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Study on the Stability of Purse Seiners in Manado

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Abstract
This study aims to estimate and analyze the static and dynamic stability of small purse seines used by the fishermen in Manado, North Sulawesi Province. Measurements were done on the main dimensions of the vessels to determine the vessel conditions in fishing operations. Results showed that the vessel on study was slim with several stability values inconsistent with the standard of International Maritime Organization. To increase the stability, the goods placement needs to be rearranged to obtain the change in the trim by head from 0.358 to 1.118, and thus, the fishing operations safety could be maintained.
Keywords: *Trim, Goods arrangement, IMO standard, fishing.*

Introduction

Fishing vessel is a very important investment in fishing fisheries business (Masengi et al., 2000), since it spends a lot of money (Pasaribu et al., 1986). It can be used in fishing operations, for marine resources collections, research, training, and monitoring activities (Ayodhyoa, 1972). Different from other ships, such as kapal penumpang atau kapal barang, fishing vessels have more complex and heavier operational functions (Kayadoe et al., 2015). Thus, a fishing vessel needs several specific requirements, i.e. movement flexibility, stability, speed, seaworthiness, and facilities (Matafi et al., 2015).

Fishermen's traditional vessels with a total length below 25 m are generally traditionally made (Mulyatno et al., 2019), and the purse seine vessels used in Manado, North Sulawesi, are traditionally made of wood (Dien, 2013). This type of fishing vessel is one of the fishing vessels with particular form variations depending upon the development locality (Pamikiran et al., 2020).

In general, the vessel stability is influenced by internal factors, such as goods placement arrangement, ship shape, and size, and external factors, such as wind, waves, and currents (Matafi et al., 2015). In spite of these, the vessel is made for the same purpose to support a fishing operation.(Pamikiran et al., 2020).

Safety in fishing operations is mostly determined by the vessel stability, the ability of the vessel to return to the initial position from the tilt position due to the external or internal forces of the ship (Hind, 1967).

The ship is called stable when the ship tends to go back to the initial position at the time it is born to the tilt position. The ship is called not stable when the ship tends to be away from the initial position at the time it is born to the tilt position. The ship is called in neutral condition when the ship stays at the position at the time it is born to the tilt position (Atwood, 1967).

Ship stability is divided into static and dynamic stabilities (Putranto et al., 2017). The former is determined by the righting arm (GZ) value while the latter is obtained by calculating the area below the static stability curve. Ship stability is one of the major requirements to ensure safety and working convenience on board (Smith, 1975). The crucial points in vessel stability are the center of gravity (G), central to the whole gravity force, the center of buoyancy (B), central to the whole buoyant force, and the metacenter (M), the intersection of the load line of B in the up-right condition and moved B` at angle Ø [9,13]. Point M is the maximum point of G. Therefore; the positions of point B vary depending on the shape of the hull under water line.

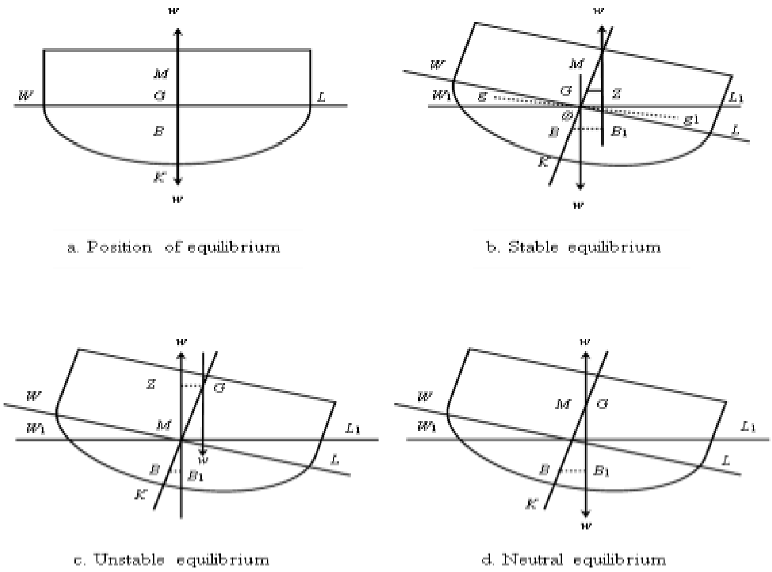

Figure 1 Ship equilibrium position (Smith, 1975). B - centre of buoyancy, G - centre of gravity, M - Metacentre, GZ - Righting arm, K - Keel, WL - Water line, w – Force, Ø - Rolling angle.

