Hydrodynamic Characteristics of 30 GT Fishing Ship Hull Form in Sulawesi Waters

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ABSTRACT

This study aims to determine the hydrodynamic characteristics of the 30 GT fishing ship hull form, operating around Sulawesi waters. The hydrodynamic study includes determinations of; i) ship main dimensions, ii) ship resistance and power, iii) ship stability and maneuvering. The main dimensions identifications were based on a several fishing ship. Ship resistance and power aproximination used Holtrop method. The investigation of ship stability and maneuvering was based on the IMO criteria. Three samples of the fishing ship were investigated. The results of the hydrodynamic analysis showed that the influences of *B/T* ratio is significant. Properly selecting the *B/T* ratio on fishing ships can be improved in power reduction and possible increase in safety of ship

Keywords*:* Hydrodynamic, hull form, fishing ship and purse-seiner

1. INTRODUCTION

Indonesia is a maritime country with a vast ocean covering two-thirds of the total area of Indonesian territory. Marine resources will be the welfare of the community if it can be used optimally. Indonesian government policy in optimizing marine resources is through ship motorization and modernization of fishing gear as well as Presidential Decree No. 1/INPRES/2010 [1], namely the construction of fishing ships above 30 gross tonnage (GT) or ships with a length of over 20 meters, and fishing gear equipped ship with in accordance with local needs without ignoring government regulations as Decree No. 06/MEN/2010 [2]. This policy is in-line with the government program to accelerate the implementation of national development priority, particularly in the field of food security.

Regional Fisheries Management (RFM) of the Republic of Indonesia is divided into eleven regions as Figure 1 [3]. The potential fish resource in each RFM is grouped into six kinds i.e.: demersal fish, shrimp, lobster, large pelagic fish, small pelagic fish, reef fish etc. Pelagic fish is one of the species that are still available in larger quantities of around 60% of 6.520.000 tons per year, but until now which the can be produced only about 550.000 tons per year. Low level marine fisheries production is believed due to lack of both mastery of the technology and adequate infrastructure. The statistical data [4] showed that 32% were outboard motors, 40% with outboard motors and the rest were without motor.

To optimize the operation of 30 GT fishing ships in Sulawesi waters, the produced ship should be adapted to local design, without neglecting the necessary design standards i.e: a plan lines drawing, hydrostatic and stability calculations, engine power calculation as well as setting the appropriate space. A difference (main) dimensions of 30 GT fishing ships operating in Sulawesi waters, generally because of the dimensions of fishing gear used and environmental conditions (wind, waves and currents). Dimension ratio characteristics of fishing ship with purse-seine type have a ratio of *L/B* which is relatively larger to withstand the side load when pulling fishing gear. Ships have a freeboard (*T/H*) is relatively lower in order to easily raise catches to deck, the ship has wider work decks with *B/T* is relatively larges.

This research focused on the study of hydrodynamic characteristics of 30 GT fishing ship hull form in Sulawesi waters (WPP-RI 713). The region is one of fisheries areas that has a great potential, around 14, 26% or 929.700 tons/year of total fishery of Indonesian.

2. LITERATUR REVIEW

A. Fishing Ship

The Law of the Republic of Indonesia No. 31/2004 [5] on Fisheries confirms that fishing ship is a ship, boat, or other floating devices to catch fish, support fishing operations, farm fish, transport fish, process fish and due research, particularly fishing ships to collect, store, refrigerate, or preserve fish during the cruise.

