Comparative Studies of Small Purse Seiner in North Sulawesi, Indonesia

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Abstract

A series measurement of coastal fishing boats (small purse seiners) has been made in North Sulawesi province, Indonesia. The goal of this study is to clarify the physical characteristics of the small purse seiners in North Sulawesi. First of all we examined the boat form of the purse seiners and practical conditions under fishing operations. Based on the data, the characteristics such coefficient of fineness and the boat's stability were calculated.

Typical fishing boats in Indonesia have conventional round hull shapes with a long bar keel. Purse seiners in North Sulawesi have different characteristics in every region, especially for principal dimensions and boat's designs.

The results of the analysis are as follows: the boat types are relatively slim around the hulls and have the round shape under water, stability values are relatively small, and the cluster based on the principal dimensions and the coefficient of fineness has been categorized into two groups and three classes.

Keywords: *Small purse seiners, stability, North Sulawesi, Indonesia*

1. Introduction

As the fishing productions of North Sulawesi are relatively little comparing to its resources, the effective fishing technology is very important to utilize the fisheries with rational and optimal standard. To develop the fisheries, the fishing boat is one of the important factors among other fishing units. In general, the fishing boats utilizing in capture fisheries is the most capital in the fishing business.

The accidents of fishing boat generally occur 1 - 2 times per year because of miss loading of catch or cargo etc. on boat deck under the bad condition of weather. Especially, from September to January, the fishermen sometimes encounter stormy weather with the wind speed of 4.7-12.5 m/s and the wave height of 2.0 - 5.0 m.

The hull designs of fishing boats in Indonesia are rather different from those in other countries. Typical fishing boats have conventional round hull shapes with a long bar keel⁽⁷⁾.

In North Sulawesi, the purse seiners operated in this area have different characteristics from other area on technical and economic aspects. Especially, the stability, principal dimensions, and boat's designs for every region in North Sulawesi have different characteristics. However, there is few report about the technical characteristic of purse seiners.

Therefore, the field experiments for the stability of small purse seiner were carried out to know the

condition of stability of purse seiners used in North Sulawesi, Indonesia.

2. Material and Methods

2.1. Data measurement

In this study, twelve fishing boats of the small purse seiners in North Sulawesi were selected. As shown in Fig. 2, these fishing boats are operating at the sea around Bitung, Manado, and Molibagu. The hull of all the boats have conventional round hull shape with a long bar keel as shown in Fig. 1. In addition, the four boats were chosen from the twelve fishing boats to calculate the static and dynamic stability.

In general, manufacture of traditional fishing boats in North Sulawesi does not use a body plan, so that all boats used in this study were needed to measure ship form and to make molded plan, as follows:

- a. Measurements covering the main dimension: L (length overall), B (moulded breadth), D (depth), L_{wl} (water line length), d (draft) (Fig. 4).
- b. Drawing hull design used a pantograph with the following procedures (Fig. 6):
 1. The length of the ship is almost divided into eleven sections from the stern to the bow in accordance with the characteristics of the hull.

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2. Utilization of the pantograph with scale 1:5 for drawing the hull in every section; the pantograph was clipped on the freeboard deck line and then the arm of the pantograph was pulled along the hull from the keel until the freeboard deck line.

Stability test by the moment system was conducted on the following procedures:

- a) Keeping the ship under still condition.
- b) Measuring the ship breadth.
- c) Place the clinometer at amidships.
- d) Sand as the burden placed on the periphery at amidships of boats as shown in Fig. 5.

- e) The angle on the clinometer indicates the inclination of the boat.

Method in this study was followed to the procedure presented by some researches^(1,2). The principal dimensions, coefficient of fineness and the boat's stability by using the moment system were calculated. The boat volume was estimated by the Simpson's rules as commonly used at naval architectural works^(1,2,3,4,5). In addition, the cluster analysis was done using the principal dimensions and the fineness coefficients to compare the characteristics of each area.