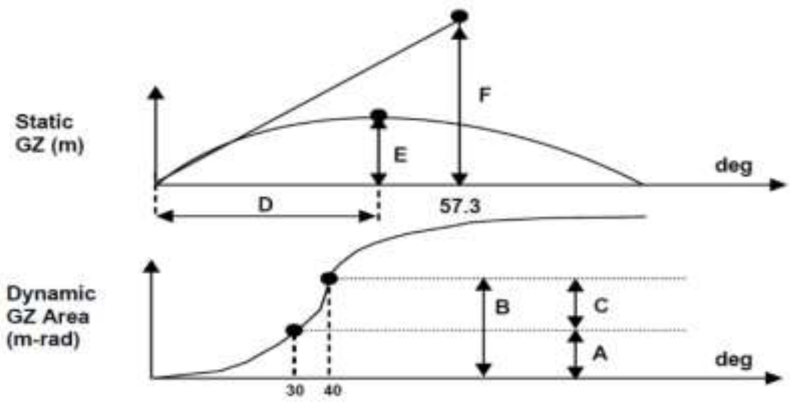

Figure 1. Stability criterion curve (Fyson, 1985). A - area under the GZ curve from 0^o to 30^0, B - area under the GZ curve from 0^0 to X^0, $X^0 = 40^0$ or less than 400, C - area under GZ curve from 30^0 to X^0, D - Righting lever/righting arm (GZ), E - Maximum value of righting lever/righting arm (GZmax), F - GM (Metacentric height)

About 50-60% of ship accidents of capsizing is caused by the loss of stability (Alvite-Castro et al., 2020). Studies on (Dien et al., 2010) and roll dumping in fishing operations (Dien et al., 2012). In a simulation study on the effect of trim on the purse seine vessel stability (Matafi et al., 2015), it was found that the addition of the trim by the head value could increase the stability of the small purse seines operated in Manado, North Sulawesi. This study is aimed at estimating the stability of the small purse seiner operated by fishermen in Manado, North Sulawesi.

Material and Methods

This study applied a descriptively experimental method, i.e a method to know the present status of an object to make a systematic It is based on the case study [in the small purse seines operated in North Sulawesi waters (Ariyanto, 1986).

Data collections used field observation and direct measurements. Measurements of the ship major dimensions covered the length over all (Loa), the total length of the ship measured from the fore edge to the rear edge, the ship width (B), the distance of one outer side to the other, the ship depth (D), the height of ship measured from the lowest deck to the lowest inner part of the ship body, and the trim, the difference between the bow and the stern.

The stability test was done through a system moment experiment as follows: a) Keeping the ship under still condition. b) Measuring the ship breadth. c) Place the clinometer at the amidships. d) Sand as the burden placed on the periphery at amidships of boats. e) The angle on the clinometer indicates the inclination of the boat (Dien et al., 2010), (Dien et al., 2012). The value of the parameters measured was then compared with the standard of the International Maritime Organization (IMO) (International Maritime Organization, 1995)

Data were processed to obtain the hydrostatic parameters using the formula of Nomura and Yamazaki (Yamazaki & Nomura, 1977) as follows:

$$\mathrm{Cb} = \frac{\nabla}{Lwl\ x\ Bwl\ x\ d}$$

$$\mathrm{Cp} = \frac{\nabla}{\mathrm{A}\otimes\ x\ Lwl}$$

$$\mathrm{C}\otimes = \frac{\mathrm{A}\otimes}{\mathrm{d}\ x\ Bwl}$$

$$\mathrm{Cw} = \frac{\mathrm{Aw}}{\mathrm{Lwl}\ x\ Bwl}$$

Where:
Cb = Block coefficient
Cp = Prismatic coefficient
C⊗ = Mid-ship coefficient
Cw = Water plane coeficient
Lwl = water line lengthr (m)
Bwl = the widest width on certain water line (m)
d = draft (m)
A⊗ = area of midship (m2)
Aw = area of certain water line (m2)
∇ = volume displacement (m3)

