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Stability Aspect of Small Fishing Vessels

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Abstract

Stability aspects of small fishing vessels were evaluated, they are purse seiner Yana and skipjack pole and line Yora 01. This issue was executed due to unclarity of stability parameters of fishing vessels during design and operation. Most traditional fishing vessels were constructed and operated without defining design parameters or stability parameters in particular at initial design phase. Due to fishermen habit that operate vessels in one day operation in the fishing ground surrounded by the islands makes fishermen do not pay special attention to stability parameters. In addition, the habit of placing all captured fish on the deck would create problem of increase vessels' height of gravity KG and decrease the important stability parameter of transverse metacenter height GMT. Generally, this parameter will affect all stability parameters. The real parameters of KG and GMT would be achieved by inclining test on the real vessel. The inclining test was executed on both vessels in the waterfront area by following all procedures in standard test. The result of inclining test was used in defining and creating loading scenario which are leaving home port, arriving at fishing ground, leaving fishing ground and arriving at home base again. Additional scenario was included for placing load (captured fishes) on deck. Purse seiner has 3 scenarios of placing 1, 2 and 3 tons on deck while skipjack pole and line has scenario of placing 1, 2, 3, 4 and 5 tons on the deck. The real loading condition of vessels were set and stability parameters for the vessel were determined. Inclining test gives a non-dimensional value of ratio KG/H where this value may be applied at future early design phase of similar fishing vessels. The study showed that placing the cargo of maximum to 3 tons on the deck of purse seiner and 5 tons on the deck of skipjack pole and line would not be a problem for stability parameters. In these scenarios it was resumed that all stability parameters satisfy the rule of stability. In addition, placing the cargo more than the existing scenario then stability parameters should be considered again. Some recommendations were made for future works of the study.

Keywords: Stability parameters; Loading conditions, Inclining test

Introduction

Background

The need of protein resources from the sea depends on any kinds of fishes which is increased recently due to domestic consumption and international market. As a big maritime country, Indonesia plays a great contribution to fulfil fish international demand. Lying at the cross of Asia-Australia continents and Pacific-Indian oceans, Indonesia has a potential of marine resources particularly any kind of fishes such as small pelagic, big pelagic and demersal fishes. Such fishes are caught by different fishing vessels and their fishing gears operated by big national fishing companies and small traditional fishing vessels owned by local private companies. Small private fishing vessels should be considered seriously due to some problems appear during their operation time [1,2]. Among those small private fishing vessels purse seiner (catching small pelagic fishes) and skipjack pole and line (catching big pelagic fishes) have a serious problem of stability parameter. Unlike other transport ships where stability parameters are evaluated at departure and arrival conditions fishing vessels should be considered at 4 loading conditions

which are: departure from home base, arrive at fishing ground, leave fishing ground and arrive at home base with difference load conditions [3,4]. In fact, our previous study showed a critical stability condition which should be deeply evaluated when the load (captured fishes) is placed on deck area or before placing them at fish hold [1,5, 6]. In addition, those small private fishing vessels are not provided with detail of stability parameters that may cause a wrong evaluation of stability parameters. A previous work was executed by the author concerning the vertical value of ship's centre of gravity KG or VCG. By providing the value of KG then the stability parameters of both fishing vessels may be clearly determined [3,4].

The value of KG is obtained from the result of inclining test executed directly on board at empty load conditions. Once the value of KG at empty load condition is determined then the whole load conditions of ship would be arranged then the value of stability parameters are also determined. In fact, the real load conditions all stability parameters are determined by the conditions of cargo and consumables carried at 4 loading conditions. Fishing ground of those two kinds of vessels depends of the migration line of such small and big pelagic fishes. The fishing ground are detected by the fishermen for a long time without using a modern device to trace the line fish migration. In addition, fishermen using a floating platform called rumpon in order to keep the moving fishes stop and stay rest beneath rumpon to be easy to be caught. Otherwise, the vessel is moving around in fishing ground to search until the catching target is fulfilled. Purse seiner fishing vessel is operated at night time when the fishes are staying under rumpon then catching process may be executed by reducing the light and using the circling net. Meanwhile, skipjack pole and line fishing vessel operate at day time starting from dawn to catch small life bait fish then catching operation are continue during the day time at open fishing ground [5,6].