(a) Body plan of Bitung3

(b) Body plan of Jayakarya2

(c) Body plan of Bitung5

(d) Body plan of Bunaken

Fig. 1 Boat body plans of the purse seiners

Fig. 2 Experimental field in North Sulawesi province

Table 1 Main dimensions of the purse seiners in North Sulawesi

Name of boat	Location	<i>L</i> (m)	<i>B</i> (m)	<i>D</i> (m)	<i>d</i> (m)	Δ (ton)	<i>KG</i> (m)	<i>GM</i> (m)
Tersanjung	Bitung	15.85	2.90	1.32	0.607	5.722	0.921	0.455
Aldies	Bitung	15.50	2.80	1.10	0.531	5.781	0.715	0.371
Bitung1	Bitung	14.72	3.81	1.44	0.864	13.012	2.206	0.273
Bitung2	Bitung	14.08	2.94	1.38	0.832	12.882	0.930	0.545
Bitung3	Bitung	10.72	2.27	0.99	0.584	4.910	0.910	0.263
Bitung4	Bitung	12.50	2.85	1.46	0.864	12.442	0.921	0.411
Bitung5	Bitung	19.20	4.26	1.74	0.576	12.571	1.556	1.033
Bunaken	Manado	20.20	4.72	1.64	0.505	10.298	0.917	0.861
Jayakarya1	Molibagu	18.72	4.10	1.60	1.192	26.118	2.171	0.361
Jayakarya2	Molibagu	19.20	4.22	1.76	0.960	23.905	2.384	0.761
Jayakarya3	Molibagu	20.16	4.70	1.58	0.920	24.507	2.265	0.460
Balantungan	Molibagu	19.84	4.35	1.81	1.050	32.656	2.075	0.349

Fig. 3 Photos of the purse seiners

Fig. 4 Measurements covering the main dimension

Fig. 5 Photo of stability test by moment system

2.2 Boat stability^(6,8)

In this study, the metacentric height *GM* and the righting lever *GZ* are estimated by the moment system as follows :

$$GM = \frac{w \cdot d}{(\Delta + w) \cdot \tan \phi} \quad (1)$$

$$GZ = \sin \phi \cdot (GM + \frac{1}{2} BM \tan^2 \phi) \quad (2)$$

Where, *w* is weight

d is distance of movement

Δ is boat's displacement

ϕ is the angle of inclination

In addition, dynamic stability D_{st} is defined as follow:

$$D_{st} = \int_0^{\phi_i} \Delta \cdot GZ d\phi \quad (3)$$

Where, ϕ_i is the angle of vanishing stability

Fig. 6 Drawing hull design used pantograph system

3. Result and Discussion

3.1 Main dimensions and Coefficient of fineness

Calculation results of fineness coefficient are shown in Table 2. It is indicated that the purse seiners in North Sulawesi are slim around the hulls and have the rounded shape. Then, damping effect for rolling motion would be very weak. Such boat form is very effective for the speed of the boat. However, for the longitudinal strength, the hull structure is weak. This suggests the hull is easily broken when big waves hit.

Table 2 Comparison of the main particulars and Coefficients of fineness

Name of boats	L/B	L/D	B/D	Cb	Cp	Cmid	Cw
Tersanjung	5.47	12.01	2.20	0.570	0.786	0.725	0.868
Aldies	5.54	14.09	2.55	0.536	0.727	0.736	0.793
Bitung1	3.86	10.22	2.65	0.358	0.597	0.600	0.691
Bitung2	4.79	10.20	2.13	0.468	0.684	0.685	0.772
Bitung3	4.72	10.83	2.29	0.446	0.764	0.584	0.718
Bitung4	4.39	8.56	1.95	0.553	0.763	0.725	0.784
Bitung5	4.51	11.03	2.45	0.398	0.605	0.545	0.699
Bunaken	4.28	12.32	2.88	0.398	0.685	0.356	0.720
Jayakarya1	4.57	11.70	2.56	0.430	0.670	0.641	0.686
Jayakarya2	4.55	10.91	2.40	0.523	0.653	0.801	0.822
Jayakarya3	4.29	12.76	2.97	0.395	0.639	0.617	0.687
Balantungan	4.56	10.96	2.40	0.527	0.734	0.718	0.834

Fig. 7 Center of gravity position against the deck

3.2 Center of gravity

Table 1 presents the results of the calculation of KG . The results show that some boats have a center of gravity (G) above the deck, as shown in Fig. 7.

