small bottom trawls in fishing operations and specifically their correlation with Loligo sp. Research by Widiatmoko et al. (2015) recommends operating small bottom trawls with a towing speed of 2-3 knots to produce Loligo sp with a catchable size. The minimum and maximum towing speed limits of small bottom trawls carried out by Nababan et al. (2018) and Widiatmoko et al. (2015) show differences, but these differences are not

significant. The difference in towing speed between the two is only 0.5 knots.

Research conducted by Widiatmoko et al. (2015) compared two small bottom trawl models (genuine and modified) with the focus variables of towing speed and size of squid caught. Widiatmoko et al. (2015) explained that squid is one type of fish caught using small bottom trawls. Squid as one of the catches in small bottom trawl fishing is also supported by research conducted by Hufiadi and Mahiswara (2009), Widyawati et al. (2014), and Septiana et al. (2019). Squid is an important economic commodity in the non-fish category (Mudzakir & Paramartha, 2012) and an Indonesian export commodity (Achsa et al., 2021). Squid is one type of fish commodity that contributes the fourth highest fish production (5.81%) in Central Java after mackerel scad (22.81%), sardinella (9.75%), and ponyfish (7.02%) (portal-data.kkp.go.id, 2023). On a national level, the volume of squid production reached 234674 tons (2.99%) with a production value of IDR 11.34 trillion in 2023 (portal data.kkp.go.id). According to Hariyoto (2023), squid is a non-fish fishery export commodity from Indonesia. Export data from the Ministry of Marine and Fisheries Affairs in 2023 recorded that squid-octopus-cuttlefish commodities were exported to 57 countries with a total of 152910 tons with an export value reaching USD 762.6 million.

According to Kartika et al. (2024), the level of squid exploitation in WPPNRI 711 can still be attempted because it has a moderately exploited status. This is different from the status of the squid exploitation level in the Java Sea (WPPNRI 712), which indicates that overfishing and over-exploited have occurred (Rizal et al., 2023). Natsir et al. (2024) also strengthened the overfishing and overexploited status of demersal fish groups in the Java Sea (WPPNRI 712). This condition indicates pressure on demersal fish groups in the Java Sea, including squid. According to Wagiyo et al. (2020), fishing factors contribute significantly to squid mortality rates compared to environmental factors. The experimental fishing method conducted by Widiatmoko et al. (2015) attempted to minimize undersized squid catches by modifying the cod-end mesh from 0.75 inches to 1.50 inches and using a particular towing speed. In demersal fishing with bottom trawls, the mesh size of the code end affects the level of selectivity of the fishing gear (Hufiadi & Mahiswara, 2009; Yang et al., 2021; Nguyen et al., 2021).

The towing speed also affects the performance of the trawl, which is related to the width of the net mouth opening. The higher towing speed caused the net mouth opening to be narrow (Jha et al., 2019). The narrow trawl mouth opening has an impact on the narrowness of the swept area, so the chances of successfully catching target fish are not optimal. According to Lu et al. (2023), high towing speed can increase fishing efficiency for certain types of fish. It shows that the pulling speed factor as a performance parameter for the success of trawl fishing operations is still influenced by the type of fish species that are the target fish. In addition to optimizing the trawl mouth opening, increasing the towing speed can also reduce the possibility of fish escaping (Herrmann et al., 2013; Brinkhof et al., 2018). Various studies have shown that towing speed affects the effectiveness of fishing, both in terms of the technical performance of the trawl and reducing the possibility of fish escaping.

Squids are a group of carnivorous animals (Ismail et al., 2013). Squid is often found at the bottom of the waters, so it is embedded as a demersal biota (Zulkifli et al., 2023). Squids caught in several waters were reported in conditions that undersize (Fauziyah et al., 2020; Suryanto et al., 2021; Pertiwi et al., 2022; Karman et al., 2023); High fishing intensity at the bottom of the waters can cause degradation of squid spawning habitat and have an impact on the decline in squid populations (Baskoro et al., 2019). The capture of squid by small bottom trawls can be explained by the characteristics of the small bottom trawl operating location at the bottom of the waters and the squid habitat at the bottom of the waters. In the context of responsible fishing, maximum catches are not sufficient. Responsible fishing requires the fulfillment of the element of selectivity of fishing gear, namely minimizing the undersize of catches. Research by Widiatmoko et al. (2015) provides us with the knowledge that catching squid that is suitable for catching can be done by modifying a small bottom trawl with a particular towing speed.

