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DESIGNING A TRIMARAN FISHING BOAT TO IMPROVE WORK SAFETY FOR TRADITIONAL FISHERMAN IN INDONESIA

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ABSTRACT

As the second largest nation in capture fisheries in the world after China, Indonesia has a very large fleet of fishing boat. The main problems encountered on fishing vessels in Indonesia are the limited technology on board, and boat safety issues. One type of fishing boat that is common in Indonesia is a boat with “Cadik” or outrigger. The characteristics of an outrigger boat are the presence of a main hull with a length of between 7 meters - 12 meters, with a main hull width ranging from 0.9 meters - 1.2 meters. The shape of the main hull of the boat which tends to be long with a small width has problems in terms of boat stability, namely the boat is easy to roll, especially when fishermen are on one side of the boat to lower the net. To overcome this issue, fishermen generally install outriggers made of bamboo on both sides of the boat to increase the balance or stability of the boat. Based on this problem, a fishing boat was designed that applies the trimaran hull concept, which is the boat with three hulls. The function of the side-hull in addition to increasing the stability of the boat also as a compartment to store fishing gear and other fishing equipment. Meanwhile, the area between the main hull and the side-hull will function as a connecting deck, thus expanding the fishermen's working area and increasing the fishermen's work safety.

Keywords: *trimaran. fishing boat, work safety*

INTRODUCTION

As an archipelagic country with potential marine wealth in the form of marine capture fisheries, Indonesia has a very large number of fishing communities that relay on the sustainability of the fisheries sector. These fishermen utilize various forms of boats to help them catch fish either at a limited distance from their village with a sailing time of less than one day, or by using larger and more complex ships with a sailing time of up to 1-2 weeks or even several months. Fishermen with an operational time of less than 1 day or one day fishing generally use simple boats, namely long-boats equipped with outriggers on both sides of the boat to ensure the stability of the boat, especially during fishing operations. The weakness found in long-boats with outriggers is the relatively limited working area of fishermen, namely only in the main hull area, while the width of the ship is wider with the presence of outriggers on both sides of the ship (Wibawa & Birmingham, 2018). So that the function of the outriggers in this case has not been utilized optimally.

Figure 1. Traditional fishing boat with outrigger made of bamboo

Based on the above, a fishing boat has been designed that adopts a trimaran hull, namely a hull with 3 hulls side by side. One hull as the main hull in the middle of the boat, while the other two hulls are on the right and left sides of the main hull as balancing hulls. A trimaran boat is known to have very good boat stability (Gaspersz & Luhulima, 2021; Amiruddin & Yudo, 2023; Waskito & Yanuar, 2021), has a smaller draft (Luhulima, 2021), and a larger deck area compared to a boat with a single

hull (Budianto et al., 2021; Mutmainah et al., 2019). In this study, the function of the side hull has been modified and optimized so that: 1) fishermen can use the side hull as additional space to store fishing gear or other equipment. 2) the shape of the side hull is designed in such a way that it has a buoyancy that can withstand the load of at least 1 fisherman so that the side hull can also function as a work area when lowering the net. 3) the area between the main hull and the side hull is also equipped with a connecting board, so that the area that previously could not be used can now be used as a work area.

The study was conducted on the design of the side hull. The distance between the main hull and the side hull has been determined at a fixed distance, while the dimensions of the side hull, namely the width of the side hull, were varied. From these variations, the ideal side hull size was identified so that the ship would remain in a safe condition with the entire surface of the main and side hulls not sinking even though the fishermen were at the outermost point of the trimaran fishing vessel.

The objective of the study is to obtain the optimum dimension of trimaran side-hull, so that the fishermen can have a wider space on board as a working area when hauling or lowering their fishing gear. This will further increase the work safety of fishermen during fishing trip.

METHODS

The trimaran fishing boat was designed by maximizing the function of the side-hull, in addition to ensuring the stability of the vessel, also to increase the working area of fishermen when hauling the fishing gear. Based on this targeted outcome, variations were made to the dimensions of the side hull. The main dimensions of the vessel used as a case study are as follows:

Table 1. Trimaran Main Hull Dimensions

Dimension	**Notation**	**Value (m)**
Length Overall	L_{OA}	7.00
Length of Water Line	L_{wl}	6.60
Breadth	B	1.20
Depth	H	0.60
Draught	T	0.25

While the side hull dimensions were varied in the width of the side hull. Variations were made to obtain the optimal dimensions of the side hull, namely with the minimum possible size for consideration of the weight of the ship, but still able to withstand the weight of the fisherman when standing on the side hull. Table 2 shows the dimensions of the side hull and variations in the width of the hull.

Table 2. Trimaran Side Hull Dimensions

Dimension	**Notation**	**Boat A (m)**	**Boat B (m)**	**Boat C (m)**
Length Overall	L_{OA}	3.50	3.50	3.50
Length of Water Line	L_{wl}	3.10	3.10	3.10
Breadth	B	0.40	0.30	0.20
Depth	H	0.45	0.45	0.45
Draught	T	0.10	0.10	0.10

In order to have optimum dimension of side-hull, the trimaran hull body is designed with three variations. The total breadth of the trimaran boat is kept constant at 3,6 meters. The design of the lines plan of the trimaran fishing boat is as shown in Figure 3, while the General Arrangement design of the boat can be seen in Figure 4 below.

