Comparative study of vessel and large pelagic purse seine dimensions at Pekalongan Fishing Port, Indonesia

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Abstract. This study comparatively examined the dimensions of large pelagic purse seine vessels and fishing gear operating at Pekalongan Fishing Port (PPN Pekalongan), Indonesia, to identify existing patterns and potential compatibility. Data on vessel dimensions (length overall, beam, depth, gross tonnage) and fishing gear specifications (net length, net depth, mesh size, net material) were collected from eight purse seine vessels through direct measurements and interviews with crew members. The average vessel length was 28.78 m (±0.80 m), with a length-to-breadth ratio of 3.47 and a breadth-to-depth ratio of 2.35, supporting vessel stability and operational efficiency. Purse seine nets averaged 1030.63 m in head rope length and 1185.50 m in ground rope length, with a tapered design increasing in depth from wings (80.28 m) to bunt (122.45 m). Analysis of net geometry revealed lower primary hanging ratios than secondary hanging ratios for each net section, allowing the net to billow outwards during setting. The ratio of net length to vessel length averaged 36.02, while net depth to net length ratio was consistently around 0.12. These findings indicate a strong compatibility between vessel dimensions and fishing gear characteristics at PPN Pekalongan, supporting safe and efficient fishing operations for large pelagic species like tuna and mackerel.

Key Words: hanging ratios, net geometry, purse seine shape, ratio dimension.

Introduction. The fisheries industry is a vital sector that contributes significantly to the national economy (Kusdiantoro et al 2019), food supply (Yanfika et al 2019), and employment (Sari et al 2021), especially in maritime countries such as Indonesia. Among the various types of fisheries, large pelagic fish capture plays an important role due to its economic value and abundant resource potential. Large pelagic fish, such as tuna, skipjack, and mackerel, are high-value export commodities that support the nation's foreign exchange earnings (Amiluddin et al 2020; Ayuningtias et al 2021; Liawatimena et al 2022).

Purse seine has been widely acknowledged as one of the most effective and efficient techniques for capturing large pelagic fish. Purse seine is a fishing gear that involves using a large net to encircle a school of fish. The bottom of the net is then drawn together like a drawstring purse, preventing the fish from escaping downwards (Pravin & Meenakumari 2016; Lee et al 2018; Cho & Lee 2025). The operational efficacy of purse seine fishing is contingent on several factors, including the congruence between the dimensions of the fishing vessel and the specifications of the purse seine gear. Ensuring minimum stability is crucial for safe and efficient fishing operations (Schuler Frantzen et al 2025), while utilizing fishing gear that aligns with the vessel's capabilities is essential for ensuring the efficient operation of the fishing process.

PPN Pekalongan is one of the largest fishing ports on the northern coast of Java Island. PPN Pekalongan plays a crucial role in the local economy through its fish auction activities and other port operations (Rahman et al 2025). PPN Pekalongan serves as the center of activity for various types of fishing vessels, including large pelagic purse seine

boats targeting catches such as *Euthynnus affinis* and *Thunnus albacares* (Saleh & Soegianto 2017). The presence of active purse seine vessel at PPN Pekalongan highlights its significance as an important hub in the national fisheries supply chain (Fitriani et al 2020). However, the diversity of fleets and fishing gear operating at a port often raises questions about the level of compatibility between the two.

A comparative study of the dimensions of vessels and purse seine fishing gear at PPN Pekalongan is crucial for understanding the extent to which alignment has been achieved. Differences in vessel dimensions, including length, width, depth, and tonnage, can affect the vessel's ability to carry and operate the fishing gear. The length of the vessel influences its stability and maneuverability (Kesaulya et al 2019), whereas wider vessels tend to have better transverse stability, which is essential during the hauling phase of purse seine operations (Shan et al 2011). Similarly, it is essential to consider the specifications of fishing gear, including net size, net depth, and mesh size, to ensure alignment with the vessel's capacity and capabilities. A discrepancy between these elements may result in various operational challenges, although the impact on catch outcomes was not the primary focus of this study. Therefore, this study aims to comparatively examine the dimensions of large pelagic purse seine vessels and their fishing gear operating at PPN Pekalongan to identify existing patterns and the potential for compatibility.

Material and Method

Description of the study site. This research was conducted at PPN Pekalongan, located in the city of Pekalongan, Central Java Province (Figure 1). The research was conducted from July to November 2025. This time frame was selected to cover the operational cycle of large pelagic purse seine vessels operating in the PPN Pekalongan area so that the data obtained could represent commonly occurring conditions.