Small bottom trawls are a type of fishing gear that is prohibited from being operated in Indonesia because they are a type of fishing gear that is not environmentally friendly (Indrawasih & Wahyono, 2017; Adhitama et al., 2017; Pahlefi & Hidayat, 2017). However, small bottom trawls are still widely used by traditional fishermen and are a source of their livelihood (Nababan et al.,

2020). Small bottom trawls in the classification of fishing gear are included in the trawl net category (He et al., 2021). According to Siregar et al. (2023) and Firdaus et al. (2017), the bycatch produced by bottom trawls tends to be more dominant than the target fish, and the bycatch tends to be discarded without being utilized. The operation of small bottom trawls causes damage to coral reefs and predominantly catches undersized fish (Indrawasih & Wahyono, 2017; Noviyanti, 2017; Subehi et al., 2017). The capture of undersized fish in small bottom trawl operations was also reported by Mahendra et al. (2015), Kurohman et al. (2018), and Pane et al. (2023). The characteristics of bottom trawl operations that are active and in direct contact with the bottom of the waters are indicated to cause a decline in the level of benthic biodiversity in the long term (Pierdomenico et al., 2018; Nedostup et al., 2022). Water areas with high trawl operation activities result in a decline in fish stocks and a decline in the quality of the aquatic environment (Tirtadanu et al., 2022). According to Bayyinah & Nurkhasanah (2021), the operation of small bottom trawls also causes conflict between fishermen. This conflict occurs due to the irresponsible operation of small bottom trawls and crashing into fishing nets that are passively installed in the waters. Innovation of small bottom trawls through future research is needed to minimize the environmental impacts that occur as a result of operating small bottom trawls as well as various small bottom trawl design engineering to increase the selectivity of small bottom trawls. The development of more friendly small bottom trawl innovations needs to be carried out through scientific research. Various modifications to small bottom trawl designs and fishing performance needed to be tested by quality scientific research. The research of Widiatmoko et al. (2015) provides insight into the performance of small bottom trawls in terms of towing speed and its relationship to specific fish species. Other potential research opportunities that can be recommended are redesigning small bottom trawls and testing their fishing performance, both on a laboratory and field scale.

3.7 Hooks and lines (Long line and Squid Jigging)

Scientific articles discussing experimental fishing methods for hooks and lines are Pamuntjak et al. (2017) and Surachmat (2018). Pamuntjak et al. (2017) conducted experimental fishing using Longline, and Surachmat (2018) used squid jigging. Both included the bait variable as an intervention factor for their research. The difference between the two is the variable type of material, the jig body, as an experimental intervention factor. In addition, the target fish that were the objects of their research were also different. Pamuntjak et al. (2017) focused on the target fish, namely the remang fish or yellow pike conger (Congresox talabon), while Surachmat (2018) focused on Loligo sp. Longline and Squid jigging are types of fishing gear included in the Hook and Line group in the classification of fishing gear (He et al., 2021). Longline is operated by stretching it horizontally in the water, while squid jigging is operated in the same way as operating a handline. Research by Pamuntjak et al. (2017) provided knowledge that although Sardinella sp bait on Longline resulted in higher yellow pike conger fish, the various types of bait used in their research did not significantly affect the yellow pike conger fish. Pamuntjak et al. (2017) and Surachmat (2018) studies show the potential for further research that can be conducted using other types of bait to catch fish targets effectively.

Fish target behavior needs to be a determining factor in the various bait before the experiment is carried out. Understanding the feeding preferences and dominant sensory systems of target fish needs to be an important factor in determining the type of bait to be tested. The bait to be tested needs to be adjusted to the feeding preferences and dominant sensory systems of the target fish. Longline is a type of fishing gear that is installed passively in waters, so the type of bait used is an important factor in determining the success of catching target fish. Surachmat (2018) states that the use of plastic fish hook jig bodies with bait produces better Loligo sp than other experimental designs applied in his research. The use of plastic fishing hook jig bodies with bait is recommended by Surachmat (2018). However, in his research, only one type of bait was used, namely Juwi fish bait (Clupea sp.). Other fishing experiments have the potential to be carried out by providing interventions in the form of varied bait and adjusting them to the eating preferences and dominant sensory systems of the target fish. According to Rahmawati (2021), the color of squid jigging and the duration of the squid jigging operation affect the number of fish caught. The type of bait, the color of squid jigging, and the duration of operation are some of the intervention factors that can be used in fishing experiments with squid jigging.