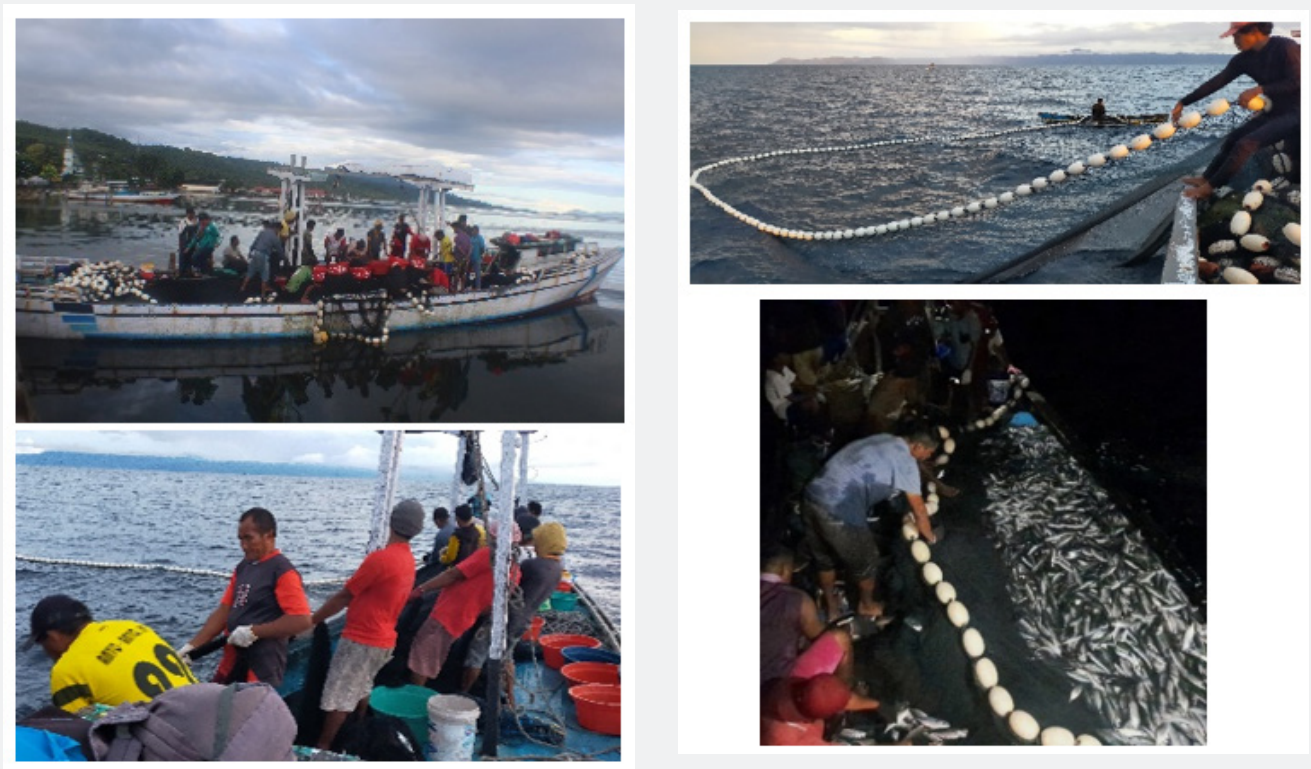

Figure 1: The real vessel and operation condition of Purse Seiner "Yana".

Review of Ship Parameters

Fishing vessel Purse Seiner

A purse seine fishing boat name Yana was selected in this study. The configuration and dimension of observed purse seiner is presented at Figures 1 & 2 and Table 1.

Fishing Vessel Skipjack Pole and Line

The dimension and configuration of Fishing vessel skipjack pole and line are presented at Figures 3-6 and Table 2.

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Table 1: Principle dimension of Purse Seiner "Yana".

No	Boat parameter	Value	Unit
1	Length overall, Loa	20.90	m
2	Length of waterline, Lwl	18,336	m
3	Beam maximum, B	3.07	m
4	Beam of waterline, Bwl	2.975	m
5	Max draft, T	0.585	m
6	Deck height, H	1.182	m
7	Weight displacement, ▲	16.190	ton
8	Speed (empty load), Vs	6 to 7.5	knot

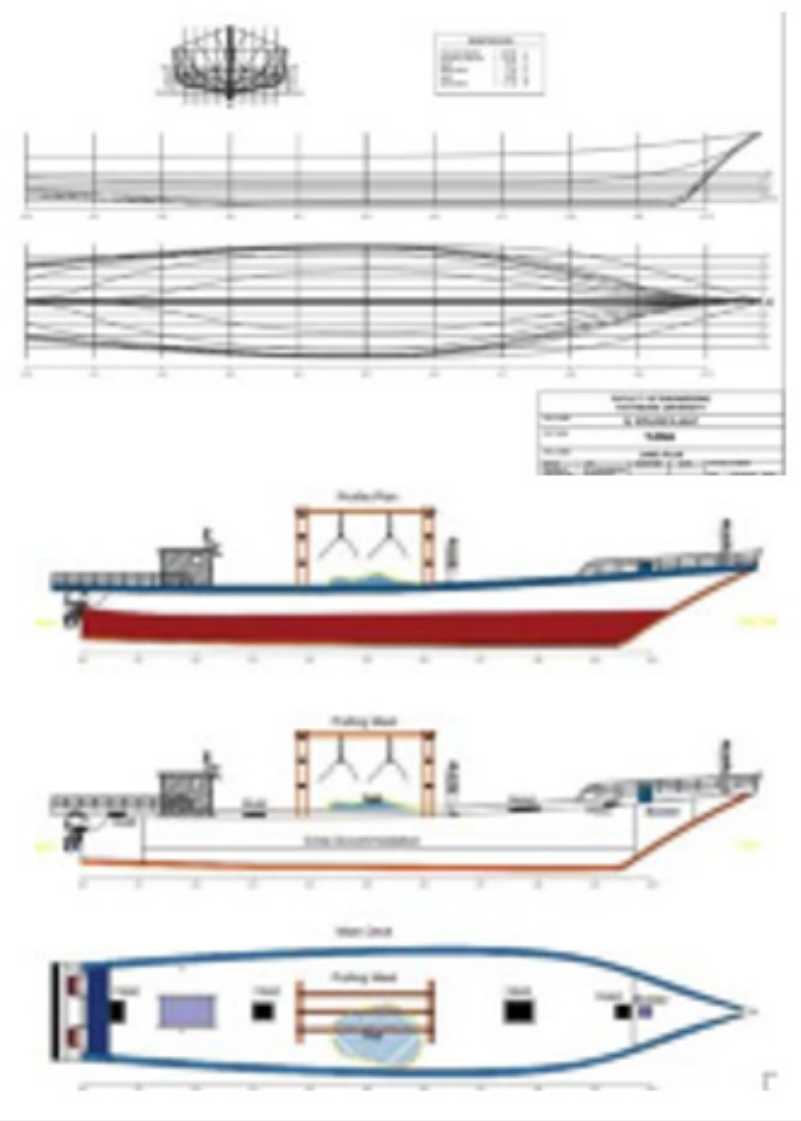

Figure 2: Lines Plan and General Arrangement of Purse Seiner "Yana".

