# CHARACTERISTICS OF CAPTURE FISHERIES SUPPLY CHAIN IN NORTH KOLAKA REGENCY, INDONESIA

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***Abstrak:***
*The capture fisheries supply chain in North Kolaka Regency, Indonesia, is characterized by its diverse fishing grounds, fish resources, and fisher groups. This study aimed to analyze the structure and dynamics of the fisheries supply chain using Principal Component Analysis (PCA) and K-Means clustering to classify fishing areas, landing sites, and fisher groups based on their characteristics. The research findings revealed significant variability in fish stock, fishing seasons, and production patterns across different fishing areas and landing sites. Surplus seasons for various fish species such as sharks, rays, and mackerel scad occurred between August and September, while medium and famine seasons were observed from October to December and January to July, respectively. Despite the diverse resources, the fish marketing system remains predominantly conventional, with weak coordination and limited access to market information. These inefficiencies hinder the optimization of economic value along the supply chain. The study highlights the importance of enhancing the integration of actors and improving cold storage facilities to boost the competitiveness and sustainability of the fisheries sector in North Kolaka Regency.*

***Key Words:*** Capture fisheries, Principal Component Analysis (PCA), K-Means clustering, Fishing seasons, Fish landing sites

## INTRODUCTION

Capture fisheries operate within a complex production system that is strongly influenced by biological characteristics of fish, spatial variability of fishing grounds, and operational behavior of actors along the supply chain (FAO, 2020). The highly perishable nature of fish products makes fisheries supply chains particularly vulnerable to inefficiencies related to landing facilities,

transportation delays, and weak coordination among stakeholders (Aung & Chang, 2021). Recent studies emphasize that differences in supply chain characteristics across regions significantly affect logistics efficiency, product quality, and income distribution among small-scale fishers (Akkerman et al., 2021). Therefore, understanding the structural characteristics of fisheries supply chains is essential for improving performance and sustainability (Christopher, 2022).

North Kolaka Regency represents a coastal area with diverse fishing grounds, fish resources, and fishing practices, resulting in heterogeneous supply chain characteristics across landing sites and fisher groups (BPS North Kolaka, 2023; 2016). However, fish distribution and marketing systems in this region remain predominantly conventional, characterized by limited market information, high dependency on middlemen, and uneven performance among fish landing centers (FAO, 2022). Empirical evidence indicates that such heterogeneity, when not systematically identified, can lead to inefficiencies, post-harvest losses, and unequal value distribution along the fisheries supply chain (Tran et al., 2021). This condition highlights the need for a structured analysis of fisheries supply chain characteristics at the regional level.

Recent approaches to fisheries supply chain analysis increasingly apply multivariate statistical methods to capture spatial, production, and operational complexity simultaneously (Zhou et al., 2020). Principal Component Analysis (PCA) is widely used to identify dominant factors differentiating fishing grounds and landing sites based on variations in fish stock composition and abundance (Kumar & Anbanandam, 2020). Furthermore, K-Means clustering enables the classification of fishing grounds, fishers, and landing sites according to similarities in production patterns and operational characteristics, providing an objective representation of supply chain structure (Liu et al., 2022). This analytical framework offers a robust scientific basis for understanding fisheries supply chain dynamics and supporting adaptive and sustainable fisheries management.

## RESEARCH METHODS

### Research Location

The research was conducted on all components of the supply chain in North Kolaka Regency, including Fishing Areas, Fish Landing Places, Fishermen Groups, Reservoirs and traders, Processing Units.

### Data Collection Techniques

Data collection was carried out through structured interviews with fishermen, collectors, traders, and processors, field observations on Fish Auction Market, fishing locations, and distribution routes, and secondary data from BPS, fisheries offices, and fisheries statistics reports. This study uses a descriptive-quantitative approach combined with multivariate statistical analysis and regional economic analysis. The methodology used includes:

Primary data was collected through interviews, field surveys, observation of fishermen, collectors, traders, and processing business actors. Data includes Location and frequency of catch, Type of fishing gear, Volume and composition of catches, Fish Auction Market location and landing characteristics, Container capacity, delivery frequency, and purchase price, as well as Capacity and type of processing business.

### Data Analysis

The research uses survey methods and descriptive-analytic approaches and multivariate statistical analysis. Supply Chain Analysis, to identify the seven main components of the supply

chain and the relationships between actors. The analysis includes product flows, information flows, and financial flows in supply chain systems.

PCA (Principal Component Analysis) Analysis, Used to Identify the largest variations of fishing area data, Determine the main factors influencing differences in fishing area and fish auction market characteristics. K-Means Clustering, to Group fishing area, fishermen, and Fish Auction Market based on fish stock characteristics, fishing seasons, and variations in production yields.

## RESULTS

The fish logistics system is structured based on the understanding of the supply chain, which is an integrated network between producers, agents, distributors, and retailers in producing and distributing fish and marketing services to the end consumer (Mentzer et al., 2001). The management of fish flows and services in the supply chain requires a thorough mapping of the entire chain, from upstream to downstream, so that the flow of products, information, and logistics activities can be accurately understood (Christopher, 2016). Each chain is analyzed by considering the number, location, and time of activities, availability of raw materials and auxiliary materials, use of equipment, and competitive conditions between business actors (Akkerman et al., 2010). In addition, the characteristics of inventory movements are an important factor because each type of inventory has different dynamics, thus affecting the length and shortness of the supply chain in accordance with the raw material fulfillment method and inventory policies applied (FAO, 2018). The fish supply chain in North Kolaka Regency can be broken down into 7 (seven) components, namely fishing locations, fishermen, fish landings, collectors, processors, traders. CharacteristicsEach component is described as follows.