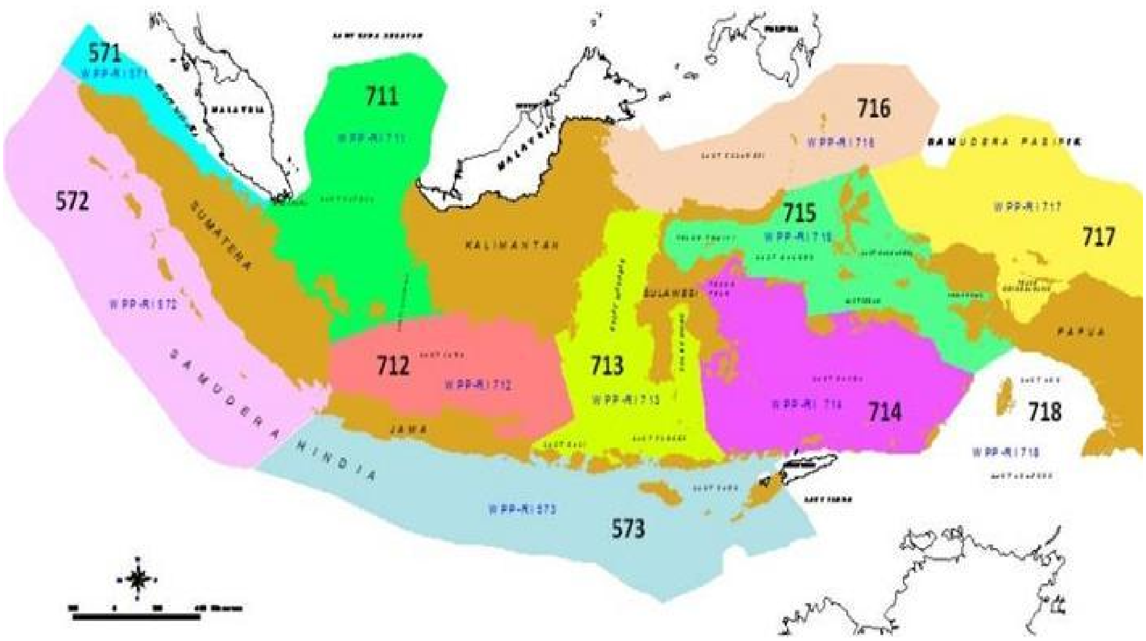


Figure 1. Fishery management region of Republic of Indonesia

In addition to the above as a function of fishing ships, ship can also be used for training guidance and inspection activities [6]. Based on the operation, fishing ships are divided into several types including: trawlers, purse-seiner, long liner, and gill-neter. The above mentioned differences in fishing gear result in different ways of operating.

Fishing ship has a number of unique character design compatrd with general merchant ships. The are[7]: a) the *L/B* ratio is relatively smaller, b) rudder and propeller blade size is relatively larger and c) generally operated with initial trim conditions on the bow of a relatively larger and it ranged between 30-40% of draft ship (*T*).

Rawson and Tupper [8] state that if the vessel is operated with a relatively larger trim condition, the motion ability posibly reduced. The important things to be considered in fishing vessel design are: cruising speed, main engine performance, stability and maneuvering, environmental parameters. The greatly affects the characteristics of ship design including: i) ship dimensions, operating on a wavy sea; ii) ship propulsion system working on a wavy sea, iii) ship control system, considering the environmental disturbances (waves and currents).

B. Ship Parameter

In the design of fishing ships, it is very important to consider the hydrodynamic characteristics of the ship. Fyson [9] identifying that there are nine parameters affect the hydrodynamic characteristics of fishing ship i.e.: ratio *L/B*, *L/T*, C_M, C_P, *LCB*, half angle of entrance (*½AE*), half angle of the run, buttock slope, and trim of ship. Similar comparison was also used in a number of fishing ships in several countries (such as the UBC series, BSRA, ITU, Webb, USNA and NPL) [10].

C. Ship Resistance

Total resistance of ships is a number of components that work through the current of ship motion which include physical effects, wave, air and others. International Towing Tank Conference (ITTC) underlines that the total resistance of ship consists of viscous resistance components (depending on the Reynolds number) and wave resistance (depending on the Froude number), practical viscous resistance is usually estimated by using the correlation line (C_F) ITTC-1957. C_F is an approach of the skin friction of a flat plate. The use form factor including the effect of hull shape on the formation of the boundary layer (boundary layer growth) and viscous components of pressure drag. For ships with a low Reynolds number, the resistance component due to friction is the most dominant. Ship waves resistance can be predicted by a number of methods, depending on the type of hull, the dimensions of size and speed of the ship as the methods developed by Holtrop [11] and [12], Digernes [13], Van Oormerssen [14] or UBC Calisal Series [15], Fao [16].