The analysis of the ship area and volume followed Simpson I (Yamazaki & Nomura, 1977):

$$\mathrm{A} = \frac{\mathrm{h}}{3}(\mathrm{y1} + 4\mathrm{y2} + 2\mathrm{y3} + \ ... + 2\mathrm{yn} - 2 + 4\mathrm{yn} - 1\ + \mathrm{y\ n}\,)$$

$$\nabla = \frac{\mathrm{H}}{3}(\mathrm{A1} + 4\mathrm{A2} + 2\mathrm{A3} + \cdots + 2\mathrm{Am} - 2 + 2\mathrm{Am} - 1 + \mathrm{A\ m})$$

$$\Delta\ = \nabla\ \mathrm{x}\ \rho$$

Where:
A = Area
∇ = Volume
Δ = Weight Displacement
h = the ship length divided by 10 sections,
y= ordinate,

n = Number of ordinates used,
H = the length of water line divided by 10 sections,
A = area on certain section (m^2),
V = volume displacement (m^3),
Δ = weight displacement (ton), and
ρ = seawater density (1.025 ton/m^3)

The stabilty testing followed Hind (1967) as follows:

$$GM = \frac{w \, x \, d}{\Delta \tan \Theta}$$

Where:
GM=gravity to metacenter (m),
w = weight (ton),
d=distance of movement (m), and
θ=inclination angle (^{O}).

The determination of the stability followed Attwood and Pangelly (1967) as follows:

$$GZ = \text{Sin } \Theta \ (GM + \tfrac{1}{2} \ BM \tan^2 \Theta)$$

$$BM = \frac{I}{V}$$

Where:
BM = distance from buoyancy to metacenter (m),
V = volume of displacement (m^3),
I = moment inertia (m^4),
GM = Gravity metacenter (m), and
Θ = inclination angle (°)

Results and Discussion

Purse seine vessel description

The major dimension, displacement, and shape coefficient are presented in Table 1. Based on the measurement and analysis, it was found that the ship on study was elongated and slender with a trim by head of 0.683.

Table 1 Purse seine vessel specification

No.	Parameter	Vessel sample
1.	Length (m)	22,50 m
2.	Width (m)	4.25 m
3.	Depth (m)	2.00
4.	Displacement (ton)	16.428
5.	Volume (m3)	16.027
6.	Cb	0.491
7.	Cp	0.613
8.	Cw	0.804
9.	C⊗	0.871
10	Trim	0.683

Figure 3. Small Purse seine vessel

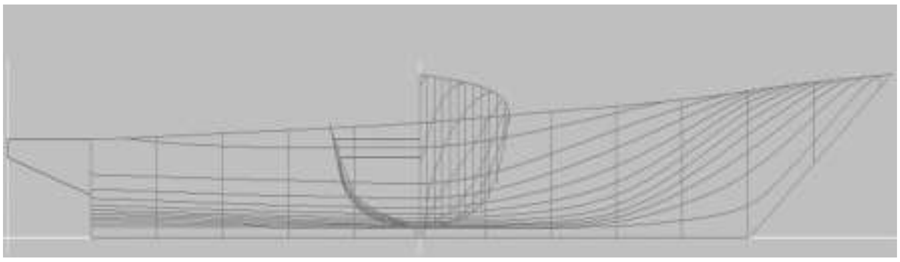

Figure 4. Purse seine vessel Hull-Line

Stability parameters

The position of the stability points, KB (Keel-Bouyancy), KG (Keel-Gravity), and KM (Keel-Metacenter), is presented in Table 2.

Table 2 Stability parameters of the ship samples

Ship sample	BM (m)	KG (m)	KB (m)	GM (m)	KM (m)
Trim by head of 0.683	2.695	2.104	0.408	0.999	3.103
Trim by head of 1.443	1.156	1.270	0.297	1.463	2.733

Table 2 demonstrates that the ship on study shows the position of points B, G, and M to the K point in stable balance condition, in which M is above G which makes KM have a bigger value than KG, meaning that the small purse seiner has a positive GM value. This positive GM value makes the righting moment move in a contradictory direction to the ship's slants so that when the ship experiences a wooble, it will be able to return to an upright position (Muckle, 1975).