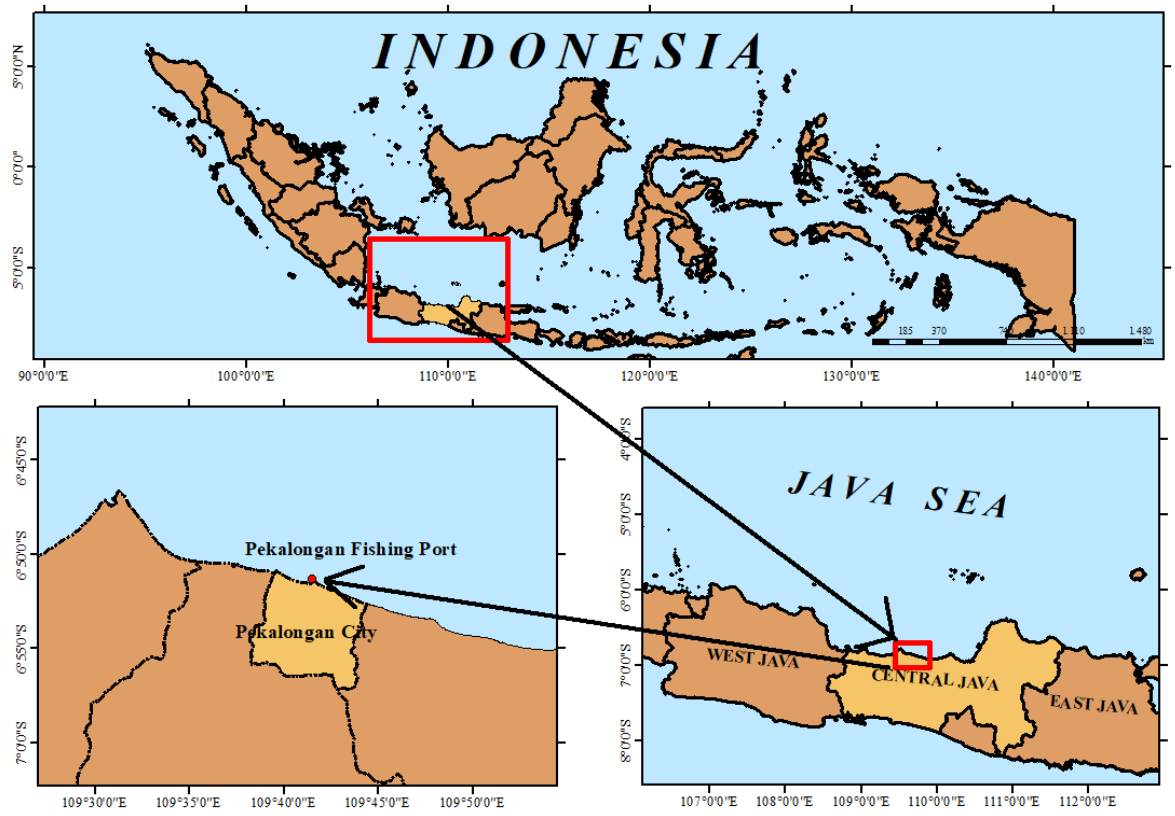

Figure 1. Location map of Pekalongan Fishing Port, Central Java, Indonesia.

Data collection methods. The sampling method used was the census method, covering a total of eight large pelagic purse seine vessels at PPN Pekalongan. The variables in this study focused on comparing vessel dimensions and fishing gear. The identified variables included the dimensions of large pelagic purse seine vessels (length overall/LOA, beam/B, depth/D, and gross tonnage/GT) and fishing gear (net length, net depth, mesh size, and type of net material). The measurement of vessel dimensions was carried out directly on large pelagic purse seine vessels. The specifications of purse seine fishing gear were recorded through direct observation of the available gear while the vessel was docked at the port, as well as through in-depth interviews with crew members responsible for the gear.

Data analysis methods. The dimensions of the vessels and specifications of the fishing gear were analyzed descriptively to illustrate the general characteristics of each variable. The techniques used included calculating the average and standard deviation and presenting the data in the form of tables, graphs, and narratives. This will provide a clear quantitative overview of the variations in vessel dimensions and fishing gear specifications at PPN Pekalongan.

Analysis of the characteristics of purse seine fishing gear was carried out to understand the geometry and proportions of the purse seine fishing gear. The hanging ratio value is calculated using the following equation (Prado & Dremiere 1990):

$$E_1 = L_1 / L_o$$
$$E_2 = H_1 / H_o$$

where: E_1 = primary hanging ratio (horizontal); E_2 = secondary hanging ratio (vertical); L_o = fully stretched net length (meters); L_1 = installed net length (meters); H_o = fully stretched net height (meters); H_1 = installed net height (meters)

The characteristics of purse seine shapes consist of two types: the horizontal ratio (a/l; b/l; c/l; l/m) and the vertical ratio (e/g; f/g). The analysis of the characteristic shape of purse seines follows the characteristic scheme of purse seine (Figure 2).