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Figure 3: Real ship and catching operation of skipjack pole and line

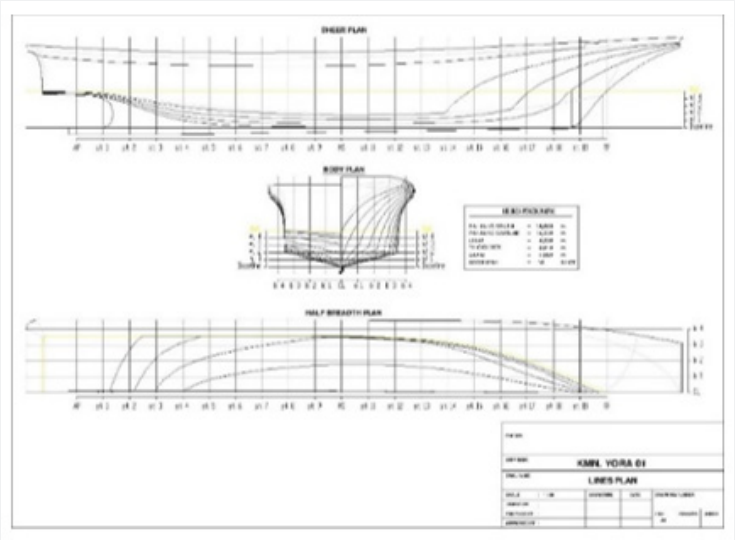

Figure 1: Histological

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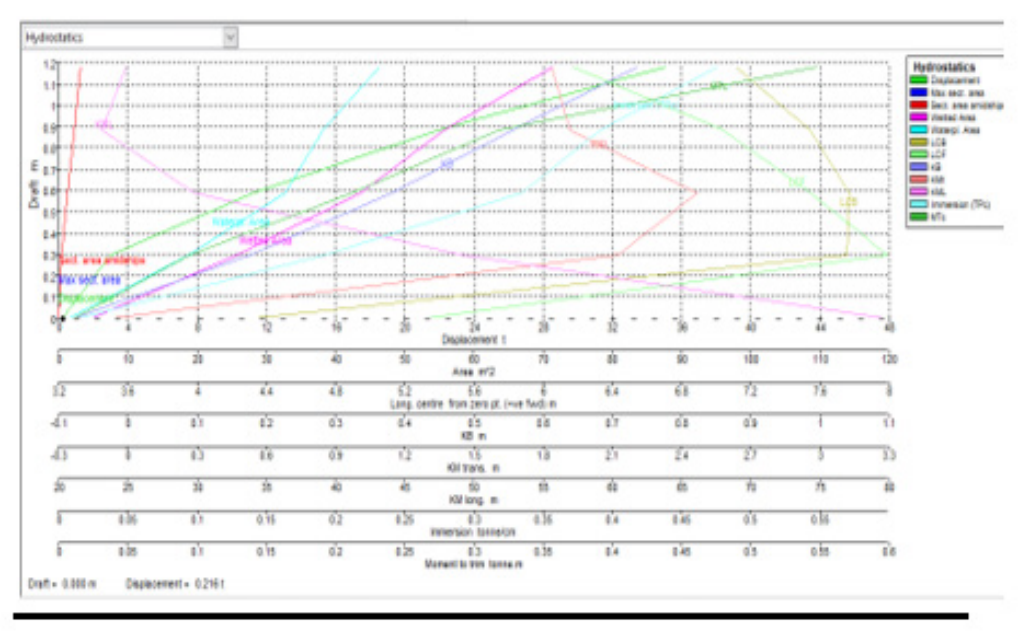

Figure 5: Hydrostatics curve of MV. Yora 01.

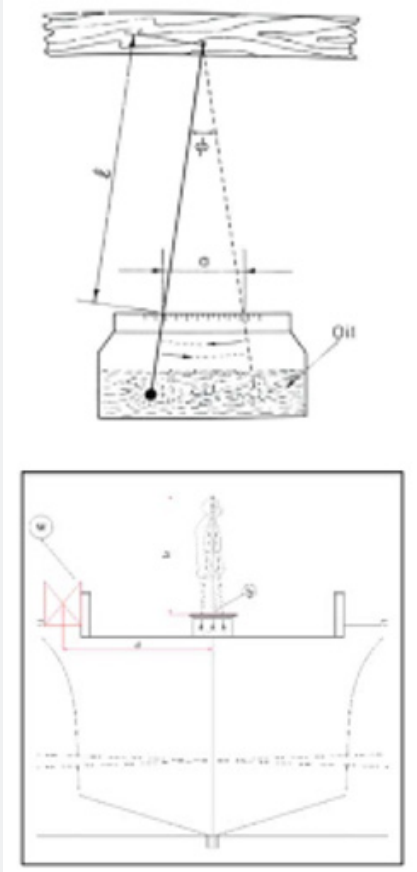

Figure 6: Scenario of Inclining Test.