Table 1. Experimental fishing research studies

No	Sources	Fishing gears	Object study	Experimental fishing
1	Widiatmoko et al. (2015)	Small bottom trawl (SBT/arad)	*Loligo s*p. (cumi-cumi)	1. Genuine SBT, Towing speed 2 knot 2. Genuine SBT, Towing speed 3 knot 3. Genuine SBT, Towing speed 4 knot 4. SBT Modification, Towing speed 2 knot 5. SBT Modification, Towing speed 3 knot 6. SBT Modification, Towing speed 4 knot
2	Ferdiansyah et al. (2017)	Folding box-shape trap (bubu lipat kotak); Folding dome-shape strap (bubu lipat kubah)	*Portunus pelagicus* (rajungan)	1. Folding box-shape trap without escape gap 2. Folding box-shape trap with escape gap 3. Folding dome-shape trap without escape gap 4. Folding dome-shape trap with escape gap
3	Pamuntjak et al. (2017)	Long line (pancing rawai)	*Congresox talabon* (remang)	1. Longline with sardinella sp. bait 2. Longline with fresh ponyfish bait 3. Longline with salted ponyfish bait
4	Ummaiyah et al. (2017)	Folding box-shape trap (bubu lipat)	*Portunus pelagicus* (rajungan)	1. Folding box-shape trap without escape gap 2. Folding box-shape trap with one escape gap 3. Folding box-shape trap with two escape gap
5	Jayanto et al. (2018)	Folding box-shape trap (bubu lipat)	*Portunus pelagicus* (rajungan)	1. Folding box-shape trap two funnel, Crepuscular time 2. Folding box-shape trap two funnel, Nocturnal time 3. Folding box-shape trap four funnel, Crepuscular time 4. Folding box-shape trap four funnel, Nocturnal time
6	Surachmat (2018)	Squid jigging (pancing cumi-cumi)	*Loligo sp*. (cumi-cumi)	1. Jig body plastic with Clupea sp. bait 2. Jig body wood with Clupea sp. bait 3. Jig body plastic without bait 4. Jig body wood without bait
7	Fitri et al. (2021)	Gill net	Total catch	1. Gill net monofilament 2. Gill net mono-multifilament

Squid and Yellow pike conger were the target fish in experimental research methods in Rembang waters conducted by Pamuntjak et al. (2017) and Surachmat (2018) using Hooks and lines fishing gear. In industrial-scale fisheries, squid fishing is carried out using large fishing gear, such as bouke-ami (Suwarso et al., 2019; Gumilang & Susilawati, 2020; Arifin et al., 2023), purse seine (Danial et al., 2023; Mustaruddin et al., 2024; Yusfiandayani et al., 2024), trawls (Prakasa et al., 2014; Ahmed & Ali, 2024; Setyohadi et al., 2024). In small-scale fisheries, squid fishing is carried out using Squid jigging (Yamashita et al., 2012; Surachmat, 2018; Rudin et al., 2020; Palawe et al., 2021; Tanjaya & Almohdar, 2023), small bottom trawls (Nababan et al., 2020; Nurmeiana et al., 2020); and Lift nets (Oktariza et al., 2016; Febrianto et al., 2017; Saragih et al., 2021; Kurnia et al., 2023).

Squid and Yellow pike conger have economic value for local fishing communities, so both types of biota are fish targets for fishing. The economic value of Squid has been discussed and explained in the discussion section on small bottom trawl. Yellow pike conger production in Central Java Province reaches 1469.02 tons/year. National Yellow Pike conger fish production in 2023 reached 34,620 tons with a production value of IDR 862.17 billion (portaldata.kkp.go.id). The statistical data from the Ministry of Marine and Fisheries Affairs indicates that Yellow pike conger fish production has economic value and contributes to the achievement of national fish production value.

Yellow pike conger is a demersal fish (Riede, 2004; Laksono et al., 2019) and is predatory (Satapoomin, 2011). According to Smith (1997), Yellow pike conger can be found in coastal waters up to a depth of 100 m and is active at night, with its primary food being crustaceans and bottom fish. Yellow pike conger fish belong to the Congridae and Muraenesocidae families (Arisandi et al., 2022). They are one of the catches of bottom longlines operating in the waters of East Lombok (Ariani et al., 2023). Yellow pike conger is also the main target fish for gillnet operations by gillnet fishermen in Indramayu (Pramesti et al., 2023). According to Hermaya et al. (2021), the part of the Yellow pike conger's body that has a selling value is the swim bladder.

Research on Yellow pike conger fish in Indonesia based on the aspect of fishing is very minimal. Various studies tend to discuss the chemical content aspects of Yellow pike conger fish in their use as processed food ingredients (Djailani et al., 2016; Laksono et al., 2019; Hermaya et al., 2021). This condition provides knowledge that research on Yellow pike conger fishing has the potential to be carried out in the future. The dynamics of the Yellow pike conger fish population were also not found in the search for Indonesian fisheries research. Potential research in the future is needed so that the status of its exploitation level can be known and efforts can be made to manage sustainable fisheries of the Yellow pike conger.

