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STABILITY AND TOTAL RESISTANCE ANALYSIS OF CATAMARAN FISHING BOAT FOR JAVA NORTH SEA AREA WITH HULLFORM MODEL AND FISHING GEAR VARIATION

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ABSTRACT

Substitution of cantrang fishing gear with other gears might give bad impact to the stability of the ship. But, catamaran boat type can improve the intended stability characteristics. The study was conducted using six variations of the catamaran hullform, namely symmetrical hull, asymmetrical straight inside hull, asymmetrical straight outside hull, which is each model has round bilge and hard chine variation. The study aims to find the lowest total resistance value. The hullform with lowest total resistance will be re-varied to 3(three) different types of fishing gear, namely cantrang, purse seine, and bottom longline for stability analysis. The result shows that the round bilge symmetrical hull type has smallest resistance with value of Rt is 8.81 kN at 8 knots. Based on IMO MSC.36(63), the result of stability analysis shows all variations of fishing gear meet the established standard.

Keywords: Resistance, Stability, Seakeeping, Cantrang, Purse Seine, Bottom Longline.

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1. INTRODUCTION

The Java North Sea is a famous area for fishery resources with a coastline of 502.69 km. Sloping beach conditions and relatively calm sea conditions make the java north sea area as a center of fish catching for fishermen in Indonesia. The issuance of Ministry of Marine Affairs and Fisheries Regulation No. 2 of 2015 and No. 71 of 2016 concerning the prohibition of the use of cantrang type of fishing gear makes many fishermen experience a decline in production. This is because the cantrang is the most widely used type of fishing gear in the java north sea. Based on data from the Department of Maritime Affairs and Fisheries of Central Java Province, it is known that out of a total of 251,520 the number of fishing equipment used by almost 50% is cantrang. The number of cantrang uses in the Batang area even reached almost 95%. Limitation of the use of cantrang fishing gear requires most fishermen to use other fishing gear, such as purse seine or longline.

The substitution of cantrang fishing gear with others is considered to be less effective because the use of one type of fishing gear is only used to catch one particular type of fish, and that is based on the season in which the fish is available. Substitution of fishing gear on fishing boats with one another does not necessarily have the same performance changes. Substitution of cantrang fishing gear with other tools can adversely affect the stability of the ship [1}.

The analysis shows the average increment of GZ value for each condition by 2.53% in KMN Purbasari (Tegal fishing boat) when cantrang is replaced with purse seine [2]. Research on KM Putra Indah I (Rembang fishing boat) also shows the average increment of GZ value for each condition by 4.03% when cantrang is replaced with bottom longline [3]. Different results occurred in the MV Barokah Rezeki (Batang fishing boat) analysis which shows a decrement of the maximum GZ value for each condition by 7.37% when cantrang is replaced with bottom longline [4], also KM Sumber Mino Mulyo (Pati fishing boat) especially full load condition when the cantrang is replaced with a purse seine which shows a decrement of the maximum GZ value up to below the minimum IMO standard (IMO A.749(18)) with value of 0.19 m [5].

Catamaran boat is an alternative to change the traditional fishing boat models that are still used one type of fishing gear become multi fishing gears. Catamaran boat have many advantages compared to traditional fishing boat in terms of resistance and stability.

The purpose of this study is to design the hulform of catamaran fishing boat that have the lowest resistance, and design the layout of ships with multipurpose fishing gear that have the stability and seakeeping performance that are according to IMO MSC.36 (63) and NORDFORSK 1987 standards.

2. METHOD OF RESEARCH

The design of catamaran fishing boat for java north sea area is using 4(four) traditional fishing boats as a reference in determining the gross tonnage (GT), length, and height of the boat. Table 1 shows main dimension of the traditional fishing boat at the java north sea.

The design of catamaran fishing boat is done using CAD software. Resistance, stability, and seakeeping analysis is done with naval architect software and then validated based on IMO MSC.36(63) for stability and NORDFORSK 1987 for seakeeping performance.

Table 1 Main Dimension of Traditional Fishing Boats

No.	Ship Name	L (m)	B (m)	T (m)	H (m)
1	KMN Purbasari	16.16	6.00	1.70	3.00
2	KM Putra Indah I	16.70	5.80	1.80	2.30
3	MV Barokah Rezeki	15.45	4.25	1.50	1.90
4	KM Sumber Mino Mulyo	17.17	4.96	1.20	3.68

Based on the characteristics of the 4(four) traditional fishing boats, Table 2 shows the result of obtained main dimension of Catamaran boat.