D. Ship Propulsion

In a conventional type of propulsion system, brake hotse power (*BHP*) is transferred from the main engine to the propeller to push the ship. Essentially, an effective power required by ship due to the presence of the mechanical components of the system and the hydrodynamic propeller shaft. The equation is below:

$$BHP = PE/.\eta_0\, \eta_H\, \eta_R\, \eta_S\, \eta_M$$

where: P_E is an effective power; η_0 is open water efficiency; η_H is the efficiency of the hull; η_R is the rotary rotative efficiency; η_S is the shaft efficiency (for the propulsion system using 4 stroke engine with the transmission gear box, shaft efficiency parameters estimated 97% [17]. To assist the designer when making quick comparison of ships power for similar type, displacement, power and speed, then the C_{AD} values can be calculated by bellow equation:

$$C_{AD} = (a^{2/3} . V^3)/(BHP/ \eta_S)$$

E. Ship Stability

The ship stability is defined as a character or nature of a ship to return to its original position after a heeling, caused by the influence of the forces acting from both inside and outside of the ship. The ability to return to its initial position is known as protects moment or enforcement moment of ships. Things that can reduce the ship stability in connection with the operation of fishing ships are: i) Payload catch excess (in the hold or on deck), it can reduce the buoyancy (freeboard) and the shift of the center of gravity of the ship. ii) The shift of the catch in the hold during the operation; it can create an unbalance of the ship, especially in the laying of the hatch. iii) At the time of trawling, and towing dredging both longitudinally and transversely can result in huge ship trim and hell, so laying gear on deck needs special attention as well as during the lifting of the catch on board

F. Ship Maneuvering

Ship maneuvering is the ability of ships to move under the control of the operation. In addition, the ship's position changes can be caused by external disturbances such as wind, waves and currents. As a function in the operation of fishing ships, chasing and catching fish as well as circular nets (purseseiner) make fishing ship maneuverability is urgently needed. A number of forces and moments equations of fishing ship hull can be used in analyzing the ship maneuvering equations, developed by Yoshimura [18], Yoshimura and Ning [7]. Kijima [19] and Kijima and Tanaka [20].

3. METHODOLOGY

A. Ship Sample

To determine the hydrodynamic characteristics of 30 GT fishing ship hull form in Sulawesi waters, 3 sample of fishing ships were used and their dimension of ship hull form, shown respectivelly in Figure 2 and Table 1.

B. Ship Hydodynamics Analysis

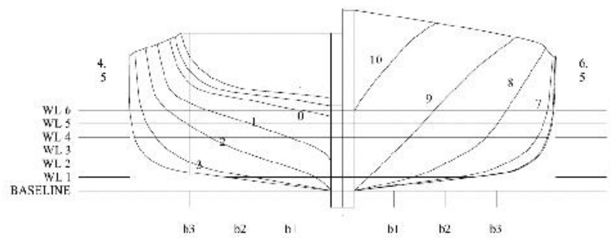
The analysis of hydrodynamic characteritic of 30 GT fishing ship hull form, systematically takes the following steps: i) Identification and comparison of hull dimensions, ii) resistance and power, iii) stability and maneuvering. Identify the dimensions of the ship and the comparison is based on the number of fishing vessels in several of countries (such as the UBC series, BSRA, ITU, Webb, USNA and NPL) [8]. Ship resistance and power calculated by using Hotrop method [9] and [10]. Ship stability and maneuverability investigated based on the IMO criteria [19].

4. RESULT AND DISCUSSION

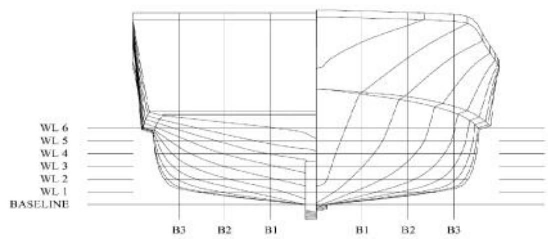
Table 2 shows an identified of main dimensions ratio of theree ship samples. The results showed that the ratio of L/B, $L/\Delta^{(1/3)}$ and C_B are lowest for ship sample 1, the ratio of B/T and *½AE* are lowest for ship sample 2, C_P is lowest for ship sample 3. This result was also compared with a number of fishing vessels (i.e. UBC series, BSRA, ITU, Webb, USNA and NPL).

Figure 3 shows a comparison of approximated total resistance coefficient (C_T) on three ships samples. Based on the analysis showed that the C_T parameter of ship sample 2 is lowest than sample 1 and 3. It is due to reduice B/T ratio. This trend can also cause the parameter of *½AE* reduice as well. Summary results of the analysis can be shown in Table 3.