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Table 2: Principle dimensions of skipjack pole and line MV. Yora 01.

No.	Boat parameter	Value	Unit
1	Boat name	MV. Yora 01	
2	Boat type	Fishing Boat Skipjack pole and line	
3	Fishing gear	pole and line	
4	Hull material	fibreglass reinforced plastic (FRP)	
5	Fishing port	Village Pelita Jaya, Seram Island, Province of Moluccas, Indonesia	
6	Autonomy	136 nautical miles	
7	Crew	29 persons	
8	Capacity	29 GT	
9	Length Overall, LOA	18.85	m
10	Length of Waterline, LwL	16.20	m
11	Beam, B	4.20	m
12	Draft, T	1.18	m
13	Dech height, H	2.01	m
14	Service speed, V	10.0	knot
15	Engine type	Yanmar 6 CH-THE 3, marine diesel engine	
16	Engine power	155 horse power	

Stability Parameters

The stability parameters of small fishing vessels are regulated in several rules to ensure the vessels are in good condition during the operation. The stability of fishing vessels should be evaluated at all loading conditions at departure and arrival conditions [3,4]. In addition, Fyson [4], stated that fishing vessels with length are greater than 24 m should fulfil the IMO Regulation 1977 with stability criteria cover large angle of inclination (Figures 7-11).

Stability parameters at initial condition may be determined as follows:

$$GM_T = KB + BM_T - KG = KM_T - KG \qquad (1)$$

Where:

GM_T = Transverse metacentre height

KB = Vertical centre of buoyancy

BM_T = Transverse radius of metacentre

KM_T = Height of metacentre above baseline

KG = Vertical centre of gravity of the vessel.

The values of KB, BMT and KMT are obtained from hydrostatics properties of the vessels. Once the value of KMT and KG are determined then the value of GMT may be achieved. The value of KG is composed on any detail of vessels' component such as hull, machinery, propulsion systems, fluids, cargoes, consumables, crew, etc. Those components are determining at design stage. In fact, those components should be verified later at real ship condition which is known as the inclining test. This action would be executed at empty condition of the vessel. From the achievement of value KG then the metacentre value GMT of the vessels may be achieved. The value of GMT may be obtained directly from the inclining test such as:

$$GM_T = (w\ x\ d\ \cos\phi) / (w\ \sin\phi) = (w\ .\ d) / (W\ \tan\phi) \qquad (2)$$

where:

W = displacement of the vessel due to the real draft

w = moving weight at a distance from CL of vessel

ϕ = angle of inclination

The criteria of ship stability parameters for fishing vessels are presented in the Regulation 28 Chapter III (International Conference on Safety of Fishing Vessels, 1977, IMO, London, 1977) [7]. In fact, for the vessels below 24 m in length this reference [8] it is recommended to use the similar criteria also below 24 m for decked vessels. In addition, the regulation issued by Maritime Coastguard Agency [9] for stability criteria of fishing vessels less than 15 m. Fishing vessels should be operated that the minimum stability criteria established by the competent authority will be met in all operation conditions. The following minimum stability criteria are recommended for decked fishing vessels less than 24 m [10-12] which is based on the FAO/ILO/IMO Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels, 2005. Safety aspects of fishing vessels are regulated in Torremolinos Protocol and The Torremolinos International Convention for the Safety of Fishing Vessels, consolidated edition,

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1995, adopted in Torremolinos, Spain 2 April 1993. This protocol stipulated standard requirements of fishing vessels' stability [3]. Insight report Lloyd's Register Foundation [4] clarified that the reason of fishing vessels' accidents caused by the lack of regulation and weak implementation of regulation. Moreover, safety code issued by Implementation Guidelines on Part B of the Code, the Voluntary Guidelines and the Safety Recommendations (FAO UN, 2014) [10] stated one practical code of ship safety is maintaining watertight integrity and ship stability. Regulation of stability for ships above 24 meter in length firmly stated in (International Conference on Safety of Fishing Vessels, 1977, IMO, London, 1977) which is the complete text from Torremolinos International Convention for the Safety of Fishing Vessels, 1977 and The International Conference on Safety of Fishing Vessels, IMO, London, 1977 [3,13]. The concept of ship stability component mostly in order to find component of ship stability [14-17].

The scenario of inclining test is presented at Figure 1.