Table 2 Main Dimension of Catamaran Boat

No.	Item	Size	Unit
1	LOA	16.35	m
2	LWL	15.00	m
3	BOA	6.69	m
4	B	1.71	m
5	T	1.55	m
6	H	2.72	m
7	Cb	0.53	
8	Δ	43.16	ton
9	Vs	8	knot

Figure 1 – Figure 3 describe the 6(six) of lines plan based on the catamaran hullform variations that will be investigated about total resistance, ship stability, and seakeeping. The hulform variation is classified as: symmetric round bilge, symmetric hard chine, straight inside asymetric round bilge, straight inside asymetric hard chine, straight outside asymetric round bilge, straight outside asymetric hard chine.

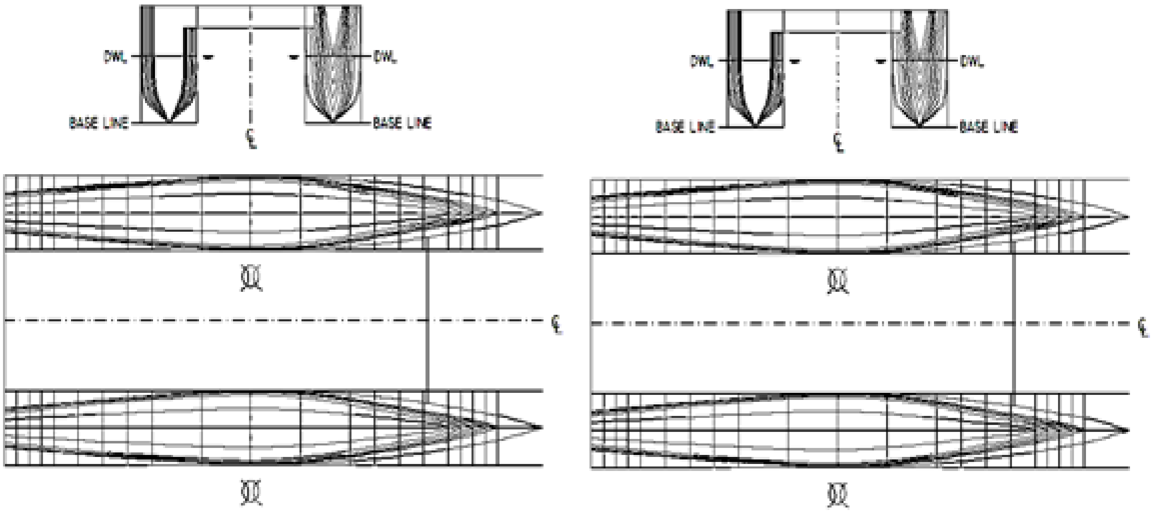

Figure 1 shows Symmetric Round Bilge and Symmetric Hard Chine

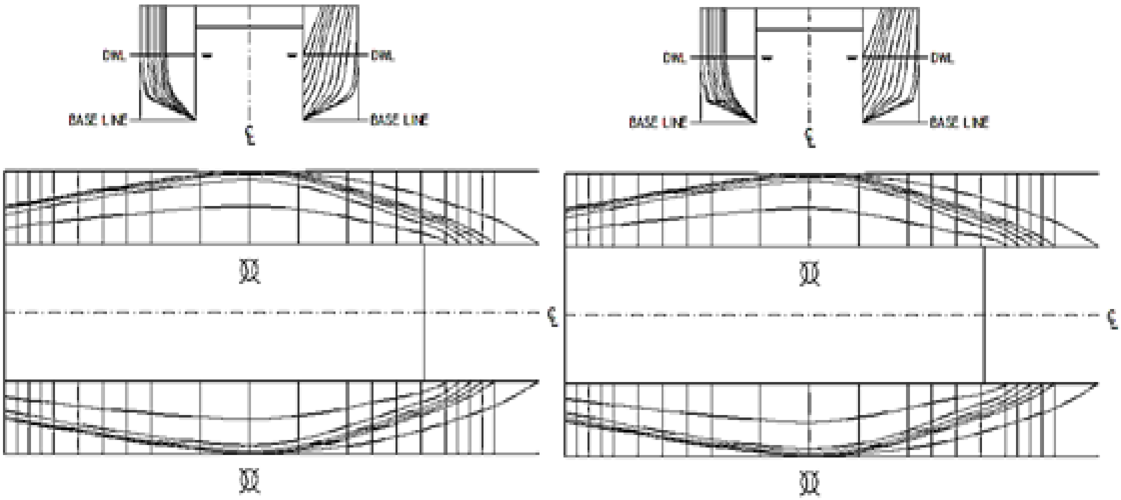

Figure 2 shows Straight Inside Asymmetric Round Bilge and Straight Inside Asymmetric Hard Chine

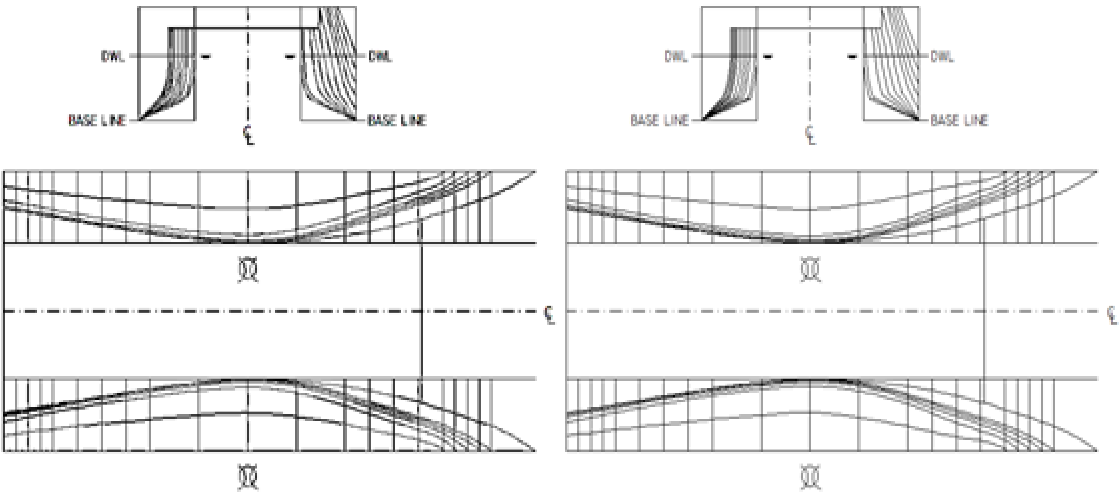

Figure 3 shows Straight Outside Asymmetric Round Bilge and Straight Outside Asymmetric Hard Chine

3. RESULTS AND DISCUSSIONS

3.1. Total Resistance

Ship resistance can be defined as a force that works against ship movements. This force is caused by direct contact between the hullship and the fluid [6, 7, 8].

The total resistance value can be seen in Table 3. This value is the total resistance in the actual size of the catamaran boat based on the calculation of coefficient total resistance (Ct) using CDF method.