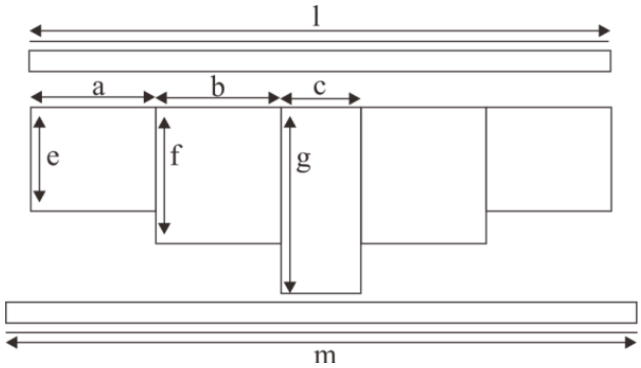

Figure 2. Scheme of purse seine design (Source: Gautama et al 2005).

After analyzing the vessel dimensions and gear characteristics separately, the next analysis is to link the two. This will involve an effort to determine whether certain vessel dimensions tend to be paired with fishing gear that has specific shapes and construction characteristics. This analysis shows the ratio between vessel and gear dimensions based on the reference from Prado & Dremiere (1990).

Results and Discussion

General characteristics of large pelagic purse seine. This study identified and measured the dimensions of several large pelagic purse seine vessels operating at PPN Pekalongan. The collected data showed considerable variation in the sizes of vessels used by the large pelagic fishing vessels in this area (Table 1). Large pelagic purse seine fishing vessels at PPN Pekalongan conduct fishing operations in Zone III and the open sea. The

operational range of large pelagic purse seines > 100 GT allows them to reach the waters of the exclusive economic zone off the coast (Wibowo et al 2016). The purse seine fishing gear used by the vessel at PPN Pekalongan also features a variety of technical specifications tailored to operational needs and targeted fish species.

Table 1

The size of large pelagic purse seine vessels at PPN Pekalongan

Parameter	*Min (m)*	*Max (m)*	*Average (m)*	*Standard deviation*
		Vessel dimension		
LOA	27.45	29.78	28.78	0.80
B	7.35	8.75	8.30	0.46
D	3.42	3.77	3.53	0.12
Tonnage (GT)	121	165	148	15
		Fishing gear dimension		
Length of wing (a)	411.76	541.18	485.00	42.38
Length of body (b)	411.76	541.18	485.00	42.38
Length of bunt (c)	51.47	67.65	60.63	5.30
Head rope (l)	875.00	1150.00	1030.63	90.06
Ground rope (m)	1050.00	1265.00	1185.50	81.30
Depth of the wing (e)	73.15	89.41	80.28	6.79
Depth of body (f)	89.41	113.79	103.66	8.42
Depth of bunt (g)	113.79	130.05	122.45	5.94

The average LOA is 28.78 meters (±0.80 m), with a very narrow range between 27.45 m to 29.78 m. This consistency implies that the vessels are designed for a specific operational niche, balancing maneuverability required for purse seining with the need for sufficient deck space and hold capacity. The average breadth of 8.30 m and depth of 3.53 m result in a length-to-breadth ratio (L/B) of approximately 3.47 and a breadth-to-depth ratio (B/D) of approximately 2.35. A moderate L/B ratio ensures directional stability, which is essential during net-setting operations, while a higher B/D ratio provides a larger deck area and greater initial stability, crucial for safe and efficient fishing operations (Farhum et al 2019; Kesaulya et al 2019; De La Torre Cortez 2025). The low standard deviation for depth (D) (0.12 m) is particularly noteworthy, indicating that this is a highly controlled parameter, likely for hull strength and volumetric capacity.

The ability of a purse seine to effectively capture fish is intrinsically linked to its dimensions, as these parameters govern the encirclement and containment of fish schools (Najamuddin et al 2021). The head rope (average 1030.63 m) and ground rope (average 1185.50 m) lengths demonstrate that these are large nets designed to encircle substantial fish schools. The design feature where the ground rope is consistently longer than the head rope in purse seine nets is intentional to create a bowl-like shape when the net is pursed. This shape is crucial to prevent fish from escaping by diving underneath. The design and operational dynamics, including the ratio of rope lengths and the sinking characteristics, are optimized to ensure the net maintains its shape and effectiveness during fishing operations (Kim & Park 2009; Hosseini et al 2011; Zhou et al 2015a; Liu et al 2020; Sasmita et al 2024).