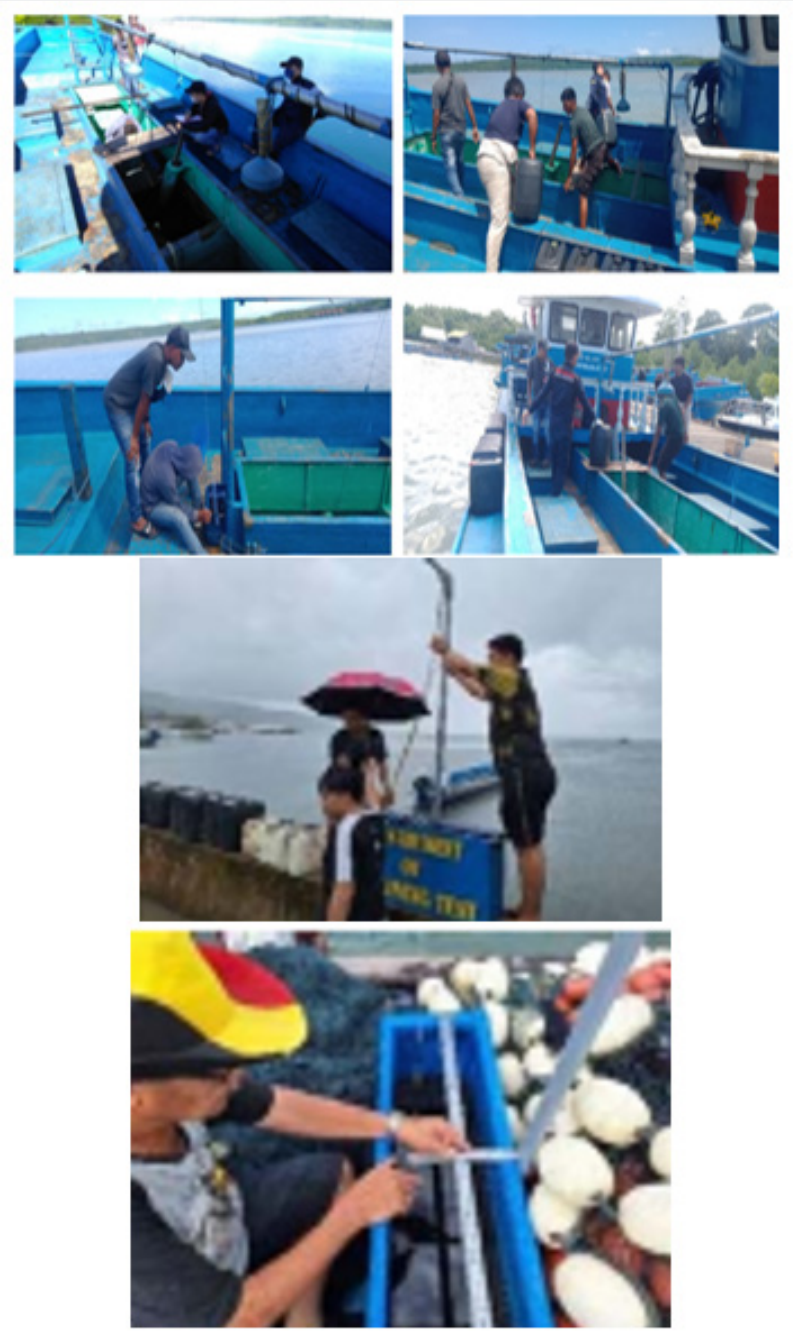

Figure 7: Preparation of purse seiner vessel "Yana" and instruments.

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Figure 8: Measurement and develop the result of the test for MV “Yana”.

Figure 9: Inclining test of Skipjack Pole and Line MV. Yora 01.

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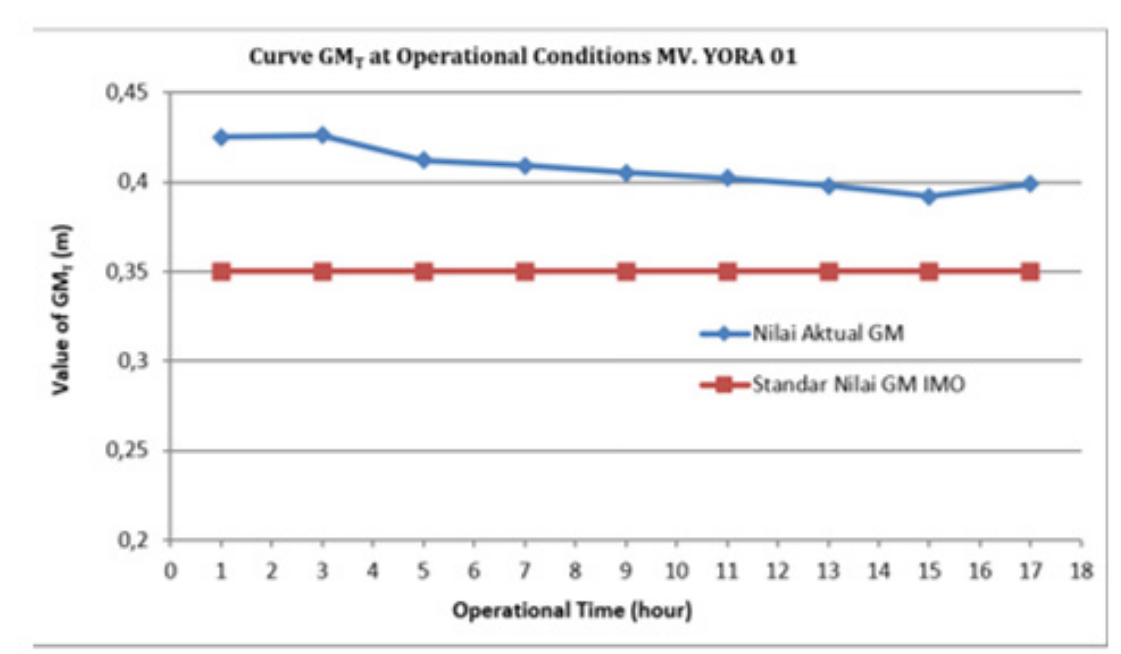

Figure 10: Curve of GMT at whole operation conditions of skipjack pole and line.