The results of the ship total resistance analysis indicate that the symmetrical round bilge hullform has the smallest total resistance value. This is due to has the smaller WSA compared to the other five models. The amount of WSA that affects ship resistance can be proven by the equation (1).

$$\mathrm{R}_t = \frac{1}{2}.v^2.\rho.WSA.C_t \quad (1)$$

where:

Rt = Total resistance (kN)

v = Vessel speed (m/s)

ρ = Density of sea water (1,025 ton/m3)

Ct = Total resistance coeficient

Table 3 Ship Total Resistance Calculation

No.	Hull Variations	Ct	WSA (m^2)	Resistance (kN)
1	Symmetric Round Bilge	0.00991	102.6	8.81
2	Symetric Hard Chine	0.01047	103.0	9.35
3	Straight Inside Asymetric Round Bilge	0.01119	109.2	10.61
4	Straight Inside Asymmetric Hard Chine	0.01158	109.6	11.02
5	Straight Outside Asymmetric Round Bilge	0.01198	109.2	11.36
6	Straight Outside Asymmetric Hard Chine	0.01302	109.6	12.38

3.2. Ship Stablity

The DWT and LWT components in the stability analysis are calculated to determine construction, machinery, navigation and accommodation, and safety equipment, fuel oil tank, lubricating oil tanks, fresh water tanks, and cargo space tanks volume requirements on the vessel.