The net is composed of three main parts: the wings, body, and bunt. The data shows that the wings and body are of identical length (average 485.00 m each), forming the main encircling wall. This design ensures that the net can encircle a large area to capture fish effectively (Sasmita et al 2024). The netting materials commonly used include nylon, which provide strength and durability. Nylon, in particular, is noted for its high strength and good sinking performance (Zhou et al 2015b; Tang et al 2018; Shan et al 2023). The bunt, or the final part where the catch is concentrated, is much shorter (average 60.63 m) but is constructed from much stronger and smaller-meshed webbing. The use of smaller mesh sizes in the bunt ensures that the catch is retained effectively (Zhou et al 2015c; Tang et al 2018; Sasmita et al 2024).

The net's depth increases progressively from the wing (80.28 m) to the body (103.66 m) and is deepest at the bunt (122.45 m). This tapered design is critical for herding the fish school effectively into the bunt during the final stages of the hauling process (Pravin & Meenakumari 2016; Cho & Lee 2025; Yuspardianto et al 2025). As the purse seine net is hauled, its volume decreases significantly. For instance, there is a 33-fold decrease in contained volume from 10 to 80% of the net being hauled (Tenningen et al 2019). The substantial depth of the bunt is essential for accommodating large, dense schools without risking net failure.

Characteristics of the purse seine shape. The characteristic features of purse seine fishing gear were analyzed by calculating the hanging ratio and various proportion ratios (Table 2). The data shows a consistent pattern across all eight vessels: for each net section (wing, body, bunt), the primary hanging ratio is consistently lower than the secondary hanging ratio. A lower primary hanging ratio allows the net to billow outwards, forming a larger initial enclosure to prevent fish from escaping outwards during the setting process (Kim & Park 2009). A key finding is the systematic decrease in both primary and secondary hanging ratios from the wing to the body to the bunt. It means the mesh opening is smallest in the bunt. High loads are often present in the bunt area during shooting and pursing, which can affect the net's performance and the distribution of fish (Zhou et al 2019).

The l/m ratio is consistently less than 1.0 (ranging from 0.83 to 0.91), confirming that the ground rope is longer than the head rope. The ratio between the head rope and ground rope is already appropriate, as the length of the ground rope is at least 10% longer than the length of the ground rope (Prado & Dremiere 1990). Hal ini sesuai dengan penelitian Sasmita (2024) in the North Coastal Java Sea, the hanging ratio for anchovy purse seines ranges between 0.926 and 0.991, resulting in a net shape that is almost trapezoidal rather than perfectly rectangular.

The ratios of wing depth/bunt depth (e/g) and body depth/bunt depth (f/g) are all less than 1.0, visually confirming the tapered design where the bunt is the deepest section. This is evident from the analysis of net geometry and sinking behavior, where the bunt experiences greater tension forces than the wing ends during pursing operations (Zhou et al 2015a).

Table 2

The characteristics of the purse seine shape

Vessel	*Primary hanging ratio*			*Secondary hanging ratio*			*Horizontal ratio*				*Vertical ratio*	
	Wing	*Body*	*Bunt*	*Wing*	*Body*	*Bunt*	*a/l*	*b/l*	*c/l*	*l/m*	*e/g*	*f/g*
PS 1	0.72	0.69	0.65	0.79	0.75	0.71	0.47	0.47	0.06	0.91	0.69	0.88
PS 2	0.61	0.59	0.57	0.68	0.66	0.64	0.47	0.47	0.06	0.89	0.67	0.84
PS 3	0.72	0.7	0.68	0.78	0.76	0.74	0.47	0.47	0.06	0.91	0.69	0.86
PS 4	0.62	0.59	0.56	0.73	0.7	0.67	0.47	0.47	0.06	0.83	0.64	0.76
PS 5	0.68	0.65	0.62	0.8	0.77	0.74	0.47	0.47	0.06	0.83	0.67	0.87
PS 6	0.69	0.66	0.63	0.79	0.76	0.73	0.47	0.47	0.06	0.87	0.65	0.84
PS 7	0.57	0.53	0.51	0.69	0.65	0.62	0.47	0.47	0.06	0.83	0.62	0.83
PS 8	0.69	0.66	0.63	0.78	0.75	0.72	0.47	0.47	0.06	0.87	0.62	0.83