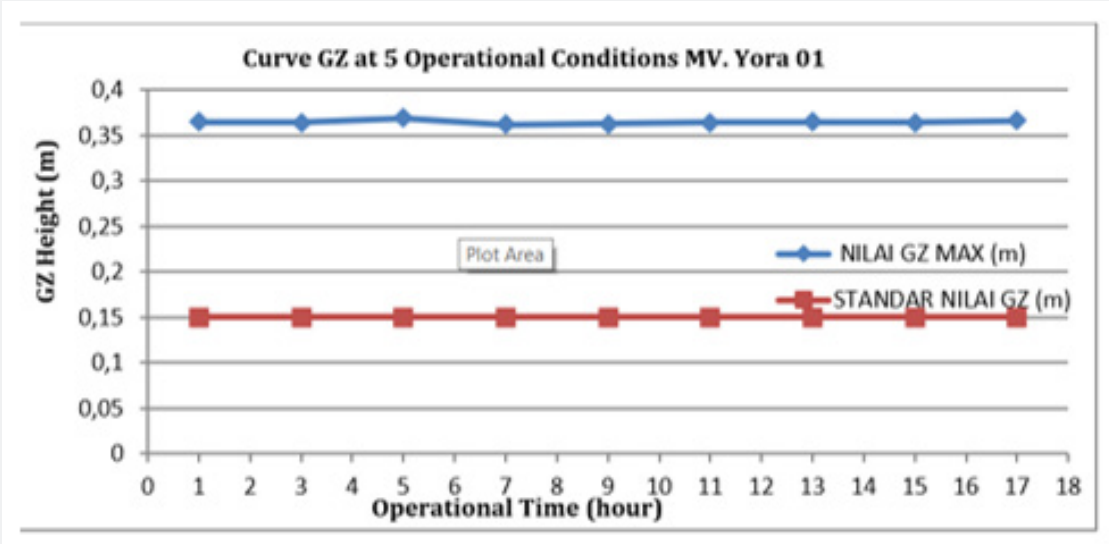

Figure 11: Curve GZ at whole operation conditions of skipjack pole and line.

The scenario of achievement the value of inclining test is explained as follow:

The value of inclination angle ϕ is obtained from:

$$\phi = a / l \ \ (in\ radians) \ \ or \ \ \phi = 57.3\ x \ \ (a/l) \ \ (in\ degrees) \quad (3)$$

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Methodology

Preparation and Executing of the Inclining Test

Results and Discussion

Result of the Inclining Test

Results of inclining test of the observed fishing boats purse seiner "Yana" are presented at Tables 3 & 4. In this test few crews and researcher were on board. Moving weights were provided by small container filled with water. During the test all internal and external effects. This test there were several scenarios arranged in order to obtain better results. In scenario 1: few crews, additional waters and fishing equipment (circle net) were placing on board. Scenario 2: full crew and equipment were placing on board. In addition, scenario E and F were executed for repeating measurement to achieve an exact value of vessel vertical centre of gravity KG. The test was executed at waterfront area and the test was executed at the condition of without cargo (captured fishes), liquids and consumables.

Table 3: Stability criteria for fishing vessels.

No.	Criteria	Value	Unit
1.	Area 0 to 30, >=	0.055	m.rad
2.	Area 0 to 40, >=	0.090	m.rad
3.	Area 30 to 40, >=	0.030	m.rad
4.	Max GZ at 30 or >, >=	0.20	m
5.	Angle of Max GZ, >=	25	deg
6.	Initial GMT, =>	0.350	m
7.	Crew crowding at one vessel side, <=	10	deg
8.	High speed turning angle, <=	10	deg
9.	Angle of steady hell condition	16	deg
10.	Area 1/Area 2 >=	100	%

Table 4: Results of inclining test of Purse Seiner "Yana".

No	Boat parameter	Unit	Value			
			Scenario 1E	Scenario 2E	Scenario1F	Scenario. 2F
1	Additional load (water)	ton	0.667	0.000	0.667	0.000
2	Personal load (crew)	ton	0.900	1.725	0.900	1.725
3	Total load	ton	1.567	1,725	1.567	1.725
4	Average draft midship	m	0.514	0.522	0.514	0.522
5	Trim (by stern)	m	0.202	0.200	0.202	0.200
6	Volume displacement	m^3	13.502	13.815	13.502	13.815
7	Weight displacement	tons	13.840	14.160	13.840	14.160
8	Metacenter height KM	m	1.915	1.863	1.915	1.893
9	Distance weight from CL	m	0.171	1.200	0.729	0.650
10	Tan ϕ	rad	0.125	0.143	0.077	0.077
11	Metacenter height GMt	m	1.062	1.020	1.066	1.024
12	Vertical center of gravity KG	m	0.853	0.873	0.849	0.876
13	Ratio KG/H	-	0.723	0.740	0.722	0.737
14	Inclination angle	deg	7.171	8.153	4.424	4.424
	Resume		Scenario 1	Scenario 2		
1	Average KG	m	0.854	0.874		
2	Ratio KG/H	-	0.723	0.740		

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Table 5: Results of Inclining Test MV. Yora 01.

No	Position	w	d	W	Iy	Ix	Tan α	
		(ton)	(m)	(ton)	(m)	(m)	radian	degree
1	Left	0.494	1.925	25.631	1.220	0.081	0.066	3.798
2	Right	0.494	1.925	25,631	1.220	0.062	0.051	2.909

Table 6: Value of GMT and KG of Yora 01.

No	Position	GM(m)	KG(m)	H(m)	Rasio KG/H (%)
1	Left	0.559	1.493	2.010	74%
2	Right	0.703	1.322	2.010	66%
	Average	0.644	1.408	2.010	70%

Table 7: Stability Parameters of Purse Seiner "Yana".