Construction needs are carried out using regulations of Germanischer Lloyd for ship with FRP material. Construction calculations are done by calculating the minimum modulus for each profile on the ship. The specified profiles are tall top hat types for web frame construction, floor web frame connection, and girder, while square top hat types for main frame construction, floor mainframe connection, beam and stiffener.

Propeller shaft is calculated according to regulations of Indonesia Classification. Calculation of the minimum diameter of the propeller shaft obtained is 30.89 mm. Shaft weight is obtained from the calculation of shaft volume multiplied by the steel density. The shaft length is determined based on the ship general arrangement. Propeller weight is taken from interpolation based on its diameter. Interpolation is carried for a 930 mm propeller diameter.

The selection of the generator was taken based on information from the TPI Klidang Lor about the MV Barokah Rezeki. The generator has a power of 30 Pk with a weight of 225 kg. Other auxiliary equipment is taken based on designing a 30 GT fishing boat. These data include safety, navigation, accommodation, mooring equipment, pumps, compressors, and electrical installations with a total component weight of 6.91 tons.

Variations in fishing gear use 3(three) fishing gear namely: cantrang, purse seine, and bottom longline. The selection of fishing gear was taken based on the MV Barokah Rezeki fishing gear (30 GT) for nets and KM Putra Indah I (40 GT) for axle or hauler. Bottom longline and cantrang fishing gear will be placed on the stern of the ship while purse seine will be placed on starboard midship.

Calculation of all DWT component requirements is taken based on the cruise radius to be used. The cruise radius to be used is 300 seamiles that is located in the WPPN RI 712 area (Figure 4). The fising ground does not exceed 100 seamiles of coastline, starting from the north coast of Batang, Tegal, Pati and Rembang for fishing ground conditions with a state of relative calm waves.

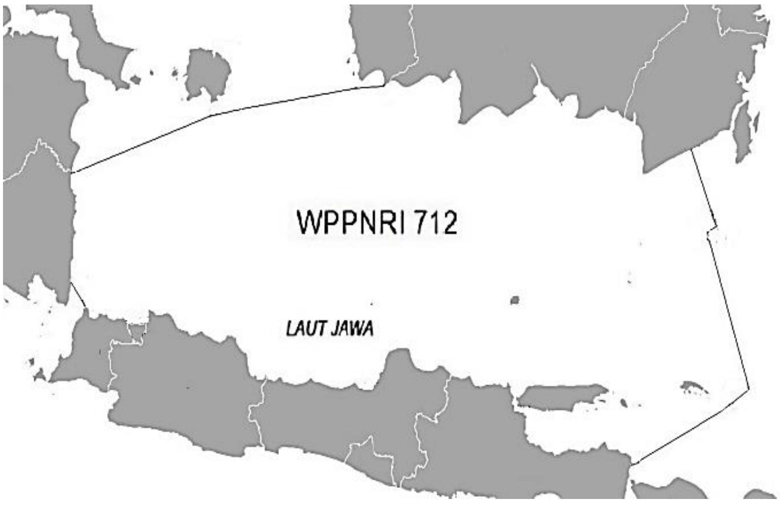

Figure 4 shows WPPN RI 712: Cruise Route of Catamaran Fishing Boat

Figure 5 – figure 7 show 3(three) different types of fishing gear are fitted in the catamaran boat. There are cantrang gear, purse seine gear, and bottom longline gear.

