Optimizing the supply chain performance of salted *Scomberoides tol* (Cuvier, 1832) in Sibolga City, North Sumatra, using the SCOR model

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Abstract. Sibolga, located on the west coast of Sumatra, is an important landing site for needlescale queenfish, *Scomberoides tol* (Cuvier, 1832), a species commonly processed into salted fish and widely traded in North Sumatra. This study examined how the product, information, and financial flows of the salted fish system operate, and assessed its performance using the supply chain operations reference (SCOR) model. A mixed-method approach was used, combining Catch Per Unit Effort (CPUE) analysis to describe catch fluctuations with qualitative mapping of distribution patterns. Over the past five years, queenfish production averaged 11.7 tons, with CPUE values ranging from 123 to 406 kg per trip, indicating substantial seasonal variation influenced by fishing effort. Two distribution routes were identified: a direct path linking fishers, processors, and consumers; and an indirect path involving collectors and retailers. The SCOR evaluation produced an overall score of 75 ("Good"), with reliability scoring highest (95.8) and asset management lowest (60.4). These results show that the system functioned effectively but remained vulnerable to environmental shifts and constraints in post-harvest handling. The findings offer practical guidance for local fisheries authorities, particularly the need to improve drying and storage facilities, strengthen financial coordination, and support more equitable income distribution among supply chain actors.
Key Words: salted needlescale queenfish, supply chain, CPUE, SCOR, performance.

Introduction. The city of Sibolga is one of the coastal areas on the west coast of Sumatra Island, known as the main center of capture fisheries in North Sumatra Province. The abundance of marine resources has made the fisheries sector the main livelihood of the local community, both through fishing and fish processing activities. Based on data from the Central Statistics Agency (CSA 2023), the volume of capture fisheries production in Sibolga City reaches more than 32,000 tons per year. Most of the catch is used for industrial processing, both on a factory and traditional scale, with the salted fish processing sector as the primary commodity that plays a vital role in the economy of coastal communities. The most well-known type of salted fish and a distinctive icon of Sibolga City is needlescale queenfish, *Scomberoides tol* (Cuvier, 1832), which is widely traded in local and regional markets. Needlescale queenfish is chosen as the primary raw material because it has thick, firm flesh and is highly resistant to the salting and drying processes, providing significant added value to the catch. This product serves as a protein source for the local community, offering substantial economic benefits to fishermen, processors, and traders in coastal areas (Jeyasanta et al 2016).

Although economically important, the development of the salted fish industry in Sibolga still faces various constraints. Seasonal variations and weather conditions cause fluctuations in the availability and quality of raw materials, disrupting the continuity of supply to processing units. At the same time, the prices of raw fish and salted products fluctuate according to catch volume and market demand, affecting the income stability of fishers and processors. Weak bargaining power among fishers further contributes to unequal value distribution within the chain, where collectors often determine prices at the production level (Soeratno et al 2016). Similar problems have been noted across many fisheries supply chains in Indonesia, including limited cold storage, traditional processing facilities, and weak coordination among actors (Wibowo et al 2019; Lailah et al 2023).

To address and improve these conditions, measuring supply chain performance is essential in identifying weaknesses and potential improvements in efficiency at each stage of the chain. One of the most widely used approaches is the Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council. The SCOR approach has been extensively applied in fisheries and seafood processing industries to assess distribution effectiveness, supply stability, and operational cost efficiency (Nguyen et al 2018; Parany et al 2024). The application of the SCOR model across various fisheries subsectors consistently demonstrates its ability to identify critical performance bottlenecks and support the formulation of targeted improvement strategies. In the seaweed industry, a SCOR-based performance measurement system was developed and integrated with Multi-Criteria Decision Making methods, enabling more objective prioritization of key performance attributes such as reliability, responsiveness, agility, cost, and asset management (Buchari & Tontowi 2024). Similarly, Syahputra et al (2023) showed that the core principles of SCOR are reflected in supply chain integration practices among fisheries Small and Medium Enterprises in Aceh, particularly in improving supply reliability, response speed to market demands, and cost efficiency through stronger coordination among supply chain actors. Meanwhile, the SCOR framework was applied to the red snapper processing industry. They found that supply chain performance varied widely from poor to excellent, with significant challenges related to raw material accuracy, post-harvest handling, and slow cash-to-cash cycles tied to asset management attributes (Manggala et al 2024). Collectively, these studies demonstrate that SCOR is a robust and adaptable framework for analyzing, evaluating, and enhancing supply chain performance across diverse fisheries industries, including capture fisheries, processing, and aquaculture.