### Fishing areas

Based on the results of the survey, it was obtained that the location or Fishing Area in North Kolaka Regency was spread over 26 sins (1 sin = 5'S x 5'E). However, based on the results of the PCA analysis, it was found that there were only five fishing area axes that had variations in the number of stocks from all types of Fish Resources that reached a difference or variability > 40% (Figure 1). Therefore, fishing area in North Kolaka Regency can be divided into five groups, namely the F1, F2, F3, F4 and F5 axis.

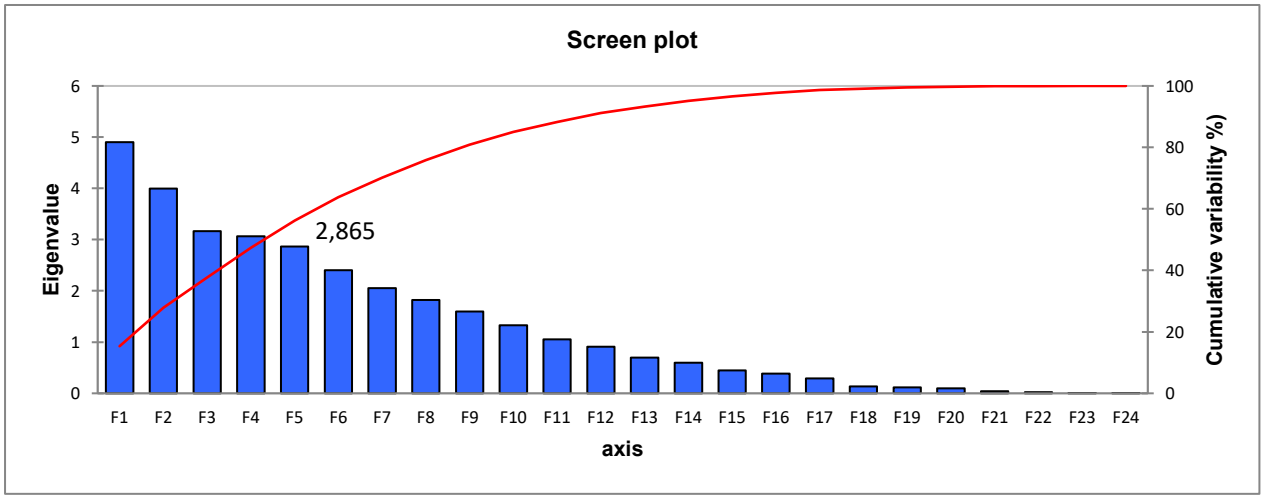


**Figure 1.** Axis Group Fishing Areas

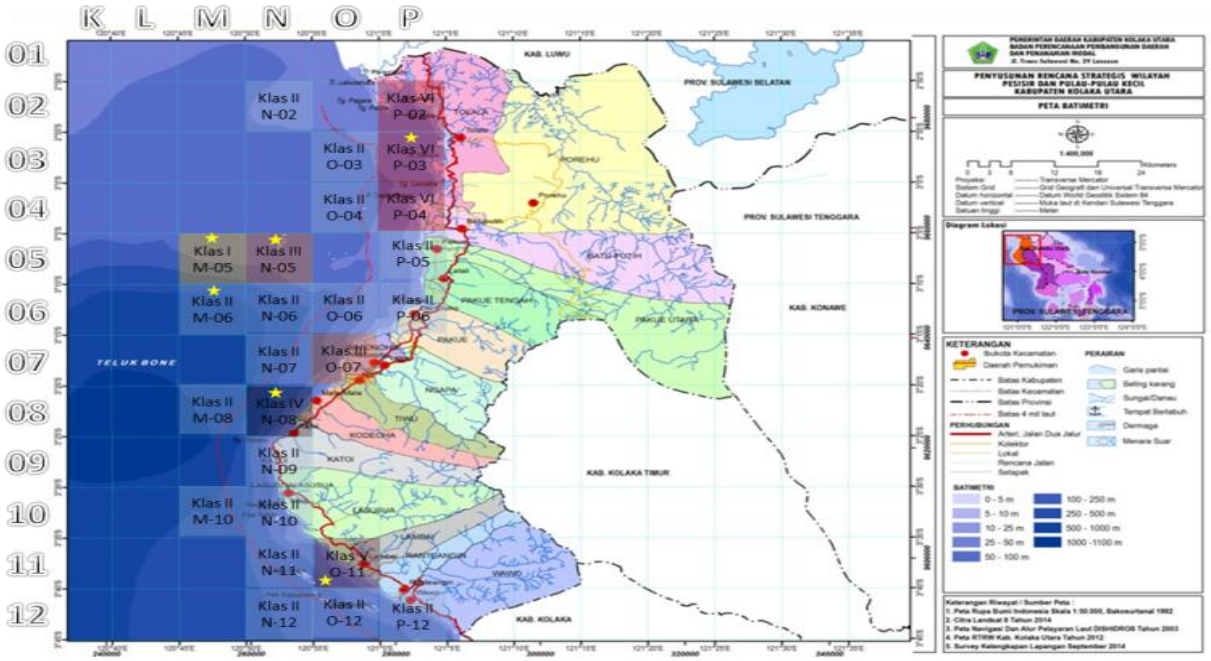


**Figure 2.** The location of the fishing area group and central (code star) is based on the stock amount of all fish resources variations.

Each fishing area cluster exhibits distinct dominant fish resource characteristics.

1) First cluster

Cluster 1 is dominated by shark, ray, and mackerel scad resources, which exhibit distinct seasonal patterns.

**Table 1.** Characteristics of the first cluster of fish resources areas in North Kolaka Regency

| Central Cluster | Description | Superior Fish Resources | | |
|---|---|---|---|---|
| | | Shark | Rays | Mackerel Scad |
| M-05 | Stock per year | 100% | 100% | 40% |
| | Bathymetry | 100-250 M | 50-100 M | 50-25 M |
| | Surplus Season | 8-9 | 8-9 | 9, 1 |
| | Medium Season | 10-12 | 10-12 | 10, 12 |
| | Famine Season | 1-7 | 1-7 | 1, 7 |

2) Second cluster

Cluster 2 represents deeper fishing areas dominated by skipjack, snapper, grouper, and needlefish.