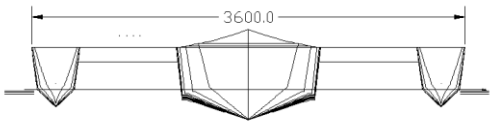

Figure 3. Design of lines plan for 0.4 meters breadth side-hull

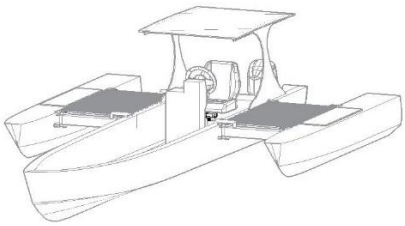

Figure 4. General Arrangement for trimaran fishing boat

As seen in Figure 4, the area between main-hull and side-hull and the area of the side-hull itself were designed to be able to be used by

fishermen as the working area. Therefore, it is important to ensure that the side-hull has the proper buoyancy to hold the fishermen weight, which is assumed to be 75 kg. Analysis was conducted on the buoyancy capacity of each side hull variation. In addition, analysis was conducted on the balance of the boat when the fishermen were on the outermost side of the side hull to see the condition of the ship's roll and trim. The analysis was conducted using Maxsurf Modeler software, by calculating the hydrostatic characteristic of the selected side-hull.

RESULTS AND DISCUSSION

To obtain the optimal side hull dimensions and the minimum draft required, three variations of the side hull dimensions were compared in terms of displacement by considering the minimum displacement required. Three designs of side-hull can be seen in Figure 5 bellow.

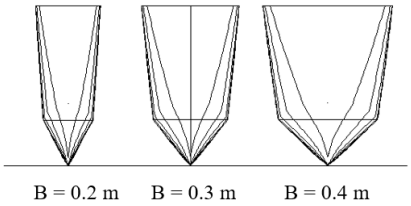

Figure 5. Lines plan of side-hull variations

In addition to taking into account the weight of the fisherman, the analysis on the side hull buoyancy capacities must also take into account the weight of the side hull construction itself. So that the minimum buoyancy needed is the total weight between the weight of the fisherman and the weight of the side hull construction.

The calculation of the structures weight of each side-hull was carried out by taking into account the area of the side hull shell expansion and the weight per square meter of the ship's structure if it is built with FRP (fiberglass reinforcement plastic) material. The results of the weight calculations for each side-hull can be seen in the table below.

Table 3. The light-weight of single side hull

Boat	Side-hull beam (m)	Light-weight (kg)
Boat A	0.4	40.0
Boat B	0.3	35.8
Boat C	0.2	31.9

By taking into account the weight of the side hull construction and considering the weight of the fisherman which is assumed to be 75 kg, the minimum buoyancy requirement for the side hull is at least in accordance with Table 4.

Table 4. The minimum buoyancy of side hull

Boat	Side-hull beam (m)	Minimum buoyancy needed (kg)
Boat A	0.4	115.0
Boat B	0.3	110.8
Boat C	0.2	106.9

Afterward, the buoyancy of each side hull was calculated at several draft conditions. The calculation results using Maxsurf software show that the buoyancy of each side hull for several water draft conditions is in accordance with Table 5 below.

Table 5. Displacement for each draft of side-hull

Boat	Side-hull beam (m)	Displacement single Side-hull (kg)		
		Draft 0.1 m	Draft 0.2 m	Draft 0.3 m
Boat A	0.4	64.95	110.50	159.35
Boat B	0.3	48.70	82.90	119.55
Boat C	0.2	32.50	55.25	79.70

Based on Table 4 regarding the minimum buoyancy requirement for each side-hull and table 5 which shows the buoyancy of each side hull at several draft conditions, hence, a graph of the relationship between the minimum buoyancy requirement for each side hull and the availability of buoyancy at several draft conditions is drawn up as Figure 6 below.

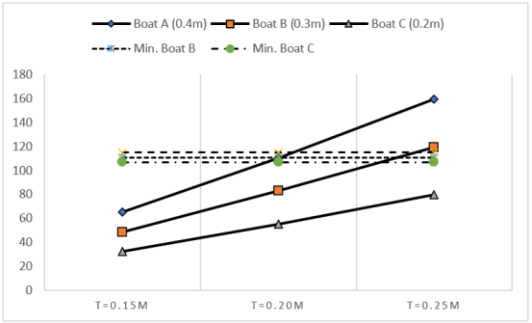

Figure 6. Minimum buoyancy required for each side-hull

The graph above shows the minimum buoyancy required and buoyancy available for each side-hull. The result show that only a side-hull with a breadth (B) of 0.4 meters can handle the weight of the fishermen and the weight of the hull construction, with a minimum draft of 0.21 meters.

CONCLUSION

Based on the results of side-hull displacement calculations for the three variations of the trimaran boat side hull, the following conclusions were obtained:

1) Trimaran fishing boats can be a substitute for fishing boats with outriggers with the advantage of a wider working area and an impact on the work safety of fishermen.
2) In this case, the minimum breadth (B) of the side hull should be 0.4 meters, with the minimum draft should be 2.1 meters. This side-hull dimension could support the weight of one fisherman with 75 kg weight and the light-weight of the side-hull structures.
3) Variations on the side-hull in terms of shape and volume under water can be done to obtain optimum buoyancy.

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