However, previous studies have not applied the SCOR model to small-scale marine product supply chains in Indonesia, including the salted needlescale queenfish chain in Sibolga. This gap leaves a limited understanding of performance issues specific to this commodity and the particular challenges faced by its actors. Based on these conditions, this study assumes that the salted needlescale queenfish supply chain in Sibolga operates efficiently at the production stage but still experiences weaknesses in coordination and information flow among actors, which may hinder overall performance and value distribution. Therefore, the objectives of this study are to: 1) Analyze the current condition and structure of the salted needlescale queenfish supply chain in Sibolga City, including product, information, and financial flows. 2) Evaluate the supply chain performance of salted needlefish queenfish in Sibolga City.

Material and method. This research employed a mixed-methods design, integrating qualitative and quantitative approaches to provide a comprehensive understanding of the supply chain's structure, performance, and dynamics. The supply chain in this study was analyzed by describing the system components consisting of product flow, information flow, and financial flow among actors involved in the salted needlescale queenfish processing activities in Sibolga City.

Tools and materials. The study was conducted in Sibolga City, North Sumatra Province, which is recognized as one of the leading centers of salted fish production on the west coast of Sumatra Figure 1. The research was conducted over three months, from July 2025 to September 2025. A system-based approach was used to thoroughly understand the interactions among components of the supply chain, from the upstream sector (fishers) to the downstream sector (traders and consumers). Data were collected from 20 fishers, 10 fish queen salted processors, and 20 distributors/traders, all selected using a purposive sampling technique based on their relevance, experience, and active involvement in the salted needlescale queenfish supply chain.

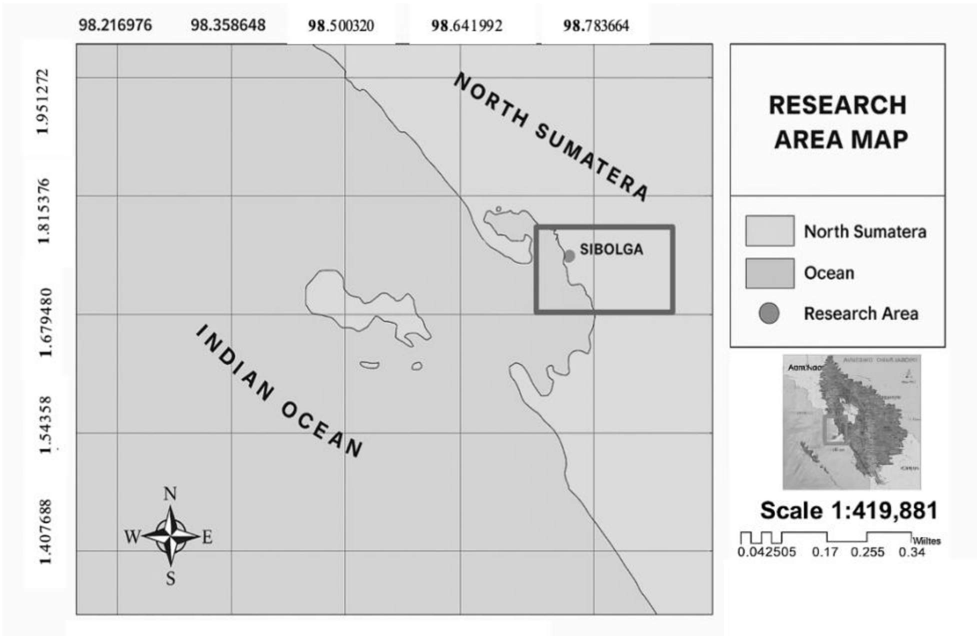

Figure 1. Research Location.

Fishery data. The catch data for needlescale queenfish used in this study were obtained from the official logbooks of the Sibolga Fish Auction and the Sibolga Ocean Fishing Port (PPN Sibolga), as well as supporting data from the Department of Marine Affairs and Fisheries of Sibolga City. These datasets cover recorded catch data for 2020-2024, which is essential for understanding the production dynamics and distribution patterns of needlescale queenfish in the study area.

The collected information includes the total catch volume (in kilograms or tons), types of fishing gear used, number of fishing trips (effort), and the economic value of production. These data were used to illustrate the availability of raw materials for salted fish processors and to analyze the relationship between fluctuations in fish catches and the sustainability of the salted needlescale queenfish supply chain in Sibolga City.

A triangulation method was employed by combining quantitative SCOR-based performance measurements with qualitative findings from interviews; the two datasets were cross-validated to ensure consistency between numerical indicators and stakeholder narratives. Quantitative data were analyzed using descriptive statistics and trend analysis, while qualitative data were coded thematically to identify recurring patterns, operational issues, and contextual explanations that support the interpretation of the quantitative results.

The analysis of catch. Fish abundance was analyzed using the Catch Per Unit Effort (CPUE) approach. According to Gulland (1982), CPUE is a method used to determine the average production rate of marine fisheries over a monthly or annual period. The level of fishery production in a given area may increase or decrease over time, and this variation can be observed through changes in CPUE values.