**Table 2.** Characteristics of the second cluster of fish resources areas in North Kolaka Regency

| Central Cluster | Description | Superior Fish Resources | | | |
|---|---|---|---|---|---|
| | | Skipjack | Snapper | Clubbing | Side |
| N-07 | Stock per year | 12% | 6% | 12% | 45% |
| | Bathymetry | 50-1000 M | 50-1000 M | 50-1000 M | 50-1000 M |
| | Surplus Season | 4-9 | 1—5 | 1-5 | 10-12 |
| | Medium Season | 10 | 6—9 | 6-9 | 1-6 |
| | Famine Season | 11-3 | 10—12 | 10-12 | 7-9 |

3) Third cluster

Cluster 3 is characterized by snapper, giant trevally, and emperor fish in shallow waters.

**Table 3.** Characteristics of the third cluster of fish resources areas in North Kolaka Regency

| Central Cluster | Description | Superior Fish Resources | | |
|---|---|---|---|---|
| | | Snapper | Cake/White | Emperor |
| P-05 | Stock per year | 3% | 5% | 6% |
| | Bathymetry | 5-50 M | 5-50 M | 5-50 M |
| | Surplus Season | 7,8 | 11-12 | 9,12 |
| | Medium Season | 9,12 | 8-9 | 6,8 |
| | Famine Season | 1,6 | 1-7 | 1,5 |

4) Fourth cluster

Cluster 4 is a specialized fishing area dominated exclusively by anchovy resources.

**Table 4.** Characteristics of the fourth cluster of fish resources areas of North Kolaka Regency

| Central Cluster | Description | Superior Fish Resources |
|---|---|---|
| | | Teri |
| N-10 | Stock per year | 5% |
| | Bathymetry | 5-500 m |
| | Surplus Season | 6—9 |
| | Medium Season | 4,5,10,11 |
| | Famine Season | 12—3 |

5) Fifth cluster

Cluster 5 shows the highest diversity of dominant pelagic and demersal fish resources.

**Table 5.** Central characteristics of the fifth cluster fish resources capture areas in North Kolaka Regency

| Central Cluster | Description | Superior Fish Resources (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Skipjack | Mackerel | Anchovy | Grouper | Trevally | Baby Tuna | Needlefish | Emperor |
| N-06 | Stock per year | 15 | 19 | 88 | 4 | 3 | 62 | 55 | 4 |
| | Bathymetry | 50-1000 M | 50-1000 M | 50-1000 M | 50-1000 M | 50-1000 M | 50-1000 M | 50-1000 M | 50-1000 M |
| | Surplus Season | 11-12 | 10-12 | 9-12 | 6-8 | 6-8 | 10-12 | 11-12 | 6-8 |
| | Medium Season | 6-7 | 1-6 | 4-8 | 9-12 | 9-12 | 1-6 | 1-7 | 9-12 |
| | Famine Season | 1-5 | 8-9 | 1-3 | 1-4 | 1-4 | 8-9 | 8-10 | 1-4 |

## Characteristics of Fishermen Catch

Capture fishers in North Kolaka Regency are classified into eight groups based on the fishing gear used. Each group exploits different fish resources and exhibits distinct catch compositions and production patterns, which allows the fisherman groups to be clustered based on their production characteristics.

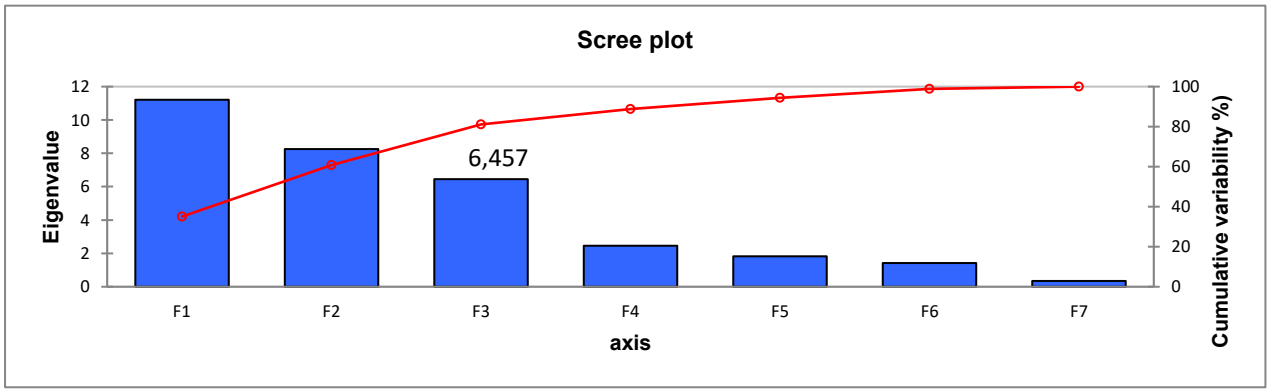

Figure 3. Grouping fishermen based on the variation and number of SDI catches.

As a result (PCA), it was obtained that there were three axes that gave a variability value > 40, namely F1, F2, and F3 (Figure 3). Based on the results of *the k-means Cluster*, the three axes were declared as the leading fishermen cluster in providing catches for all types of existing fish resources stocks. The three clusters in question are Handlines fishermen, Seine net fishermen and scoop net fishermen.

1) Handlines Fisherman

   The types of fishing gear commonly used by fishers in North Kolaka Regency include shark handlines, other handline variants, conventional handlines, vertical handlines, trolling lines, and squid lines. The total number of fishing trips conducted annually for each gear type was 46, 207, 94, 235, 60, and 55 trips, respectively.