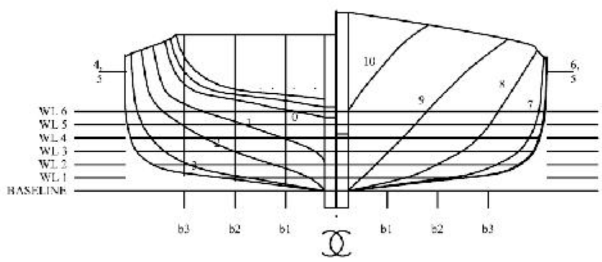
Figure 4 shows a comparison of admiral coefficient (C_{AD}) for analyzed three ship samples. It shows that the C_{AD} parameter of ship sample 2 has lower than ship 1 and 3. Therefore the ship sample 2 requires lowers power to propel the ship. A summary result of the analysis is shown in Table 4.



a) Hull form of ship sample 2



b) Hull form of ship sample 1



c) Hull form of ship sample 3

Figure 2. Hull form of ship sample

Table 1. Main dimensions of ships sample

Sample	*Loa*	*L*	*B*	*H*	*T*	*Disp*	C_B	*V*
Ship 1	19	17.79	4.4	1.6	1.1	43.971	0.44	10
Ship 2	26	24.028	4.2	1.8	1.2	65.71	0.447	10
Ship 3	23	20.75	5	1.6	1.1	62.40	0.451	10

Table 2. Main dimension comparison of ship sample

Sample	C_B	*L / B*	*B/T*	$L/a^{1/3}$	C_P	*½ AE*
Ship 1	0.44	4.043	4	5.383	0.672	23.47
Ship 2	0.447	5.721	3.5	6.443	0.618	18.68
Ship 3	0.451	4.15	4.5	5.798	0.613	24.64
Series						
UBC	0,53 - 0,61	2,6 - 4,0	2 – 4	3 – 4,47	0.65 – 0.842	30
BSRA	0,53 - 0,63	4,3 – 5,8	2 – 4	4,35 – 5,1	0.645 – 0.656	-
ITU	0,35 - 0,56	3,3 – 5,0	2 – 3,2	3,4 – 6,1	-	-
Webb	0,42 - 0,53	3,2 – 5,75	2,3	3,85 – 5,22	-	-
USNA	-	2.00 – 3.07	3.0-4.1	-	0.57 – 0.75	10 – 18
NPL	-	4.4 – 5.8	2.0-2.6	-	0.60 – 0.70	5 -30

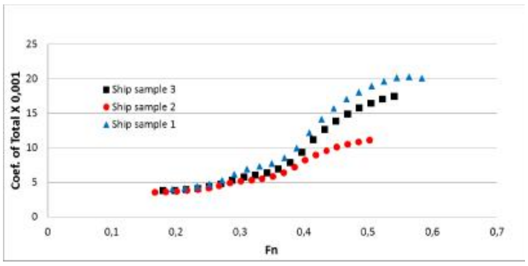


Figure 3:Comparison of total resistance coefficient (C_T) of ship sample

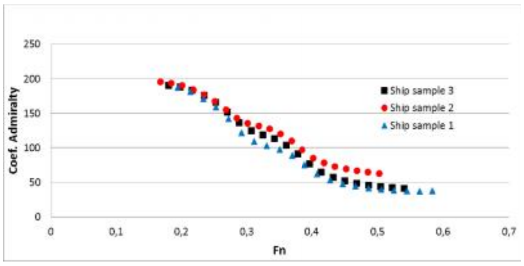


Figure 4. Comparison of admiral coefficient(C_{AD}) of ship sample

Table 3. Total resistance coefficient paramater of ship sample

Sample	R_T	C_{RR}	C_W	C_F	C_V
Ship 1 (10^{-3})	9,997	7,832	6,441	2,164	2,808
Ship 2 (10^{-3})	5,491	3,419	2,247	2,071	2,52
Ship 3 (10^{-3})	6,936	4,821	3,504	2,116	2,696

Table 4. Admiral coefficient parameter of ship sample

Sample	*Fn*	*SHP*	*Disp.*	C_{AD}
Ship 1	0.36	152/175	43.971	75.43
Ship 2	0.36	128/175	65.71	127.23
Ship 3	0.36	165/175	62.40	103.8

Figure 5 displays the large angle stability of the analyzed three ship samples. It shows that the stability parameter of ship sample 3 is superior than sample 1 and 3. The good stability of the sample ship 3 is possible because the ship has *B/T* ratio is largest. However, for all samples analyzed complied with IMO criterion (A749-18). A summary result of analysis is shown in Table 5.