Ratio between vessel and large pelagic purse seine dimensions. The ratio of purse seine length to vessel length (LOA) (Table 3) demonstrates the enormous operational scale of these vessels. The structural integrity and operational effectiveness of large pelagic purse seines are significantly influenced by their dimensional configurations, which dictate the net's sinking characteristics and overall fishing efficiency (Zhou et al 2014). The data shows a range from 31.88 to 39.33, with a mean value of approximately 36.02. This indicates that the purse seine nets are, on average, over 36 times longer than the vessels that deploy them. According to Prado & Dremiere (1990), the minimum value should be 15. In Panimbang, the purse seine nets are 1,000 meters in length and 50 meters in depth, while the vessels are 30 GT with engines of 120 HP (Irnawati et al 2021). This exceptionally

high ratio is a direct adaptation for capturing expansive, fast-moving pelagic schools. These nets are used to target species such as skipjack, mackerel tuna, and tuna, which are known for their speed and large school sizes (Tang et al 2017; Baihaqi et al 2021).

The second ratio, net depth / net length, exhibits remarkable consistency across the fleet, ranging narrowly from 0.11 to 0.13 (Table 3). This parameter, effectively the net's aspect ratio, averages 0.12. This indicates that the net's depth is consistently about one-twelfth of its total length. This consistency in the aspect ratio is crucial for the operational efficiency and stability of the purse seine nets, ensuring they maintain their shape and function effectively during fishing operations (Liu et al 2020; Shan et al 2023). Nets with a lower length-height ratio (i.e. deeper nets) generally exhibit better sinking performance. This is because the increased depth allows the net to reach greater depths more quickly, which is crucial for effective fishing operations (Zhou et al 2015a, b; Tang et al 2017; Shan et al 2023).

Table 3

Ratio between the purse seine and the vessel

Vessel	*Net length / vessel length*	*Net depth / net length*
PS 1	37.15	0.12
PS 2	33.75	0.13
PS 3	39.33	0.11
PS 4	34.03	0.12
PS 5	36.78	0.12
PS 6	36.10	0.12
PS 7	31.88	0.13
PS 8	37.11	0.11

Fishing grounds. Purse seine fishing gear is classified as an active fishing method designed to encircle and capture fish that form schools within the water column, particularly pelagic species. Target species of purse seine fisheries range from small to large pelagic fish, including the longtail tuna (*Thunnus tonggol*), which exhibits strong schooling behavior and high susceptibility to active fishing operations (Dewi & Husni 2018). Purse seine vessels based at the Archipelago Fishery Port (AFP) of Pekalongan operate across extensive and multi-regional fishing grounds, reflecting the migratory nature of pelagic fish resources. These fishing areas include the Java Sea, waters surrounding islands such as Karimunjawa, Bawean, Masalembo, Matasiri, and Kangean, the Natuna Sea, the Makassar Strait, the Flores Sea, and the Timor Sea (Chodriyah & Hariati 2010).

Ecologically, pelagic fish inhabit the pelagic zone of the water column, predominantly at depths of up to approximately 200 m from the surface. These species commonly form large schools within surface and epipelagic layers, and their distribution is strongly influenced by oceanographic factors such as plankton availability, and ocean currents. Small pelagic species, including sardines (*Sardinella* spp.), scads (*Decapterus* spp.), and round scads (*Rastrelliger* spp.), benefit from high primary productivity in neritic waters, where they primarily feed on phytoplankton and zooplankton. In contrast, large pelagic species are more frequently encountered in oceanic waters, although they may enter coastal and neritic zones under favorable environmental conditions. The migratory patterns of pelagic fish are closely linked to food availability, sea surface temperature, and prevailing ocean currents. Large pelagic species are known to undertake long-distance, transboundary migrations, whereas small pelagic fish exhibit daily vertical migrations and seasonal horizontal movements in response to environmental variability and changes in primary productivity (Humston et al 2000; Block et al 2011; Dewi & Husni 2018; Yang et al 2023).

Conclusions. This study concludes that the dimensions of large pelagic purse seine vessels at PPN Pekalongan exhibit limited variation and tend to be uniform, with an average vessel length of approximately 28.78 meters. The length-to-beam and beam-to-depth ratios support vessel stability and operational efficiency. The specifications of the purse seine

also vary but are designed to optimize fish capture, featuring appropriately proportioned components such as head rope and ground rope lengths that form an effective net enclosure. The analysis of the relationship between vessel dimensions and fishing gear characteristics reveals a strong compatibility, indicating that the vessels and fishing gear used at PPN Pekalongan are well-aligned. This alignment supports safe and efficient fishing operations, fulfilling the research objective of identifying patterns and potential harmonization between vessel dimensions and purse seine gear at this fishing port.

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

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