Code: A.749(18) Ch.3 Applicable to all ships and Reg.28.Ch III.1977 for fishing vessels								
No	Criteria	Value	Unit	Actual	(cargo on deck)			Status
				Empty	1 ton	2 tons	3 tons	
A. Empty condition (departure)								
1	Area 0 to 30. >=	0.005	m.rad	0.116	0.102	0.101	0.094	pass
2	Area 0 to 40. >=	0.090	m.rad	0.180	0.156	0.155	0.144	pass
3	Area 30 to 40. >=	0.030	m.rad	0.064	0.056	0.054	0.049	pass
4	Max GZ at 30 or >.>=	0.20	m	0.368	0.334	0.312	0.295	pass
5	Angle of Max GZ.>=	25	deg	33.6	31.8	31.5	30.9	pass
6	Initial GMT. >=	0.350	m	1.020	0.887	0.833	0.778	pass
7	Crew crowding. <=	10	deg	8.3	8.55	8.70	8.90	pass
8	Turning angle. <=	10	deg	1.0	1.2	1.26	1.30	pass
9	Severe wind. <=	16	deg	1.3	1.30	1.30	1.30	pass

Table 8: Stability Parameters of MV. Yora 01 at Departure Conditions.

Regulasi 28 Chapter III dari (International Conference on Safety of Fishing Vessels, 1977, IMO, London, 1977)					
Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	0.0550	m.rad	0.0643	Pass	+16.99
3.1.2.1: Area 0 to 40	0.0900	m.rad	0.1200	Pass	+33.31
3.1.2.1: Area 30 to 40	0.0300	m.rad	0.0556	Pass	+85.45
3.1.2.2: Max GZ at 30 or greater	0.200	m	0.365	Pass	+82.50
3.1.2.3: Angle of maximum GZ	25.0	deg	45.5	Pass	+81.82
3.1.2.4: Initial GMt	0.150	m	0.425	Pass	+183.33
3.1.2.5: Passenger crowding: angle of equilibrium	10.0	deg	8.5	Pass	+15.24
3.1.2.6: Turn: angle of equilibrium	10.0	deg	4.0	Pass	+60.06
3.2.2: Severe wind and rolling				Pass	
Angle of steady heel shall not be greater than (<=)	16.0	deg	6.3	Pass	+60.77
Angle of steady heel / Deck edge immersion angle shall not be greater than (<=)	80.0	%	22.01	Pass	+72.49
Areal / Area2 shall not be less than (>=)	100.0	%	237.47	Pass	+137.47

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Table 9: Stability Parameters of MV. Yora 01 on Arrival at Fishing Ground.

Regulasi 28 Chapter III dari (International Conference on Safety of Fishing Vessels, 1977, IMO, London, 1977)					
Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	0.0550	m.rad	0.0641	Pass	+16.56
3.1.2.1: Area 0 to 40	0.0900	m.rad	0.1195	Pass	+32.81
3.1.2.1: Area 30 to 40	0.0300	m.rad	0.0554	Pass	+84.75
3.1.2.2: Max GZ at 30 or greater	0.200	m	0.364	Pass	+82.00
3.1.2.3: Angle of maximum GZ	25.0	deg	45.5	Pass	+81.82
3.1.2.4: Initial GMt	0.150	m	0.425	Pass	+183.33
3.1.2.5: Passenger crowding: angle of equilibrium	10.0	deg	8.5	Pass	+14.92
3.1.2.6: Turn: angle of equilibrium	10.0	deg	4.0	Pass	+60.11
3.2.2: Severe wind and rolling				Pass	
Angle of steady heel shall not be greater than (<=)	16.0	deg	6.3	Pass	+60.61
Angle of steady heel / Deck edge immersion angle shall not be greater than (<=)	80.0	%	22.03	Pass	+72.46
Areal / Area2 shall not be less than (>=)	100.0	%	236.16	Pass	+136.16

Table 10: Stability Parameters of MV. Yora 01 on leaving Fishing Ground.

Regulasi 28 Chapter III dari (International Conference on Safety of Fishing Vessels, 1977, IMO, London, 1977)					
Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	0.0550	m.rad	0.0613	Pass	+11.42
3.1.2.1: Area 0 to 40	0.0900	m.rad	0.1175	Pass	+30.60
3.1.2.1: Area 30 to 40	0.0300	m.rad	0.0563	Pass	+87.53
3.1.2.2: Max GZ at 30 or greater	0.200	m	0.363	Pass	+81.50
3.1.2.3: Angle of maximum GZ	25.0	deg	44.5	Pass	+78.18
3.1.2.4: Initial GMt	0.150	m	0.389	Pass	+159.33
3.1.2.5: Passenger crowding: angle of equilibrium	10.0	deg	8.5	Pass	+15.28
3.1.2.6: Turn: angle of equilibrium	10.0	deg	4.0	Pass	+60.30
3.2.2: Severe wind and rolling				Pass	
Angle of steady heel shall not be greater than (<=)	16.0	deg	5.9	Pass	+62.99
Angle of steady heel / Deck edge immersion angle shall not be greater than (<=)	80.0	%	21.68	Pass	+72.90
Areal / Area2 shall not be less than (>=)	100.0	%	273.41	Pass	+173.41

Table 11: Stability Parameters of MV. Yora 01 on arriving at home base.