Figure 6 shows a comparison of numerical simulations of turning circle for three ships sample tested. The simulation results shows that the ship sample 2 has a ratio D_T/L and A_D/L, which is lower than the

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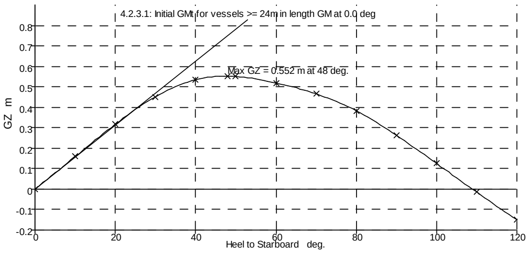
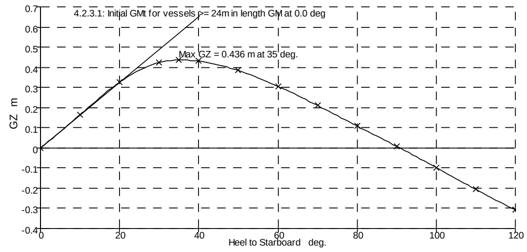
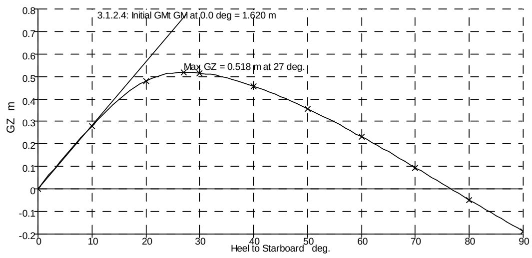
sample ships 1 and 3. However, the three samples analyzed all of which comply with IMO (D_T/L <5 and A_D/L<4.5). A summary result of analysis is shown in Table 6.



Ship sample 1



Ship sample 2



Ship sample 3

`Figure 5.Stability curve of ship sample

Table5: Stability parameter of ship sample

Sample	*Displ.*	*KG*	*Area 0 – 30 deg*	*Area 0 - 40 deg.*	*Area 30 – 40 deg*	*Max Gz of 30 deg.*	*Angle of Max Gz*	*Initial GMt at 0 deg,*
IMO Criterion			>3.151	>5.157	>1.719	>0.2	>25	>0.35
Ship 1	43.971	1.247	7.064	12.04	4.976	0.552	48 deg.	0.895
Ship 2	65.71	1.129	7.113	11.445	4.332	0.436	35 deg.	0.933
Ship 3	62.40	1.161	10.447	15.356	4.908	0.518	27 deg.	1.620

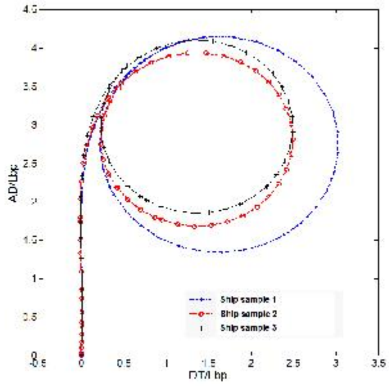


Figure 6. Turning circle of the sample ships

Table 6. Turning circle of the sample ships

Sample	Rudder areas (A_R)	DiameterTactical(D_T)	Advance (A_D)
IMO Criterion [21]		5L	4.5L
Ship 1	0.55	3.07L	4.13L
Ship 2	0.55	2.49L	3.93L
Ship 3	0.55	2.49L	4.10L

5. CONCLUSIONS

A study of hydrodynamic characteristics of 30 GT fishing ship hull form was conducted. Comparison of the results of analized 30 GT fishing ship hull form with several fishing ships and IMO criteria were covered. It shows that the influences of *B/T* ratio on ship is significant. Properly selecting the *B/T* ratio of fishing ship can be improved in power reduction and possible increase in safety of ship.

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