   Handline fisheries in North Kolaka Regency produced 11 major fishery resources, including sharks (*Selachimorpha*), rays (*Batoidea*), skipjack tuna (*Katsuwonus pelamis*), mackerel (*Rastrelliger spp.*), snappers (*Lutjanus spp.*), groupers (*Epinephelus spp.*), giant trevally (*Caranx ignobilis*), baby tuna (*Thunnus spp.*, juvenile stage), squid (*Loligo spp.*), and emperor fish (*Lethrinus spp.*). These catches were generated by shark handlines, conventional handlines, vertical handlines, trolling lines, squid lines, and other handline variants. All shark and ray catches (100%) were obtained exclusively using shark handlines.

   Furthermore, other handline variants accounted for 86% of the total mackerel (*Rastrelliger spp.*) catch and also contributed to catches of mackerel (50%), groupers (24%), emperor (13%), snappers (11%), skipjack tuna (9%), and giant trevally (3%). Conventional handlines captured three main species: giant trevally (17%), snappers (10%), and emperor (6%). Vertical handlines produced five species: snappers, groupers, mackerel, giant trevally, and emperor, with respective contributions of 26%, 17%, 14%, 15%, and 11%. Trolling lines targeted skipjack tuna, snappers, groupers, and baby tuna, contributing 1%, 2%, 4%, and 6% of the total catch of each species. More specifically, squid lines exclusively targeted squid, accounting for 91% of the total squid catch in North Kolaka Regenc

2) Seine Net Fisherman

   To obtain fishing catches, seine net fishers in North Kolaka Regency commonly operate seven types of seine nets, including ring seine, skipjack seine, flying fish seine, common seine, modified flying fish seine, crab seine, and beach seine. The average annual fishing effort for each gear type is 160, 402, 264, 249, 30, 40, and 45 trips, respectively. Fish resources harvested using these purse seine gears comprise mackerel scad (*Decapterus* spp.), skipjack tuna (*Katsuwonus pelamis*), flying fish (*Exocoetidae*), frigate tuna (*Auxis* spp.), Indian mackerel (*Rastrelliger kanagurta*), grouper (*Epinephelus* spp.), trevally (*Carangidae*), juvenile tuna (*Thunnus* spp.), *needlefish* (*Scomberoides* spp.), squid (*Loligo* spp.), sardine (*Sardinella* spp.), emperor (*Lethrinus* spp.), crab (*Portunidae*), rabbitfish (*Siganus* spp.), malaja rabbitfish (*Siganus* spp.), short mackerel *(Rastrelliger brachysoma), tiko*, *sisile*, and *buibui (locally know)*.

   Based on the diversity of captured fish resources, the conventional seine net represents the fishing gear with the highest multivariate catch composition, capturing a total of eight fish resource types. The species caught using this gear include Indian mackerel, trevally, emperor, rabbitfish *malaja*, short mackerel, *tiko*, *sisile*, and *bubui*. The respective contributions of these species to the total catch of each resource were 34%, 22%, 5%, 23%,

84%, 100%, 100%, and 100%, respectively. Furthermore, the conventional seine net demonstrates a higher degree of gear specificity for capturing *tiko*, *sisile*, and *bubui*, as all catches of these species were exclusively obtained using this fishing gear.

3) Scoop Net Fishermen

The fishing performance of scoop net fishers is supported by two types of fishing gear, namely the scoop net and the hand-operated push net. Small anchovies (*Stolephorus* spp.) constitute the sole target catch of both fishing gears. Annually, the scoop net is operated for approximately 200 fishing trips. In contrast, the hand-operated push net is operated less intensively, with only about 64 fishing trips per year.

**Fish Landing Sites**

Based on the survey results, a total of fourteen main fish landing sites were identified in North Kolaka Regency. However, considering the distribution of administrative districts as well as the composition of fish resources and the volume of landed stocks, these sites can be represented by four central fish landing sites that are commonly used by local fishing communities. This classification is supported by the results of the Principal Component Analysis (PCA), as illustrated in Figure 4.

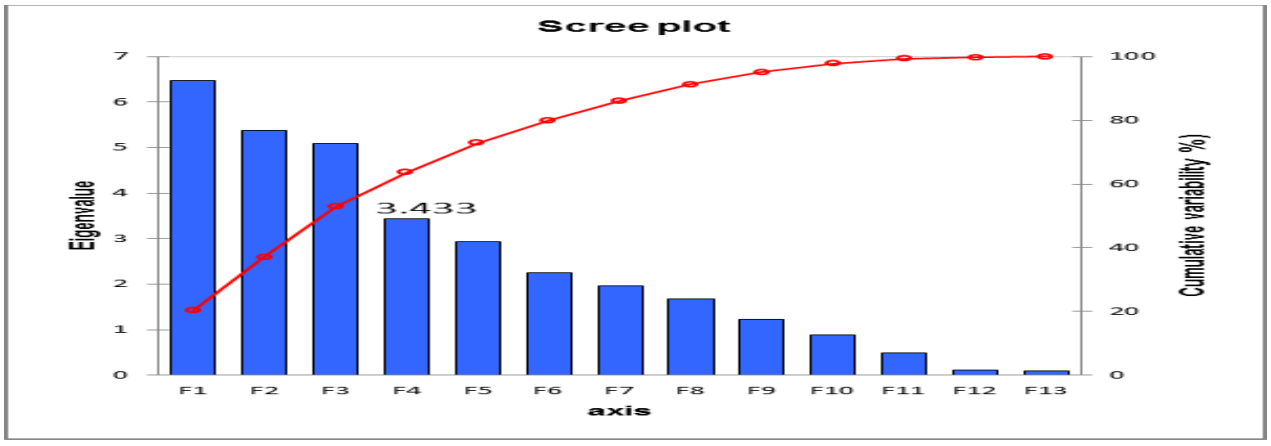


**Figure 4.** Clustering of Fish Landing Sites Based on Variations in Fish Species Composition and Stock Volume Landed in North Kolaka Regency