The CPUE value serves as an indicator of the level of fish resource utilization and is calculated using the following equation:

$$CPUEi = \frac{Catch_i}{Effort_i} = 1,2,3 \ldots n$$

Where:
$CPUE_i$: catch per unit effort
$Catch_i$: catches
Effort: fishing effort
I: index or indicator of the data unit number
1, 2, 3...n: total number of data units (such as the number of trips or samples)

Needlescale queenfish are caught using various types of fishing gear, each with different efficiency levels. Therefore, in calculating CPUE, it is necessary to standardize the fishing gear to equalize the effectiveness among gear types.

In this regard, the present study also includes calculating the fishing power index (FPI) to analyze the effectiveness of different fishing gears in supporting capture operations. According to Sparre & Venema (1998), the FPI value can be calculated using the following formula:

$$FPI = \frac{CPUE_{fishing\ gear}}{CPUE_{standard}}$$

Where:
FPI: Catchability index that compares the effectiveness of certain fishing gear
$CPUE_{fishing\ gear}$: CPUE of observed fishing gear
$CPUE_{standard}$: CPUE of fishing gear used as reference (standard)

According to Gulland (1982), the CPUE method is used to estimate the average annual production of marine fisheries. Changes in CPUE values can identify variations in fishery production within a specific area. The CPUE for needlescale queenfish is calculated as the total catch of needlescale queenfish (catch) divided by the total fishing effort.

Before calculating CPUE, fishing gear standardization is necessary, as the production data for needlescale queenfish in Sibolga involve several types of fishing gear, including purse seine, gillnet, stern trawl, and lift net. Standardizing the fishing gear makes it possible to determine a comparable standard trip value, ensuring that the actual CPUE value accurately represents fishing productivity.

An increasing CPUE trend over the years indicates that fishery resources in the area remain relatively healthy and that fishing activities are still economically viable. Conversely, a declining CPUE trend may suggest the onset of overfishing (Nurani et al 2021).

The analysis of the salted needlefin queenfish supply chain. The data related to the supply chain flows, namely the product, financial, and information flow, of the salted needlescale queenfish industry in Sibolga City, were analyzed using a descriptive method. This approach involved conducting in-depth interviews with respondents and performing field observations. The results were then illustrated in a supply chain schematic diagram, which depicts the stages from raw material supply and processing to distribution and final marketing to consumers.

The respondents in this supply chain analysis included respondents such as fishers, salted needlescale queenfish processors, and retailers, as well as relevant stakeholders from the Department of Fisheries and Food Security of Sibolga City and the Sibolga Ocean Fishing Port (PPN Sibolga).

The analysis of the performance of the supply chain. The SCOR model was applied to manage and analyze data effectively, enabling the organization of information and the formulation of performance targets required for this study. Both primary and secondary data collected were converted into quantitative numerical form to facilitate further analysis. The metrics used in the SCOR method are presented as follows. The SCOR model was applied to manage and analyze data effectively, enabling the organization of information and the formulation of performance targets required for this study. Both primary and secondary data collected were converted into quantitative numerical form to facilitate further analysis. The metrics used in the SCOR method are presented as follows.

Table 1

Benchmarking performance of the salted needlescale queenfish supply chain

Level 1 process	*Performance attribute*	*SCOR metric*	*Implementation in the study*
Plan	Supply chain reliability	Perfect order fulfillment	The conformity of product quantity and quality of salted fish with market demand.
Source	Supply chain responsiveness	*Order fulfilment lead time*	The speed of processing and delivering products to the market.
Make	Supply chain agility	Flexibility	The ability to adjust production during unfavorable weather or raw material shortages.
Deliver	Supply chain cost	Cost of good sold	The efficiency of drying, salting, packaging, and transportation costs.
Return	Supply chain asset management	Cash to cash cycle time	The utilization of drying equipment, drying racks, and inventory turnover speed.

Source: Adapted from (Arin et al 2013; Chotimah et al 2018), with modifications based on the current study.

The formula used in the performance calculation is as follows (modifying the calculation formula from Arin et al 2013):

$$Weight: \frac{Significant\ Value}{Total\ significance\ value}$$

Where:
Significance value: Range 1-3 (1 = significant, 3 = very significant)

$$Score: Weight\ x\ rating\ x\ 100$$

Where:
Rating: Range 1-4 (1 = weak, 4 = strong).
Assessment: meeting expectations = high

This model assesses supply chain performance through five key processes: Plan, Source, Make, Deliver, and Return. Performance indicators include reliability, responsiveness, agility, cost, and asset management (Stewart, 1997).

Table 2

SCOR-Based performance evaluation criteria

Monitoring system	*Monitoring indicator*
> 90	Excellent
72-90	*Good*
51-71	*Average*
40-50	*Marginal*
< 40	*Poor*

Source: Chotimah et al (2018).