Regulasi 28 Chapter III dari (International Conference on Safety of Fishing Vessels, 1977, IMO, London, 1977)					
Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	0,055	m.rad	0.0623	Pass	+13.34
3.1.2.1: Area 0 to 40	0,090	m.rad	0.1181	Pass	+31.25
3.1.2.1: Area 30 to 40	0,030	m.rad	0.0558	Pass	+85.95
3.1.2.2: Max GZ at 30 or greater	0,200	m	0.351	Pass	+75.50
3.1.2.3: Angle of maximum GZ	25	deg	43.6	Pass	+74.54
3.1.2.4: Initial GMt	0,350	m	0.371	Pass	+147.33

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3.1.2.5: Passenger crowding: angle of equilibrium	10	deg	8.7	Pass	+13.35
3.1.2.6: Turn: angle of equilibrium	10	deg	4.3	Pass	+57.09
3.2.2: Severe wind and rolling				Pass	
Angle of steady heel shall not be greater than (<=)	16	deg	6.2	Pass	+61.11
Angle of steady heel / Deck edge immersion angle shall not be greater than (<=)	80	%	23.42	Pass	+70.73
Areal / Area2 shall not be less than (>=)	100	%	106,23	Pass	6,23

The results of inclining test for fishing boat skipjack pole and line MV. Yora 01 is presented at Tables 5-7.

The test was executed at vessel empty condition without cargo (captured fish), liquids and consumables. All internal and external effects were avoided during the test.

Resume from the inclining test:

a) An average ratio of KG/H of purse seine fishing vessel is 0.73 or KG = 0.73 H

b) An average ratio of KG/H of skipjack pole and line fishing vessel is 0.70 or KG = 0.70 where H is deck height of the vessel

c) This value of ratio KG/H may be applied at initial design stage of the vessel.

Results of Stability Parameters

Results of stability parameters of purse seiner fishing vessel Yana is presented at Table 7. In this scenario the vessel at departure condition has no cargo. It was set as an empty condition. Furthermore, catching operation for most purse seiner mostly is executed at rumpon, a certain spot provided by fixed floating platform where fishes stay beneath it. The vessel comes at this spot and wait until the down for catching process. The results of catching are varied. Our experiences found that the results varied from 0.5 to 3 tons. Therefore, in this scenario the loads are varied from 1 to 3 tons. The results of stability parameters purse seiner Yana are presented at Table 7.

Furthermore, the results of stability parameters of fishing vessel skipjack pole and line MV. Yora 01 are presented at Tables 8-11. Unlike purse seiner, skip jack pole and line operates for hours where it can reach one day time from the early morning until the afternoon. The vessel operates in the fishing ground to search and catch tuna or skipjack tuna fishes. In this case, it can catch the fish at several spots and according to the authors' experiences the maximum catching can reach 5 tons. The variation of load on the deck during operation was varied from 1 to 5 tons then the load condition when leaving and arriving at home base are presented also. The scenario of catching operation was set for these steps which are departure from home base, arrive at fishing ground, 5 periods of operation at fishing ground, leave fishing ground and arrive at home base. Thus, there are 9 steps of operation with time interval of 2 hours for each step.

Discussion

The result of inclining test KG and GMT give a useful guidance in determining the stability parameters of the vessels in various loading conditions. The parameter vertical centre of gravity KG of empty vessel does not change for ship while other load components such as cargo, liquid, consumable are changing then the parameter of ship stability will change due to operation conditions.

It was found from the inkling test that:

a) Average ratio of KG/H of purse seine fishing vessel is 0.73 or KG = 0.73 H where H is deck height of vessel

b) Average ratio of KG/H of skipjack pole and line fishing vessel is 0.70 or KG = 0.70

In fact, this value of ratio KG/H may be applied at initial design stage of similar fishing vessel.

Generally, placing the cargo on deck during vessel's operation may reduce the value of stability due to greater KG or lower GMT. In addition, when ship reach home base the value of stability parameters reduces due to reduce liquids at ship bottom that may increase KG or lower GMT.

Placing the cargo (captured fishes) on the deck of purse seiner at the maximum up to 3 tons would not be problem where at this condition the stability parameters satisfy the regulation. However, an attention should be made when placing cargo more than 3 tons on deck then further evaluation should be made.

Placing the cargo on deck during operation of skipjack pole and line will reduce the value of stability parameters. Furthermore, at the maximum of 5 tons cargo on deck this scenario is still satisfy the regulation of vessel's stability. However, with reducing of stability parameters particularly GMT when leaving the fishing ground should be considered seriously.

Conclusion and Recommendation

Conclusion

Some points may be withdrawn from this study including:

a) The real value of ratio KG/H = 0.73 obtained from inclining test (empty condition) for purse seiner and KG/H = 0.70

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for skipjack pole and line were used as reference for determining the whole stability parameters of the observed vessels.

b) These values of ratio KG/H may be used as reference for new initial design phase or other operational purposes stability parameter of similar fishing vessel.

c) Generally, loading condition of placing cargo on deck will decrease stability quality at significant but in the case of observed fishing vessels of purse seiner and skipjack pole and line the vessels are still in stable condition.

d) Decreasing of stability parameters of those two observed vessels due to placing cargo on deck is still be accepted. However, for the cargo of more than 3 tons on purse seiner and 5 tons on skipjack pole and line these scenarios should be considered and evaluated again.

Recommendation

a) It is recommended to use the nondimensional ratio of KG/H as reference at initial design stage or other operational purposes for similar fishing vessel.

b) Catching proses at one-night fishing may be doubled where the first catchment may be placed in fish holds and the second catchment may be placed on deck. In this scenario, the stability parameters should be evaluated further.

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