In Fig. 7, there are five boats that center of gravity (G) position is above the deck, and G positions of the seven boats are under the deck. From field observations, there are five boats that have a house like the bridge on the deck, and there are two boats approaching the G position close to the deck because the house is not too big, and G position of other five boats without house are under the deck.

Fig. 8 shows that the length of the boats does not affect to the high value of KG . However, the value of KG is determined by the existence of the house on the deck.

From these results, it is clear that the existence of houses on the deck will strongly affect the G position.

3.3 Stability

Calculated results of static stability are shown in Table 3. The GZ values for the four fishing boats show the regional characteristics. The GZ values on every fishing boat are relatively small (Table 3).

Table 3 GZ_{Max} and Dynamical Stability

Name of boat	Static Stability		Dynamical stability	
	angle (°)	GZ_{Max}	angle (°)	(m.rad)
Jayakarya2	30.00	0.249	26.62	0.245
Bitung3	42.50	0.304	21.14	0.198
Bunaken	45.00	0.684	21.41	0.349
Bitung5	42.50	0.450	31.36	0.385

The broken lines in Fig. 9 indicate the heeling angle that the deck side is even to the sea level. As the deck of small purse seiners are not water tight construction, sea water will flood into the boat when heeling angle exceed this angle. The practical angles on the purse seiners used in this calculation are 21.14 deg for Bitung3, 26.62 deg for Jayakarya2, 31.36 deg for Bitung5 and 21.41 deg for Bunaken (Fig. 9), respectively.

Fig. 8 Relationship between L and KG

Fig. 9 Stability curves of the purse seiners

3.4 Cluster analysis

To investigate regional characteristics of the small purse seiners, the cluster analysis was applied using the parameters, principal dimension, fineness coefficients and stability parameters, as shown in Fig. 10. The purse seiners in North Sulawesi used in this study are categorized into two groups and three classes.

The first group has only one class from the contents of the boat used in Molibagu. The second

group consists of fishing boats used in Bitung and Bunaken.

Grouping is dominated by the displacement of boats shown in Fig. 11, the first group is 23.905 tons – 32.656 tons and the second group is 4.910 tons – 13.012 tons. Further, the second group is divided into two classes based on the length of the boat, in this case, the first class has a length of 10.72 m – 15.50 m and the second class has a length of 15.85 m – 20.20 m.

Fig. 10 Dendrogram of the purse seiners

Fig. 11 Scatter diagram between displacements and L

4. Conclusions

Through the present analysis, we summarized as follows:

- (1) The boat types in North Sulawesi are relatively slim around the hulls and have the round shape under water.
- (2) As the GZ values of purse seiners in North Sulawesi are relatively small, the boats will easily upset during fishing operations.
- (3) Dynamic stability value is relatively small. Hence, seawater easily enters into the boat while sailing on rough sea, especially from September to January.
- (4) The purse seiners in North Sulawesi are classified into two groups and three classes, from the cluster analysis.

As there are frequent accidents at sea during fishing operations, we show some suggestions:

- (1) Fishermen should know the safe condition of weather to engage fishing operations. If the weather condition is not suitable, fishing operations should be canceled.
- (2) Fishermen should recognize how to arrange catch, cargo, etc. on the board so the boat will easily upset because of miss loading on the deck.

5. Acknowledgement

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Question and answer

Seichi Takeda (Tokyo University of marine sciences and Technology) :

Are there any agency recorded marine accidents in North Sulawesi, Indonesia?

Are the above-mentioned agencies conducting record about all of marine accident?

Heffry Veibert Dien :

Information about the marine accident can be obtained from:

1. Marine Police Department.
2. Department of marine and fisheries (especially for fishing boat).

Jun Kayono (Tokyo University of marine sciences and Technology) :

Why are the boats types of North Sulawesi relatively slim?

Why are GM values of purse seiner in North Sulawesi relatively small?

Heffry Veibert Dien :

Fishermen need high speed fishing boat so hull shape is slim. As the existence of house on the deck strongly affects the stability, the GM value of the fishing boats with house is relatively small.