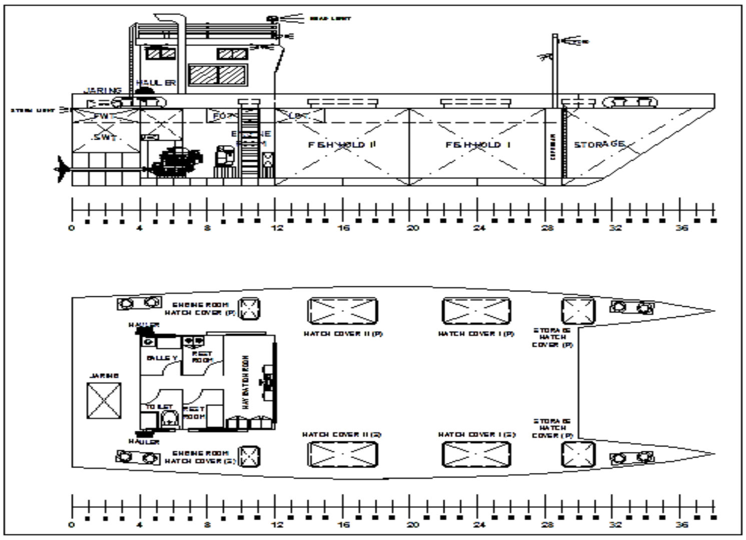

Figure 5 shows General Arrangement of Catamaran Fishing Boat using Cantrang

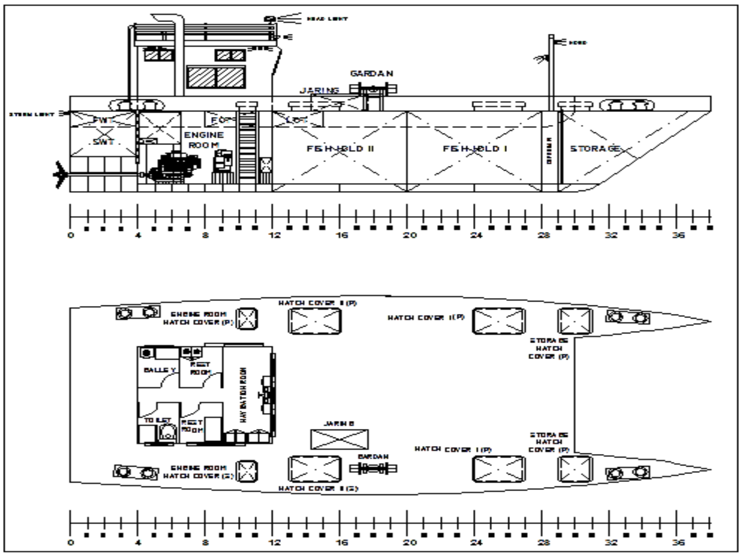

Figure 6 shows General Arrangement of Catamaran Fishing Boat using Purse Seine

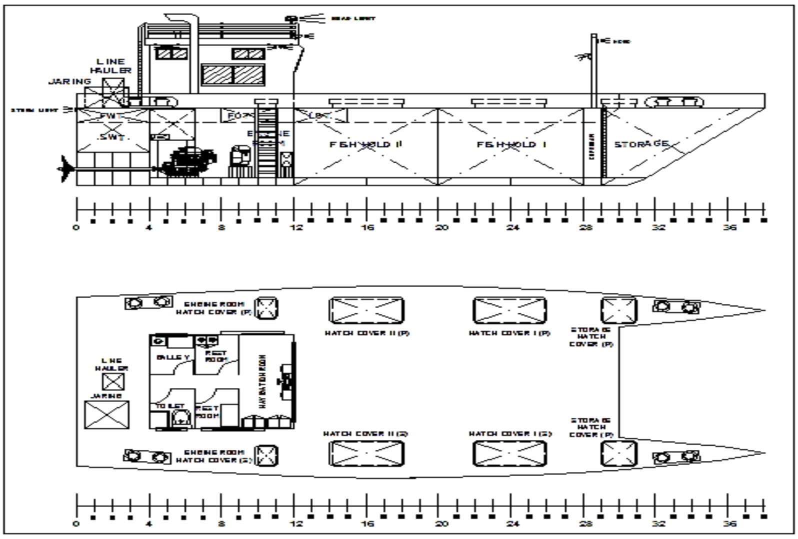

Figure 7 shows General Arrangement of Catamaran Fishing Boat using Longline

The weight of each LWT component with a variety of fishing gear can be seen in the following Tables 4 and 5.