As shown in Figure 4, four principal axes explain more than 50% of the total variability, indicating that the characteristics of all fish landing sites can be adequately represented by axes F1–F4. Based on the K-means clustering results, these axes correspond to four fish landing site clusters, namely Tolala, Ranteangin, Tiwu, and Pakue Tengah. Among these, Tolala and Pakue Tengah exhibit unique landing characteristics and therefore function as standalone fish landing site clusters. In contrast, Tiwu represents other landing sites, including Kodeoha, Lasusua, and Wawo, based on similarities in species composition and landed stock volume. Similarly, Ranteangin serves as a representative fish landing site for Batu Putih, Pakue, Watunohu, Ngapa, Katoi, and Lambai. The characteristics of each central landing site are described in the following sections.

1) Tolala fish landed site

The total volume of fish landed site accounts for approximately 17% of the regency's total capture fisheries production. The main fish resources landed include mackerel scad, skipjack tuna, anchovy, snapper, giant trevally, baby tuna, emperor, rabbitfish, mullet, and yellowtail.

**Table 6.** Performance Tolala Fish Landing Site, North Kolaka Regency

| Fish Resources | Suply | | | |
|---|---|---|---|---|
| | Fishing area | GT Boat | Frequency | Total |
| Mackerel | N-02 | 5 | 108 | 59% |
| Skipjack | N-02 | 1 | 112 | 3% |
| | O-03 | 0,5 | 102 | 3% |
| Anchovy | N-02 | 5 | 99 | 3% |
| Snapper | P-02 | 0.25 | 60 | 4% |
| Giant Trevally | P-02 | 1 | 70 | 6% |
| Baby Tuna | O-03 | 0.5 | 102 | 20% |
| Emperor Fish | P-02 | 0.5 | 111 | 8% |
| Rabbitfish | P-02 | 0.4 | 92 | 20% |
| Mullet Fish | P-02 | 0.5 | 120 | 15% |
| Yellow Tail | P-02 | 0.5 | 120 | 100% |

Tolala fish landed site serves as the sole landing site for yellowtail originating from fishing ground P-02, operated by vessels of 0.5 GT. Annually, yellowtail landings reach a frequency of 120 trips per fisher, supplying 100% of the total catch of this species. In contrast, scads are landed 108 times per year per fisher, contributing 59% of the total scad catch, and are sourced from fishing ground N-02 using 5 GT vessels. Similarly, anchovy landings from N-02 using 5 GT vessels occur 99 times per year per fisher, accounting for 3% of the total anchovy catch. Skipjack tuna is landed from fishing grounds N-02 and O-03 using 1 GT and 0.5 GT vessels, with landing frequencies of 112 and 102 times per year per fisher, respectively. Likewise, baby tuna is landed from O-03 using 0.5 GT vessels with a frequency of 102 landings per year per fisher, contributing 20% of its total catch. Furthermore, snapper, trevally, emperor, rabbitfish, and mullet are landed from fishing ground P-02 using vessels of 0.25, 1, 0.5, 0.5, 0.4, and 0.5 GT, respectively, with landing frequencies of 60, 70, 111, 92, and 120 times per year per fisher, contributing 4%, 6%, 8%, 20%, and 15% of the total catch of each respective species.

2) Ranteangin Fish Landing Center

The total volume of fish landed at the Ranteangin Fish Landing Center accounts for approximately 0.5% of the total capture fisheries production in North Kolaka Regency. The main fish resources landed at this site include skipjack tuna (Katsuwonus pelamis), groupers (Epinephelus spp.), trevallies (Carangidae), and emperor (Lethrinus spp.). Ranteangin functions as a primary landing center for skipjack tuna and groupers originating from Fishing Ground N-02, operated using 3 GT vessels. Annually, landings of skipjack tuna and groupers reach a frequency of approximately 170 trips per fisher, contributing 2% and 11%, respectively, to the total catch of each species in the regency.

Landings of trevallies and emperor are sourced from Fishing Ground O-11 using 1 GT vessels, with landing frequencies reaching 100 trips per fisher per year. These species contribute 4% and 5%, respectively, to the total catch of each corresponding fish resource. A detailed description of these landing characteristics is presented in Table 7.

**Tabel 7.** Performance Ranteangin Fish Landing Site, North Kolaka Regency

| Fish Resources | Suply | | | |
|---|---|---|---|---|
| | Fishing area | GT Boat | Frequency | Total |
| Skipjack | N-12 | 3 | 170 | 2% |
| Grouper | N-12 | 3 | 170 | 11% |
| Giant trevally | O-11 | 1 | 100 | 4% |

| | | | | |
|---|---|---|---|---|
| Emperor | O-11 | 1 | 100 | 5% |

3) Tiwu Fish Landing Site

The total fish stock landed at Tiwu Fish Landing Site accounts for approximately 6% of the total capture fisheries production of North Kolaka Regency.