Results and Discussion

The needlescale queenfish catch. Over the past five years, the production and CPUE values for talang fish landed in Sibolga City have exhibited significant fluctuations. In 2020, production started at 7,720 kg with a CPUE of 123 kg per trip. This increased in 2021 to 17,604 kg, with a CPUE of 144 kg per trip. However, in 2022, production saw a substantial decline to just 2,785 kg, even though the CPUE rose dramatically to 406 kg per trip. In 2023, production rebounded to 16,483 kg with a CPUE of 167 kg per trip. There was a slight decrease in production in 2024, dropping to 13,813 kg; however, fishing efficiency improved with a CPUE of 209 kg per trip. The production and CPUE results for fresh talang fish are illustrated in Figure 2.

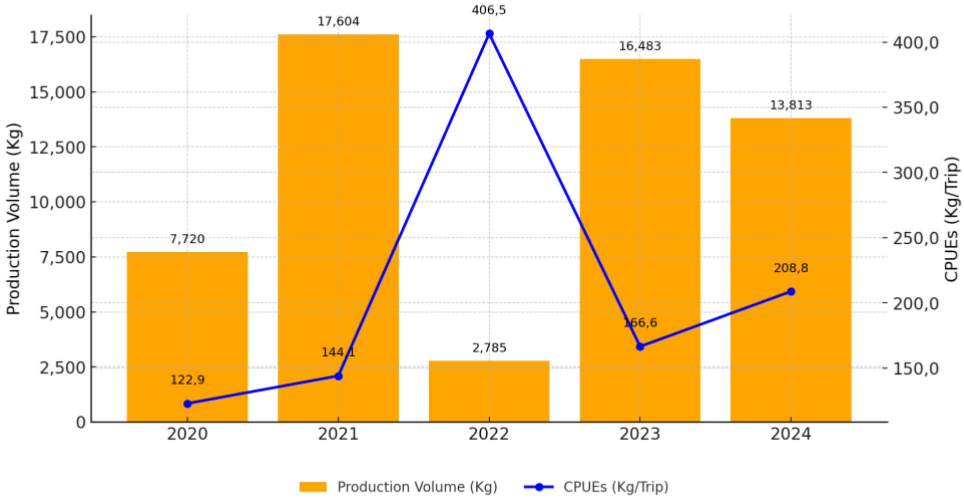

Figure 2. Catch per unit effort and catch of needlescale queenfish from 2020 to 2024.

The observed fluctuations in fish resources reflect the dynamics influenced by environmental factors and fishing intensity. This finding aligns with a study conducted in Karangantu, where CPUE values in crab fisheries also displayed considerable variability (Krisnafi et al 2019). It is important to note that CPUE is not always directly proportional to fish abundance; it can be affected by technological advancements, fisher behavior, spatial distribution of fish, and the environmental conditions of the fishing grounds (Harley et al 2001). Consequently, many fisheries studies apply CPUE standardization to enable more accurate interpretations as indicators of relative abundance (Hoyle et al 2024).

Similar observations regarding fluctuating CPUE due to seasonal changes and fish aggregation patterns have also been reported for small pelagic and neritic tuna fisheries in Indonesian waters (Wujdi & Suwarso 2016; Budiasih & Dewi 2015). The fluctuation pattern of needlescale queenfish CPUE in Sibolga corresponds with the characteristics of tropical pelagic fisheries in Indonesia, where monsoon systems, ocean currents, and food availability significantly influence interannual seasonal variations. These factors contribute to fish aggregating in specific areas (spatial aggregation), which impacts the accessibility of fish to fishing gear and alters catchability. For instance, a study by Wujdi & Suwarso (2016) in the South China Sea revealed that tuna catch composition varied seasonally, with Euthynnus affinis being the dominant species during the east and second transitional monsoon seasons. As a result, fishing units operating at the right time and in the right area achieved higher CPUE values. Similarly, in Palabuhanratu, skipjack (*Katsuwonus pelamis*) and tongkol (*Euthynnus affinis*) exhibited distinct seasonal dynamics. At the same time, the long-term decline in CPUE in this region has been interpreted as an indication of increasing fishing pressure and resource exploitation (Nurani et al 2021).

The phenomenon observed in Sibolga in 2022, where total production sharply declined while CPUE increased dramatically, can be characterized as a low-production, high-CPUE anomaly. This condition was likely caused by reduced fishing effort (e.g., fewer vessels or fishing trips) or increased fish aggregation in specific areas, resulting in a higher catch per trip despite the overall lower total production. Other studies have indicated that CPUE can remain high even when fish stocks are declining due to hyperstability, where fish form dense schools and fishers concentrate their efforts in areas with high fish density (Ward et al 2013). This condition is also identified as a potential bias in modern CPUE assessment guidelines (Hoyle et al 2024).