Table 4 Ship Total Resistance Calculation

Item	Weight (ton)	LCG (m)	TCG (m)	VCG (m)
Cantrang Ship	24,40	5,79	-0,03	1,92
Purse Seine Ship	24,57	5,93	0,04	1,93
Buttom Longline Ship	24.32	5,60	0,00	1,91

Table 5 Ship Total Resistance Calculation

Item	Berat (ton)	LCG (m)	TCG (m)	VCG (m)
Fish Hold	16,66	8,38	0,00	1,53
Fuel Oil Tank	1,33	4,09	0,00	2,46
Lubricating Oil Tank	0,17	5,38	0,00	2,46
Fresh Water Tank	2,13	0,86	0,00	2,46
Sea Water Tank	3,56	0,89	0,00	1,69

Stability analysis is carried out using 3(three) conditions according to IMO, namely (1) the condition of the ship with empty cargo and 100% consumable. (2) The condition of the ship is on fishing ground with a 50% cargo space. (3) The condition of the ship is still on fishing ground with 100% cargo space.

Stability analysis was also carried out to describe the state of the ship while doing fishing operations by giving fish weight in areas near fishing gear. The burden is given assuming the weight of the catch is 4.5 tons. This analysis is only carried out for purse seine vessel. The analysis was not carried out on variations of cantrang and bottom longline fishing gear. This is due to the moment heeling when fishing operation on the purse seine vessel and does not occur on cantrang and bottom longline vessels. The results of stability analysis can be seen in Figures 8 to Figure 10 and Tables 6 to Table 8 in the form of GZ curves from the 3(three) conditions and stability criteria according to IMO MSC. 36 (63).

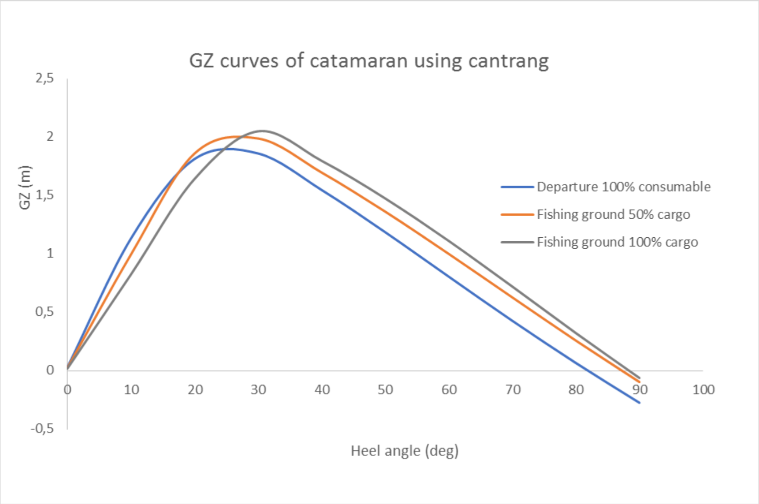

Figure 8 shows GZ Curves of catamaran using cantrang

Table 6 Stability Criteria of catamaran using cantrang

No.	IMO MSC.36 (63)	Value	Loading Condition			Result
			Departure (0% cargo, 100% consumable)	Fishing ground (50% cargo)	Fishing ground (100% cargo)	
1	0° - 30° of area under curve	≥3,714 m.deg	31.416	32.386	36.312	all pass
2	Angle of Max. GZ	≥10°	25.50	26.40	30.00	all pass

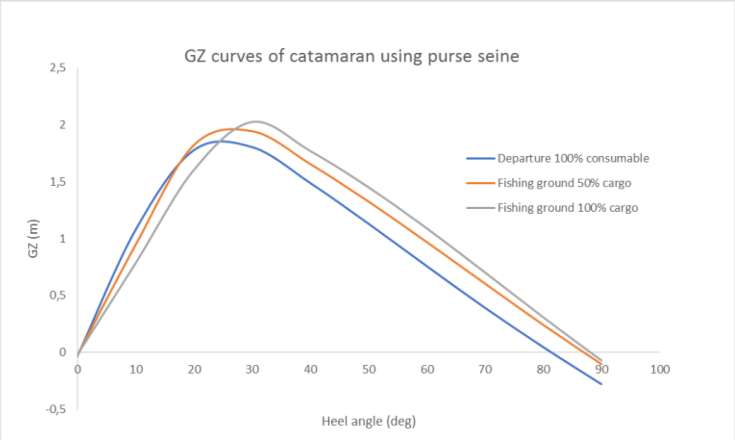

Figure 9 shows GZ Curves of catamaran using purse seine

Table 7 Stability Criteria of catamaran using purse seine

No.	IMO MSC.36 (63)	Value	Loading Condition			Result
			Departure (0% cargo, 100% consumable)	Fishing ground (50% cargo)	Fishing ground (100% cargo)	
1	0° - 30° of area under curve	≥3,714 m.deg	30.187	31.196	34.994	all pass
2	Angle of Max. GZ	≥10°	25.50	26.40	30.00	all pass