**Tabel 8.** Performance Tiwu Fish Landing Site, North Kolaka Regency

| SDI | Pasok | | | |
|---|---|---|---|---|
| | Fishing area | GT Kpl | Frekuensi | Total |
| Skipjack tuna | O-07 | 2 | 300 | 26% |
| Mackerel Tuna | O-07 | 2 | 300 | 59% |
| Anchovy | O-07 | 0.5 | 64 | 1% |
| Snapper | O-07 | 1 | 140 | 4% |
| | N-07 | 0.12 | 250 | 6% |
| | N-08 | 0.4 | 155 | 3% |
| Grouper | N-07 | 0.12 | 250 | 12% |
| | N-08 | 0.3 | 210 | 3% |
| Giant Trevally | O-07 | 1 | 140 | 6% |
| | N-08 | 0.5 | 100 | 3% |
| | O-08 | 0.15 | 163 | 1% |
| Sardine | N-08 | 0.2 | 170 | 32% |
| | O-08 | 0.15 | 163 | 12% |
| Emperor | N-08 | 0.5 | 40 | 4% |
| Rabbitfish | O-08 | 0.15 | 154 | 25% |
| | N-08 | 0.5 | 40 | 15% |
| Malaja rabbitfish | N-08 | 0.5 | 40 | 77% |
| Mullet | O-08 | 0.15 | 154 | 28% |
| Rerata | | 0.6 | 157 | 18% |

The landed fish resources consist of skipjack tuna (*Katsuwonus pelamis*), mackerel tuna (*Euthynnus affinis*), anchovy (*Stolephorus spp*.), snapper (*Lutjanus spp*.), grouper (*Epinephelus spp*.), trevally (Caranx *spp*.), sardine (*Sardinella spp*.), emperor (*Lethrinus spp*.), rabbitfish (*Siganus spp*.), malaja *rabbitfish*, and mullet (*Mugil spp*.). These fish resources are landed from four fishing grounds, namely O-07, N-07, N-08, and O-08, using vessels with an average capacity of 6 gross tons (GT). The landing frequency reaches an average of 157 trips per year per fishing vessel. Accordingly, each fish resource contributes an average of 18% per species to the total landings at this site. The largest contribution is provided by mackerel tuna, accounting for 59% of the total landings of this species in North Kolaka Regency. Landings of mackerel tuna from fishing ground O-07 occur up to 300 trips per year using vessels with an average capacity of 2 GT. In contrast, anchovy represents the smallest contribution, accounting for only 0.5% of the total anchovy landings in the regency. Anchovy landings from fishing ground O-07 occur at a frequency of approximately 64 trips per year, using vessels with an average capacity of 0.5 GT. A more detailed description of these conditions is presented in Table 8.

4) Pakue Tengah Fish Landing Site

The total supply of landed fish at Pakue Tengah Fish Landing Site accounts for approximately 4% of the total capture fisheries production of the regency. The fish resources landed at this

site include skipjack tuna, frigate tuna, waneedlefish, snapper, grouper, trevally, baby tuna, needlefish, squid, emperor, mullet, female mackerel, flatfish, and lawa.

**Tabel 9** Performance Pakue Fish Landing Site, North Kolaka Regency

| Fish Resources | Suply | | | |
|---|---|---|---|---|
| | Fishing area | GT Boat | Frequency | Total |
| Skipjack tuna | O-03 | 0.2 | 128 | 1.5% |
| | N-07 | 1 | 120 | 5% |
| | N-05 | 1 | 115 | 3% |
| Frigate tuna | N-05 | 1 | 115 | 8% |
| WaNeedlefish | N-05 | 1 | 125 | 100% |
| Snapper | P-03 | 0.5 | 90 | 7% |
| | O-07 | 0.4 | 87 | 1.7% |
| | P-06 | 0.5 | 76 | 1.8% |
| Grouper | O-07 | 0.7 | 96 | 10% |
| | P-06 | 0.5 | 76 | 4% |
| Giant trevally | N-05 | 1 | 125 | 6% |
| | P-03 | 0.5 | 90 | 11% |
| | O-07 | 0.4 | 87 | 3% |
| Baby Tuna | O-03 | 0.2 | 128 | 12% |
| Needlefish | N-07 | 1 | 120 | 45% |
| Squid | O-07 | 0.5 | 55 | 91% |
| Emperor | O-07 | 1 | 105 | 5% |
| | O-03 | 0.25 | 120 | 5% |
| Mullet fish | P-04 | 0.7 | 102 | 19% |
| Female mackerel | O-03 | 0.25 | 120 | 16% |
| | O-06 | 0.1 | 171 | 84% |
| Flatfish | P-03 | 0.5 | 90 | 100% |
| Lawa | P-04 | 0.7 | 102 | 100% |
| Average | | 0.6 | 106 | 28% |

Pakue Tengah serves as the exclusive landing site for flatfish, waneedlefish, and lawa, which are landed respectively from fishing grounds N-05, P-03, and P-04 using vessels of 1.0, 0.5, and 0.7 GT. Other fish resources represent part of the broader regional distribution system and are landed from fishing grounds O-03, N-07, N-05, P-03, O-07, P-06, P-04, and O-06, operated by vessels with an average capacity of 0.6 GT. Excluding flatfish, waNeedlefish, and lawa, the average landing frequency at Pakue Tengah reaches 106 trips per year per vessel, supplying an average of 17% of the total landings for each fish species. Squid represents the largest contribution, accounting for 91% of the total squid landings in North Kolaka Regency. Squid landings from fishing ground O-07 occur at a frequency of 55 trips per year per vessel with an average vessel capacity of 0.5 GT. In contrast, skipjack tuna shows the smallest contribution, accounting for only 1.5% of the regency's total skipjack landings, with a landing frequency of 128 trips per year per vessel from fishing ground O-03 using vessels with an average capacity of 0.2 GT. A more detailed description of these conditions is presented in Table 9.

**Characteristics of Fish Collectors**

The opening of the Trans-Sulawesi land transportation corridor has created opportunities for communities in North Kolaka Regency to expand the marketing areas of fish resources landed

by local fishers. This development enables local actors to function as intermediaries, distributing fish products to a wider consumer market. Consequently, the capacity of fish collectors becomes a critical factor, particularly in terms of purchasing power and holding capacity for fish landings. As providers and distributors, fish collectors are also constrained by quality standards, size specifications, and species requirements in meeting final consumer demand. More importantly, the highly perishable nature of fish imposes additional limitations, requiring adequate storage systems and appropriate distribution frequency. In this context, the characteristics of fish collectors at each central fish landing site can be further described as follows.