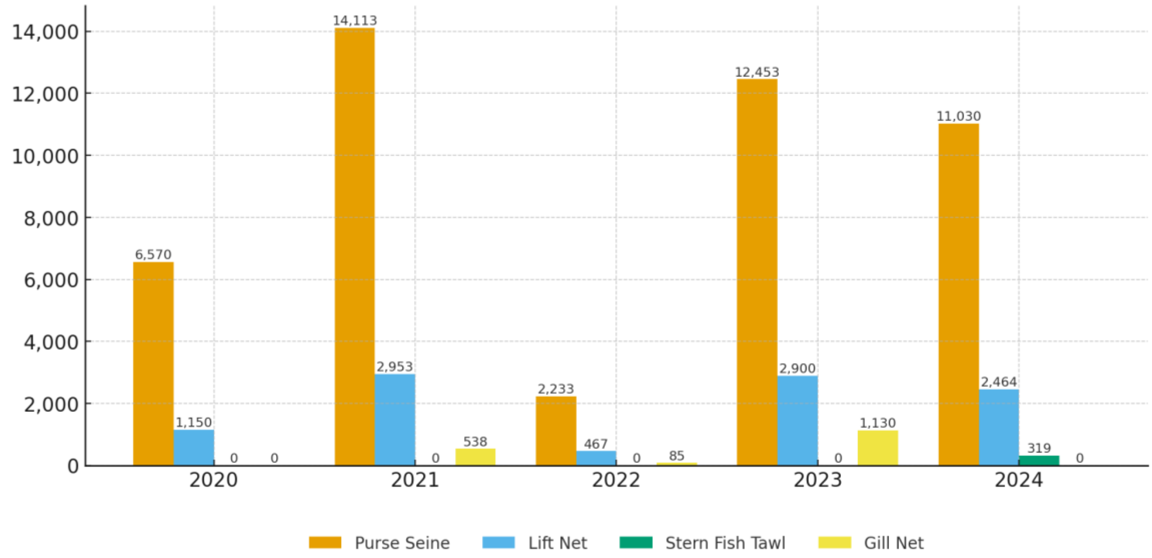

Figure 3. Production volume of needlescale queenfish in (Kg) by fishing gear type.

The production volume of needlescale queenfish in Sibolga City by fishing gear type is presented in Figure 3. The results show that purse seine gear has dominated the catch over the past five years, with the highest production recorded in 2021 at 14,113 kg. The lift net was the second-largest contributor, showing moderate fluctuations, while the gillnet and stern trawl contributed relatively smaller portions. The dominance of purse seine gear indicates its high efficiency in capturing pelagic species such as needlescale queenfish, which migrate in open waters. The findings of this study, which indicate that purse seine gear predominantly captures pelagic fish species, are consistent with previous research that found that purse seine fisheries in Indonesian waters, particularly in the western and central regions of Java, mainly target pelagic schooling species, including skipjack tuna, scads (*Decapterus spp*.), and mackerels (*Scomberomorus spp*.). This pattern reflects the ecological behavior of pelagic fish, which tend to form dense aggregations in the upper water column, making them highly susceptible to purse seine operations (Wujdi & Suwarso 2016; Yusfiandayani et al 2022). The decline in catch observed across all gear types in 2022 was likely due to environmental changes and reduced fishing effort, whereas the subsequent increase in 2023-2024 suggests stock recovery or more favorable fishing seasons (Nurani et al 2021). The variation among gear types also reflects differences in selectivity and operational areas: purse seines are more effective when fish form surface aggregations. At the same time, lift nets rely heavily on lighting and nighttime water conditions (Budiasih & Dewi 2015).

Supply chain flow of salted needlefish queenfish in Sibolga City. The supply chain flow represents a logistics network that connects suppliers, manufacturers, distributors, retailers, and end consumers across all stages of product distribution. In the supply chain system of salted needlescale queenfish in Sibolga City, the stakeholders involved include fishers as raw material suppliers, processors of salted needlescale queenfish as producers, collectors or wholesalers as distributors, retailers as intermediaries in product sales, and local as well as regional consumers as the final recipients of the product. This structure reflects the functional interconnection among actors in maintaining the sustainability and efficiency of product distribution throughout the supply chain.

Supply Chain I involves fishers, salted needlescale queenfish processors, and end consumers. In this flow, the processors play a dual role as producers and retailers (downstream integrators). After obtaining raw materials from fishers, the processors carry out salting and drying processes, then sell the finished salted fish products directly to consumers. Sales are conducted offline, through the processors’ shops, and online, via social media platforms and digital marketplaces. This model represents a shorter, more efficient supply chain, as processors interact directly with buyers without intermediaries.