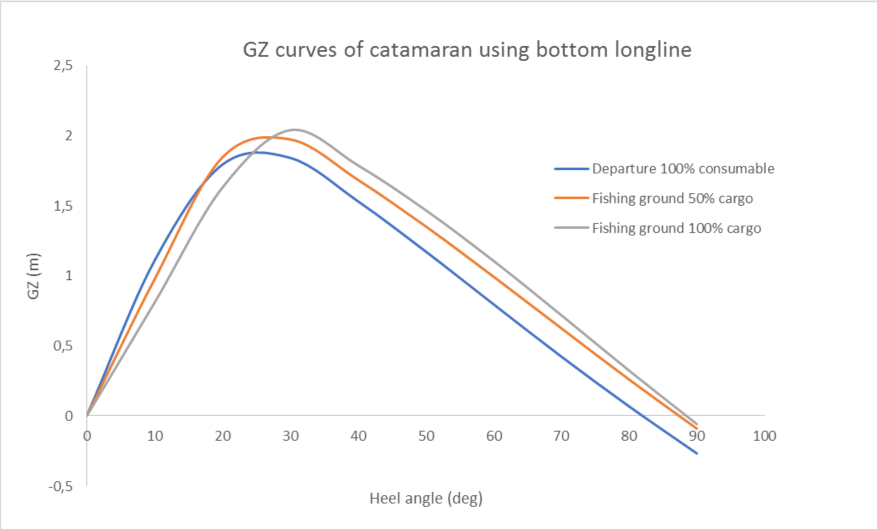

Figure 10 shows GZ Curves of catamaran using bottom longline

Table 8 Stability Criteria of catamaran using bottom longline

No.	IMO MSC.36 (63)	Value	Loading Condition			Result
			Departure (0% cargo, 100% consumable)	Fishing ground (50% cargo)	Fishing ground (100% cargo)	
1	0° - 30° of area under curve	≥3,714 m.deg	30.868	31.940	35.721	all pass
2	Angle of Max. GZ	≥10°	25.50	26.40	30.00	all pass

All conditions and variations in the installation of fishing gear meet the IMO MSC.36 (63) criteria. Figures 11 - Figure 13 show that the maximum GZ of catamaran boat is greater than that of GZ of traditional fishing boats. All Figures show the loading condition of departure with 100% consumables of each variation of fishing gear has the lowest maximum GZ value.

All loading conditions of catamaran using cantrang has a maximum GZ value respectively, 1.906 m, 2.024 m, 2.061 m. This value is still greater when compared to the largest GZ value of KM Putra Indah I (traditional fishing boat using cantrang) which is 0.74 m with the difference in the righting arm to 157.57%. All loading conditions of catamaran using purse seine has a maximum GZ value respectively, 1.861 m, 1.982 m, 2.032 m. This value is still greater when compared to the largest GZ value of KMN Purbasari (traditional fishing boat using purse seine) which is 0.716 m with the difference in the righting arm to 159.92%. All loading conditions of catamaran using bottom longline has a maximum GZ value respectively, 1.886 m, 2.008 m, 2.032 m. This value is still greater when compared to the largest GZ value of KM Putra Indah I (traditional fishing boat using bottom longline) which is 0.74 m with the difference in the righting arm to 154.86%.

The value of angle of vanishing stability has increased from departure loading condition (with 100% consumables) to fishing ground loading condition (with 100% cargo). This occurs because the point of VCG shifts down due to the fish hold. The lower the VCG position, the higher the value of angle of vanishing stability, and vice versa.

4. CONCLUSION

Based on the results of the analysis in the discussion section, the authors take the following conclusions: (1) Symmetrical round bilge hull model has the smallest value of ship resistance of 8.81 kN. Vessels with hard chines have greater resistance compared to round bilge because they have a larger WSA. Symmetrical vessels have a smaller bow angle of attack compared to asymmetrical vessels. (2) All variations of fishing gear in each condition of the ship meet the criteria of IMO MSC.36 (63). Catamaran ships have better stability compared to traditional fishing boat because they have larger righting arms.

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