**1) Characteristics of Fish Collectors at Tolala Fish Landing Site**

Based on fish species, seven types of fish are handled, namely mackerel scad, skipjack, anchovy, baby tuna, emperor, rabbitfish, and mulletfish. on average, two collectors operate for each commodity, with a mean holding capacity of approximately 1,045 tons/year/fish type. The highest purchase price is observed for mullet, reaching IDR35,000/kg. The largest procurement volume is recorded for mackerel scad, amounting to 5,875 tons per year, with a total shipment frequency of 147 deliveries per year and an average of 59 shipments annually. Further details are presented in Table 10.

**Tabel 10.** Performance of Fish Collector at Tolala Fish Landing Site, North Kolaka Regency

| Fish Resources | Storage capacity (ton/thn) | Purchase Price (Rp/kg) | Number of collectors | Shipment Frequency | |
|---|---|---|---|---|---|
| | | | | Month | Day |
| Mackerel scad | 5,875.0 | 10,000 | 6 | 147 | 59 |
| Skipjack tuna | 382.6 | 20,000 | 1 | 10 | 4 |
| Anchovy | 668.0 | 30,000 | 2 | 17 | 7 |
| Baby Tuna | 184.3 | 20,000 | 1 | 5 | 2 |
| Emperor | 114.3 | 20,000 | 1 | 3 | 1 |
| Rabbitfish | 67.2 | 20,000 | 1 | 2 | 1 |
| Mulletfish | 23.0 | 35,000 | 1 | 1 | 0 |
| Average | 1,044.9 | 22,143 | 2 | 26 | 10 |

2) Characteristics of Fish Collectors at Ranteangin Fish Landing Site.

The fish resources received from local capture fishers at the Ranteangin Fish Landing Site include mackerel scad, skipjack tuna, anchovy, Indian mackerel, snapper, grouper, spanish mackerel, trevally, baby tuna, emperor, rabbitfish, and mullet. On average, approximately six collectors are involved for each fish commodity, with a mean purchasing price of IDR24,167/kg/species. The average annual purchasing capacity of collectors reaches 5,717 tons, indicating a relatively high absorption capacity for fish landings. The mean total shipping frequency is 143 deliveries per month and 57 deliveries per day. The highest annual shipping frequency is recorded for anchovy, reaching 1,556 shipments per year (Table 11).

**Tabel 11.** Performance of Fish Collector at Ranteangin Fish Landing Site, North Kolaka

| Fish Resources | Storage capacity (ton/thn) | Purchase Price (Rp/kg) | Number of collectors | Shipment Frequency | |
|---|---|---|---|---|---|
| | | | | Month | Day |
| Mackerel scad | 215 | 10.000 | 1 | 5 | 2 |
| Skipjack tuna | 2.736 | 20.000 | 3 | 68 | 27 |
| Anchovy | 62.252 | 30.000 | 53 | 1.556 | 623 |
| Indian mackerel | 146 | 30.000 | 1 | 4 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Snapper | 820 | 20.000 | 2 | 21 | 8 |
| Grouper | 602 | 30.000 | 2 | 15 | 6 |
| Spanish mackerel | 69 | 30.000 | 1 | 2 | 1 |
| Giant trevally | 824 | 25.000 | 2 | 21 | 8 |
| Baby Tuna | 181 | 20.000 | 1 | 5 | 2 |
| Emperor | 499 | 20.000 | 1 | 12 | 5 |
| Rabbitfish | 75 | 20.000 | 1 | 2 | 1 |
| Mulletfish | 184 | 35.000 | 1 | 5 | 2 |
| Average | 5.717 | 24.167 | 6 | 143 | 57 |

3) Characteristics of Fish Collectors at Central Pakue Fish Landing Site.

The fish collectors operating at the Central Pakue Fish Landing Site handle a wide range of fish resources, including sharks, mackerel scad, skipjack tuna, mackerel tuna, anchovy, Indian mackerel, snapper, grouper, trevally, sardine, emperor, rabbitfish, malaja rabbitfish, goby, mullet, and sea cucumber.

**Tabel 12.** Performance of Fish Collector at Central Pakue Fish Landing Site, North Kolaka

| Fish Resources | Storage capacity (ton/thn) | Purchase Price (Rp/kg) | Number of collectors | Shipment Frequency | |
|---|---|---|---|---|---|
| | | | | Month | Day |
| Shark | 808 | 353.000 | 2 | 20 | 0 |
| Mackerel scad | 11.976 | 3.593 | 11 | 299 | 120 |
| Skipjack Tuna | 5.854 | 1.756 | 6 | 146 | 59 |
| Bullet Tuna | 5.566 | 1.670 | 6 | 139 | 56 |
| Anchovy | 383 | 6.000 | 1 | 10 | 4 |
| Indian Mackerel | 144 | 30.000 | 1 | 4 | 1 |
| Snapper | 703 | 20.000 | 2 | 18 | 7 |
| Grouper | 756 | 20.000 | 2 | 19 | 8 |
| Giant trevally | 428 | 20.000 | 1 | 11 | 4 |
| Sardine | 26 | 20.000 | 1 | 1 | 0 |
| Emperor | 502 | 20.000 | 1 | 13 | 5 |
| Rabbitfish | 208 | 20.000 | 1 | 5 | 2 |
| Malaja rabbitfish | 77 | 20.000 | 1 | 2 | 1 |
| Goby | 4.837 | 6.000 | 5 | 121 | 48 |
| Mulletfish | 132 | 20.000 | 1 | 3 | 1 |
| Sea cucumber | 70 | 350.000 | 1 | 2 | 1 |
| Average | 689 | 46.000 | 2 | 17 | 7 |

On average, each fish commodity is handled by approximately two collectors. The average storage capacity reaches 689 tons per year, with an average purchase price of IDR 64,000 per kg across fish species. The largest stock volume is represented by mackerel scad, reaching 11,976 tons per year. The average total monthly shipment frequency is 299 shipments per year, while daily shipments occur at an average of 120 times per year. The lowest shipment frequency is observed for sardine, which is delivered only once per year. Further details are presented in Table 12.