Supply Chain II involves fishers, processors, retailers, and end consumers. In this model, processors sell salted fish to retailers, who then market the products to consumers through direct sales in traditional markets or online platforms. Retailers typically purchase salted fish in bulk from processors and resell them in smaller quantities to end customers. Both supply chain models indicate that salted needlefish from Sibolga City are marketed not only to local consumers but also to other regions, including Medan, Pekanbaru, and Batam, and even outside Sumatra Island to Jakarta, Yogyakarta, Bandung, and Surabaya through online sales and e-commerce marketplaces.

The structure and mechanism of the salted needlescale queenfish supply chain in Sibolga City show a pattern similar to the glass eel supply chain I in Central Sulawesi, where multiple actors collaborate to sustain production and marketing continuity. However, in supply chain II, a slight difference is observed, as the number of actors involved is greater, resulting in a longer distribution channel and more complex marketing interactions (Mahi et al 2018).

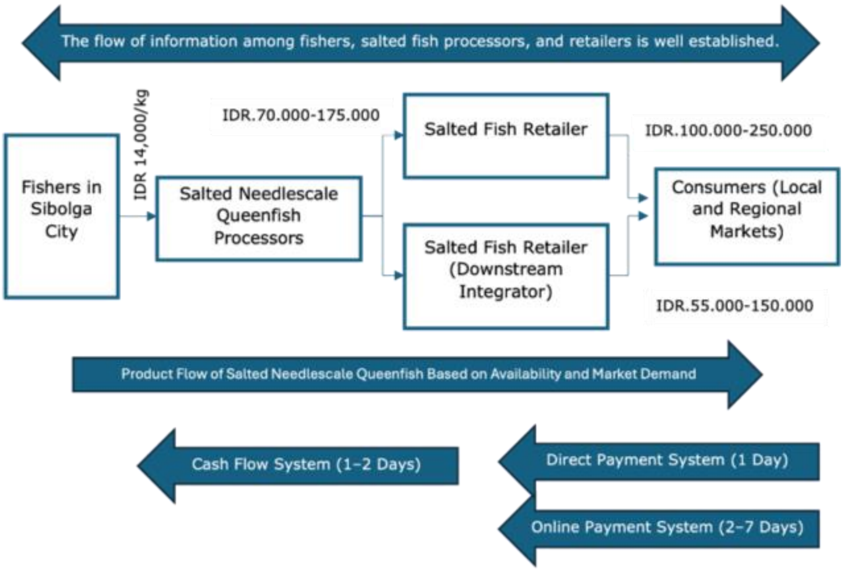

Figure 4. Flow patterns of products, money, and information in the salted needlescale queenfish supply chain in Sibolga City.

Supply chain management of salted needlescale queenfish in Sibolga City

Product flow. The product flow in the salted needlescale queenfish supply chain in Sibolga City illustrates the movement of commodities from fishers, as raw material suppliers, to salted fish processors as the primary producers, and finally to retailers and end consumers. The first pattern represents a direct relationship between processors and consumers, while the second involves retailers as intermediaries in the distribution process.

Processed salted queenfish products are marketed directly to consumers through processors' shops, retail stores, and online sales platforms such as social media and digital marketplaces. This distribution model is similar to the fishery supply chain system at PPS Cilacap, which relies on direct consumer channels and digital platforms to expand market reach (Ghaffar et al 2023).

To maintain product quality, raw materials for salted fish processing are sourced directly from fishers. Processors prefer fresh and unfrozen fish, as the freshness of raw materials significantly affects the selling price of the final product. Salted needlescale queenfish are known for their thick flesh and long shelf life. The short delivery time from fishers to processors is, therefore, crucial to maintaining product quality.

According to Manggala et al (2024), the efficiency of product flow is influenced by the smoothness of raw material supply, transportation conditions, and the ability of business actors to utilize information technology in logistics.The digitalization of maritime supply chains can shorten distribution channels, increase product value-added, and expand market access (Wahju et al 2022; Nasution et al 2023).

Financial flow. The financial flow in the salted needlescale queenfish supply chain in Sibolga operates through cash payments, bank transfers, and digital transactions. Transactions between fishers and processors are typically carried out in cash, one to two days after the fish are delivered. In contrast, transactions between processors and retailers use cash or direct bank transfers.