3.8 Traps

The Folding box-shape trap and Portunus pelagicus are an inseparable pair. Various studies proved that Portunus pelagicus is the main target fish of folding box-shape traps (Ernawati et al., 2014; Ningrum et al., 2015; Susanto et al., 2023). In this study, three articles were found discussing experimental fishing using folding box-shape traps, namely research conducted by Ferdiansyah et al. (2017), Ummaiyah et al. (2017), and Jayanto et al. (2018). Ferdiansyah et al. (2017) conducted an experiment using the escape gap as an intervention factor. Ummaiyah et al. (2017) also experimented with using escape gaps as an intervention factor but with a various number of escape gaps. Meanwhile, Jayanto et al. (2018) provided intervention in the form of a different number of funnels and different operating times in their experiment. Research by Ferdiansyah et al. (2017) showed that a folding dome-shaped trap with an escape gap caught Portunus pelagicus with an effectiveness rate of 42.85%. Ummaiyah et al. (2017) stated that based on the proportion of target fish to bycatch, the folding box trap can be declared environmentally friendly because the catch of Portunus pelagicus exceeds 60% of the total catch. However, when viewed from the aspect of the size of crabs that are suitable for catch, the treatments tested still produced crabs that are suitable for catch below 60%. Jayanto et al. (2018) research provides information that folding box-shape traps with four funnels have a better level of effectiveness compared to the use of 2 funnels, and the best time to catch crabs is between noon and evening (Crespular). Research conducted by Ferdiansyah et al. (2017), Ummaiyah et al. (2017), and Jayanto et al. (2018) provide different intervention variables. However, there are similarities in the orientation of the research objectives, namely for the effectiveness of

environmentally friendly fishing. Another opportunity for experimental fishing research is to combine intervention variables that have been carried out by Ferdiansyah et al. (2017), Ummaiyah et al. (2017), and Jayanto et al. (2018).

The exploitation status of blue swimming crabs in the Tiworo Strait, Southeast Sulawesi, is at a moderate level (Permatahati et al., 2020). The exploitation status of blue swimming crabs in the Toronipa Waters, Southeast Sulawesi, is at an over-exploited level for male crabs and moderate for female crabs (Muchtar et al., 2019). Research by Anggoro et al. (2022) in Bengkulu Waters resulted in the utilization level of male and female crabs with an over-exploited status. Data from the Ministry of Marine and Fisheries Affairs (2022) recorded the potential for blue swimming crabs in the Java Sea of 23,508 tons/year with fully-exploitation status. The exploitation status of blue swimming crabs varies in each water area. Different environmental conditions and fishing pressures in each water area can be contributing factors. Rembang waters are included in the Java Sea waters. The full-exploitation status for blue swimming crabs still allows for additional fishing efforts but requires stringent supervision. The blue swimming crabs caught in Rembang waters are categorized as young crabs (Wibowo et al., 2019) and are dominated by immature female crabs (Maghfirani et al., 2019). The results of research by Wibowo et al. (2019) and Maghfirani et al. (2019) on blue swimming crab fishing need real attention. The level of crab exploitation in Rembang waters is indeed in the fully exploited category. However, there are indications that the blue swimming crabs caught are young crabs and immature female crabs. Research by Jayanto et al. (2018) focuses on increasing the chances of catching crabs by increasing the number of funnels. Meanwhile, research conducted by Ferdiansyah et al. (2017) and Ummaiyah et al. (2017) focuses on minimizing the catch of small crabs with the presence of escape gaps. To anticipate excessive crab exploitation, an innovation in folding traps is needed that can minimize small crabs in the future.

Blue swimming crabs are one type of biota that lives on the bottom of the waters and are included in the category of demersal biota groups (Susanto et al., 2022; Karman et al., 2023). The folding trap is operated at the bottom of the water (Mahiswara et al., 2018; Munir & Zainuddin, 2019), and the bottom of the water is the primary habitat of blue swimming crabs. Male blue swimming crabs tend to be in shallow waters, while female crabs tend to be spread in deep waters (Adlina et al., 2014). The further from the coast, the larger the crab size, but the blue swimming crab biomass decreases (Adam et al., 2006). Blue swimming crabs can be found at the bottom of the waters with muddy, sandy, or muddy substrate types (Nuraini et al., 2009; Ihsan, 2018; Putri et al., 2023). The depth of the water affects the catch of crabs caught in folding traps (Wulandari et al., 2014). The factors are different crab population groups, and crab sexes have different preferences for substrate conditions and depths (Asphama et al., 2015). Thus, the location of the folding trap operation and the blue swimming crab habitat explain the dominance of blue swimming crab catches in the folding trap.