4) Characteristics of Fish Collectors at Tiwu Fish Landing Site

The fish resources handled at Fish Auction Market Tiwu include skipjack tuna, needlefish, snapper, grouper, trevally, baby tuna, emperor, mullet, female mackerel, flatfish, and lawa. On

average, each fish species is handled by one collector, with an average handling capacity of approximately 224 tons per year. The average purchasing price across species is IDR21,364 per kilogram. The largest volume handled at this landing site is flatfish, reaching 619 tons per year. The average monthly shipment frequency for flatfish is 15 shipments per year, with an average daily shipment frequency of six times per year. In contrast, the lowest shipment frequency is observed for snapper, with only one shipment per month and one shipment per day over the course of a year. Further details are presented in Table 13.

**Tabel 13** Performance of Fish Collector at Tiwu Fish Landing Site, North Kolaka Regency

| Fish Resources | Storage Capacity (ton/thn) | Purchase Price (Rp/kg) | Number of collectors | Shipment frequency | |
|---|---|---|---|---|---|
| | | | | Month | Day |
| Skipjack | 195 | 20,000 | 1 | 5 | 2 |
| Needlefish | 310 | 20,000 | 1 | 8 | 3 |
| Snapper | 78 | 25,000 | 1 | 2 | 1 |
| Grouper | 78 | 25,000 | 1 | 2 | 1 |
| Giant trevally | 310 | 20,000 | 1 | 8 | 3 |
| Baby Tuna | 195 | 20,000 | 1 | 5 | 2 |
| Emperor | 121 | 30,000 | 1 | 3 | 1 |
| Mullet fish | 215 | 20,000 | 1 | 5 | 2 |
| Female mackerel | 121 | 15,000 | 1 | 3 | 1 |
| Flatfish | 619 | 20,000 | 2 | 15 | 6 |
| Lawa grouper | 215 | 20,000 | 1 | 5 | 2 |
| Average | 224 | 21,364 | 1 | 6 | 2 |

**Characteristics and Capacity of Fish Processing Enterprises**

Fish processing represents the closest downstream component in the fisheries supply chain for increasing the value added of fishers' catches. However, in North Kolaka Regency, the presence of processing enterprises remains very limited and is restricted mainly to traditional fish-drying activities. The raw material used is also narrowly focused, relying almost exclusively on anchovy resources. Spatially, these processing activities are concentrated in only three sub-districts Kodeoha, Katoi, and Lasusua specifically in Kamisi Village, Ujung Tobaku Village, and Lasusua Village. Each location is operated by a single processing actor. Annual production capacities reach approximately 1.8 tons in Kamisi, 10 tons in Ujung Tobaku, and 19 tons in Lasusua. Notably, the dried lure product from Pitulua Village has penetrated inter-district markets, achieving a selling price of approximately IDR 90,000 per kg.

**Tabel 14** Performance of Fish Collector at Central Pakue Fish Landing Site, North Kolaka Regency

| Subdistrict | Village | Type of fish | Type of processing | Jumlah (ton/thn) | Price (IDR/kg) |
|---|---|---|---|---|---|
| Kodeoha | Kamisi | Anchovy | Drying | 1.8 | 7.500 |
| Katoi | Ujung Tobaku | Anchovy | Drying | 10 | 7.500 |
| Lasusua | Pitulua | Lure | Drying | 19 | 90.000 |

**Marketing Mechanisms and Flow of Fisheries Products**

The fish marketing system in North Kolaka Regency can be classified as a conventional marketing system. This is reflected in the presence of multiple producers (fishers), traders, and retailers operating independently, each pursuing mechanisms aimed at maximizing individual profits. There is little evidence of coordinated efforts to optimize performance or value generation at the level of the overall marketing system. In the distribution of fish from fishing grounds to final consumers, each actor in the supply chain performs its core functions in a fragmented and poorly coordinated manner. Information on fishing potential is largely based on individual fishers' experience, while market information at the collector and processing levels remains limited and dependent on financial capacity, constraining the development of potential fishers and product diversification. Marketing communication and promotion are predominantly passive, negotiation on prices and supply volumes is weak, and ordering of supporting inputs is conducted individually outside the supply chain system. In addition, financing of inventories is not managed collectively, quality-related risks are shifted among actors, and physical ownership and handling of fish are constrained by inadequate cold storage facilities. Payment mechanisms and distribution cost management are underdeveloped, and transactions are dominated by cash-based exchanges with minimal managerial authority or institutional involvement in governing the fisheries supply chain.

## Conclusion

The capture fisheries supply chain in North Kolaka Regency involves seven main components with highly diverse characteristics, ranging from fishing grounds to final consumers. Each component plays a critical role in maintaining the continuity of fish supply from harvesting to market distribution. The PCA and K-means clustering analyses successfully identified five main clusters of fishing grounds, four clusters of fish landing sites, and three clusters of dominant fisher groups, indicating significant differences in fish stocks, fishing seasons, and production potential across areas. However, the fish marketing system remains largely conventional, characterized by strong dependence of fishers on collectors and limited cold storage capacity. Market information mechanisms are not yet functioning optimally, preventing fishers from maximizing the economic value of their catches. Fish processing activities are still limited and mainly dominated by dried anchovy and lure products, resulting in relatively low value added, while opportunities for product diversification remain underutilized.

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