For online transactions, consumers make payments via marketplaces or e-wallets, with processors receiving the funds within 2-7 days, depending on the delivery system and customer confirmation. The movement of prices along the salted needlescale queenfish supply chain in Sibolga showed apparent differences in the value each actor captured. At the upstream level, fishers sold fresh queenfish for only IDR 14,000 per kilogram, a price that reflected both their weak bargaining position and their reliance on daily catch availability. Once the fish were salted and dried, processors sold the finished product to retailers at much higher prices between IDR 70,000 and 175,000 per kilogram, depending on the product's quality and dryness, as well as market conditions. Besides supplying retailers, many processors also sold directly to consumers through their own shops or market stalls, where prices ranged from IDR 55,000 to 150,000 per kilogram, allowing them to secure a larger portion of the added value. At the final stage, retailers offered the product to consumers at IDR 100,000 to 250,000 per kilogram, reflecting the highest price point in the chain. These differences indicate that processors who sold directly to customers and downstream retailers benefited the most from price increases, while fishers received the smallest share of the overall value.

The sales system also affects prices in addition to quality and size. Online sales are generally more expensive due to marketplace administration and 10-14% tax fees. This system indicates that some supply chain actors have adapted to the digital financial ecosystem, which aligns with contemporary developments in supply chain management. According to Nurhayati et al (2023), integrating electronic financial systems is a key driver of efficiency in modern fishery value chains. Meanwhile, fisher empowerment models based on supply chain management and maritime vocational education emphasize the importance of financial literacy and digital adaptation among small-scale fishery enterprises (Pomeroy et al 2020; Purwiyanto et al 2025).

Information flow. The information flow in the salted needlescale queenfish supply chain in Sibolga City is two-way, moving upstream to downstream and vice versa. Information exchanged among supply chain actors includes product prices, raw material quality, stock availability, and purchase and sales volumes (Lowing 2020).

The upstream-to-downstream flow occurs when fishers or collectors provide information to processors regarding catch volumes, availability of fresh fish, and selling prices at the fisher level. Conversely, the downstream-to-upstream flow occurs when processors or retailers give feedback about product quality, specific size preferences, and consumer demand changes in local and external markets.

The price of fresh needlescale queenfish fluctuates depending on availability and season, and the price of processed salted fish also varies across markets. The lack of uniform information among sellers contributes to price variability among different retail outlets. Information exchange ensures coordination among fishers, processors, retailers, and consumers. Information about raw material prices, supply volume, production schedules, and market demand trends is shared through direct communication and digital media, such as mobile phones, WhatsApp, and Facebook. The two-way communication between fishers and processors accelerates raw material purchasing decisions, while the information exchange between processors and retailers allows production adjustments based on market needs. The success of fishery supply chains depends on information transparency and commitment among actors (Prodhan et al 2023).

This finding aligns with Yapanto (2025), who emphasized that digital transformation in fishery marketing systems is essential for improving efficiency and market information accuracy. Moreover, data integration through digitalization fosters adaptive, transparent, and efficient supply chains (Wahju et al 2022). Indonesia’s fisheries development still faces challenges related to data and information availability, which limit effective planning and resource management (Tangke 2011). Establishing a digital-based information system could minimize data inconsistencies and enhance coordination among supply chain actors (Firdaus et al 2023).

The small-scale salted-fish value chain in Sibolga follows a typical Southeast Asian pattern, in which upstream fishers have the lowest bargaining power and capture the smallest share of value, while processors and traders at the mid- to downstream levels retain relatively higher margins. Regional analyses indicate that in countries such as Myanmar and Cambodia, dried and salted fish chains rely on long intermediary networks, in which collectors and wholesalers rather than fishers appropriate most of the economic gains due to their control over grading, aggregation, and market access (WorldFish 2019; Belton et al 2022). By contrast, Thailand's small-scale processed sea-fish sector exhibits more advanced upgrading: community enterprises function as semi-formal processors with improved drying technologies, packaging, and direct market linkages, enabling them not the fishers to capture the largest share of value added within the chain (Trakulsunti et al 2025). Compared with Thailand, Sibolga's supply chain remains technologically basic and highly dependent on fluctuating CPUE at the fishing stage, reinforcing a profit distribution pattern in which fishers remain price-takers, processors obtain moderate value through simple drying and salting, and downstream traders capture the most significant economic benefit. Overall, Sibolga's structure reflects the broader vulnerabilities of small-fisheries chains in Asia, whereas the Thai case demonstrates how upgrading at the processing stage can shift value capture toward midstream actors and improve overall chain performance.

Supply chain performance. Evaluating supply chain performance is essential to determining the effectiveness of product distribution, setting objectives, assessing performance outcomes, and establishing actions for future improvement programs (Chotimah 2018). The success level of supply chain performance can be assessed through measurable aspects such as reliability, responsiveness, flexibility, and cost efficiency within the supply chain process. The SCOR model adopts five key performance attributes reliability, responsiveness, agility, cost, and asset management effectiveness, which are conceptually grouped into two dimensions: effectiveness (the ability of the supply chain to fulfill orders accurately, on time, and flexibly) and efficiency (cost control and optimal asset utilization) (Haider & Mohailan 2020; Özkanlısoy et al 2023).