The design and construction of the folding trap are also adjusted to the behavior of the blue swimming crabs. The shape of the entrance (funnel) of the folding trap with a certain angle of inclination increases the chances of catching crabs by crawling into the folding trap (Boutson et al., 2009; Susanto et al., 2014; Fitri et al., 2017; Wijayanti et al., 2018; Aditya et al., 2020; Utami et al., 2020; Susanto et al., 2021). The folding trap is operated by using bait as an attractant to attract crabs into the folding trap. The type of bait used by local fishermen is fish pieces. The type of bait used is according to the blue swimming crab's food preferences. The stomach contents of adult crabs consist of plankton, meat, mollusks, small crustaceans, small fish, and polychaeta (Erlinda et al., 2016; Romano & Zeng, 2016). According to Yolanda et al. (2022), blue swimming crab food consists of microalgae, crustaceans, and detritus. Based on the characteristics of their food, blue swimming crabs are included in the carnivorous biota group (Safaie, 2016). Various studies have revealed that the bait factor is effective in catching blue swimming crabs with folding traps (Perdana et al., 2016; Satriawan et al., 2017; Hambali et al., 2023). The design and construction of folding traps and the location of operation of folding traps and bait are important factors in blue swimming crab fishing. They can explain the capture of blue swimming crabs in folding traps predominantly.

3.9 Gillnet

The next experimental fishing is based on gillnet fishing gear, conducted by Fitri et al. (2021). Fitri

et al. (2021) experimented with modified gillnets (monomultifilament material, adding swivel component and essens bait) and compared them with local fishermen's gillnets (monofilament material, without swivel and bait). The results of Fitri et al. (2021) research showed that the productivity of mono-multifilament gillnets was higher than the monofilament gillnets tested. Fitri et al. (2021) research did not target a specific fish but was oriented toward the total catch. Fitri et al. (2021) research has not provided interventions for other variables, so opportunities for further research are still open to be carried out. Several variables that can be intervention factors in experimental fishing with gillnets include operating time (Minggo, 2022), level of selectivity (Rengi et al., 2021), technical specifications and construction (Prihantoko et al., 2023), density and size structure of fish (Olin et al., 2009), and financial feasibility of the fishing business (Zain et al., 2016).

4. CONCLUSION

The results of the study showed that 9 (nine) types of fishing gear were the objects of research in the coastal area of Rembang Regency in 2013-2022, namely Small pelagic purse seine, Boat seine (cantrang), Folding box traps (bubu lipat), Gillnet, Trammel net, Small bottom trawl (arad), Boat seine (dogol), Squid jigging (pancing cumi), and Longline (pancing rawai). The research pattern based on fishing gear consists of a combination of fishing gear (combined fishing gear or multi gears) and one type of fishing gear (single fishing gear). The types of fishing gear studied in combination are Small pelagic purse seine and Cantrang, Folding box trap and Gillnet, Gillnet and Cantrang, and Cantrang and Trammel net. The types of fishing gear studied in single fishing gear are Small bottom trawl, Dogol, Squid jigging, and Longline. The results of grouping articles based on the main topic of the study show that there are 8 (eight) main topics, namely Fisheries policy, Safety at sea, Fisheries bioeconomics, Fisheries market product, Fishing productivity, Fisheries stocks, Fishing methods, and Fisheries socio-economics. Non-experimental fishing methods studies have been conducted on 4 (four) types of fishing gear: Cantrang (Boat seine), Trammel net, Dogol (Boat seine), and One boat-operated purse seine for small pelagic fish. Experimental fishing method research has been conducted on 5 (five) types of fishing gear: Small bottom trawl, Folding box traps, Longline, Squid jigging, and Gillnet. The experimental fishing methods that have been conducted consist of code end mesh size and towing speed on the small bottom trawl, escape gap and operating time on folding box trap, fish-hook material and bait on hook and line, and adding some component material for modification on Gillnet (mono-multifilament material, adding swivel component and essence bait). The results of this study provide knowledge about various fishing gear on the coast of Rembang and various main research topics that have been conducted on these fishing gear. In the research on experimental fishing methods based on fishing gear, it is known that there are two concepts of studies, namely, efforts to increase production and efforts to increase sustainable fishing. The potential future for research on experimental fishing methods in the coastal area of Rembang is still wide open. In the future, research on experimental fishing methods needs to be directed at responsible fishing efforts and the sustainability of fisheries resources.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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