In this study, the average SCOR scores analyzed for each actor in the salted needlescale queenfish supply chain in Sibolga City are presented in Table 3. SCOR matrix factors were assessed for all primary stakeholders, including fishers, salted fish processors, and retailers. Each factor in the SCOR matrix covering the dimensions of reliability, responsiveness, flexibility, cost, and asset efficiency was evaluated using a weighted scoring system, where ratings and scores were assigned according to the role and contribution of each actor within the supply chain.

Table 3

SCOR-Based supply chain performance evaluation for salted needlescale queenfish in Sibolga City

SCOR factor	*Weight*	*Rating*	*Score*	*Performance indicator*
Plan (reliability)	0.22	4.3	95.2	Excellent
Source (responsiveness)	0.17	3.9	67.0	Average
Make (agility)	0.22	3.9	87.2	Good
Deliver (cost)	0.21	3.8	80.1	Good
Return (asset management)	0.17	3.5	60.4	Average

Source: Field data.

The SCOR assessment showed that the salted needlescale queenfish supply chain in Sibolga achieved an overall score of 75, placing it in the "Good" category and indicating generally effective coordination among fishers, processors, and retailers. The Plan (Reliability) score was the highest at 95.8, indicating efficient order fulfillment supported by long-standing trading ties, although seasonal fluctuations in catch still caused irregular raw material supply. The Source (Responsiveness) score of 67 indicated that procurement operated at a moderate level but remained constrained by traditional logistics and a lack of cold-chain support constraints commonly faced by small-scale fisheries exposed to weather disruptions (Bassett et al 2022). The Make (Agility) score of 87 demonstrated that processors were able to adjust drying times and production volumes in line with market needs (Özkanlısoy et al 2023). The Deliver (Cost) score of 80 reflected efficient distribution, aided by a short marketing chain and direct sales, a pattern also observed in small-scale seafood enterprises in Thailand (Trakulsunti et al 2025). The lowest score appeared in the Return (Asset Management) dimension (60.4), indicating slow inventory turnover, weather-dependent drying practices, and minimal investment in storage and handling facilities.

The high reliability score was consistent with findings in other Indonesian fisheries, where long-standing social networks helped maintain order fulfillment even under seasonal fluctuations (Wibowo et al 2019). The moderate responsiveness score aligned with observations by Bassett et al (2022), who reported that small-scale fisheries in Indonesia and the Philippines often experienced procurement delays due to weather and limited logistics support. Sibolga's strong agility also reflected patterns noted by Wulandari (2023), who found that processors in aquaculture supply chains could adjust production quickly when raw material availability changed.

The cost performance mirrored the efficiency commonly observed in short, community-based seafood chains, similar to that of small-scale processing enterprises in Thailand (Trakulsunti et al 2025). In contrast, the low asset-management score followed regional trends in dried-fish systems, where weak storage facilities, limited technology, and minimal feedback among actors have long restricted the use of assets (Belton et al 2022; WorldFish 2019). Similar issues were recorded in Indonesia's cold-chain logistics, where inconsistent storage capacity reduced overall system performance (Nattassha et al 2019).

Addressing these weaknesses requires coordinated interventions. Policy support through microfinance, improved post-harvest facilities, and the adoption of weather-independent drying technology remains essential, in line with FAO guidance for improving small-scale fisheries (FAO 2015). These needs were also highlighted by Pratiwi et al (2022), who stressed the importance of better market infrastructure and stronger local governance for small-scale fisheries. Enhancing cooperatives, strengthening information flow, and improving coastal market facilities would benefit processors and traders. At the same time, fishers could contribute by planning harvests more systematically, improving onboard handling, and engaging in cooperative marketing to improve responsiveness and value distribution along the chain.

Conclusions. The CPUE values from 2020 to 2024 showed apparent annual variation influenced by seasonal conditions and changes in fishing effort. The unusually high CPUE in 2022, despite low total catch, pointed to reduced effort rather than an actual increase in stock abundance. The SCOR assessment indicated that the salted needlescale queenfish supply chain in Sibolga performed reasonably well, with an overall score of 75 supported by very high reliability and strong agility, although asset management remained the weakest part of the system. Taken together, these results showed that the supply chain functioned effectively but remained vulnerable to environmental changes and post-harvest constraints. Improvements were most needed in inventory control, drying and storage capacity, and the coordination of financial and information flows between actors. Better post-harvest equipment, easier access to small-scale financing, and improved market facilities would benefit processors and retailers, while fishers could help stabilize supply by coordinating harvesting and improving handling practices at sea. Future studies should integrate environmental indicators to better understand how CPUE patterns relate to stock conditions and supply chain stability, and should explore the use of digital traceability and real-time information systems to strengthen coordination and improve the precision of SCOR-based evaluations.

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