GZ is the righting arm of the ship to return to the initial position shown by the shift of point G when the balance changes to point G' after being wooble. The distance from G to G' is GZ (Hind, 1967; Smith, 1975). The shift of the point in each condition will yield different stability curve image (Figures 5 and 6). The GZ values are given in Table 3.

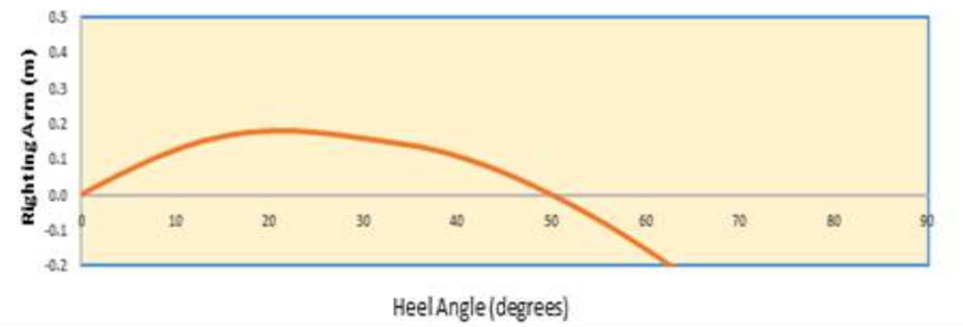

Figure 5. Stability curve trim by Head 0.358

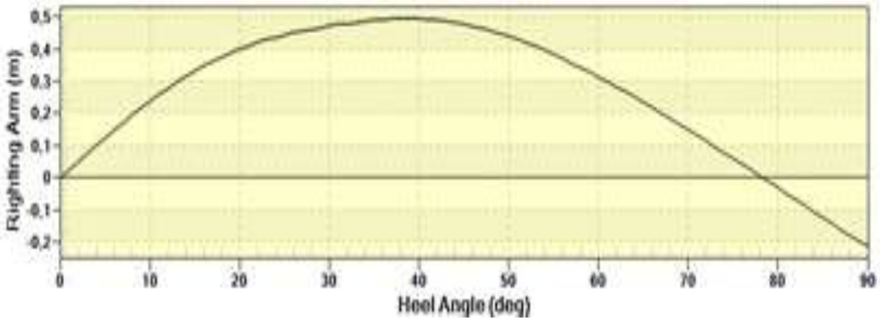

Figure 6. Stability curve of trim by Head 1.118

Table 3 GZ value of the purse seiner on study and standard imo value

GZ curve value	Standard IMO (Minimum value)	Trim by Head 0.358	Trim by Head 1.118
A (0-30^0)	0.055 m-rad.	0.069 m-rad	0.145 m-rad
B (0-40^0)	0.090 m-rad.	0.093 m-rad	0.230 m-rad
C (30-40^0)	0.030 m-rad.	0.024 m-rad	0.085 m-rad
D (GZ angle)	30 deg	26.29 deg	30.56 deg
E (GZ)	0.2 m	0.175 m	0.518 m
F (GM)	0.15 m	0.999 m	1.463 m

Based on GZ estimation (Table 3), the fishing vessel on study has good static and dynamic stability, two stability parameters are still below the IMO standard (vessel sample of Trim by Head 0.358), namely the GZ angle and the curve area of 30^0-40^0 which causes the ship stability decline and consequently influences safety in fishing operations. It could result from in item placement on the ship deck. To increase the ship stability, the goods placement arrangement could be done on the bow part and below the ship deck. The rearrangement of goods placement yielded the trim by head to change from 0.358 to 1.118 (Table 3). The rearrangement of goods placement changes the G point position and makes the point G shift toward the keel (K), then the distance point G to M becomes bigger (increased GM value. Table 3 at the trim by head of 1,118 and Figures 4 and 5 shows that the GZ angle changes from 26.29^0 to 30.56^0 and the GZ value from 0.175 m to 0.518 m, indicating that the trim change could increase the vessel stability.

Conclusion

The small purse seiners operated in Manado waters, North Sulawesi, had good stability and could yield safety during the fishing operation. Nevertheless, the goods arrangement onboard should also be considered to increase the vessel stability. The change in the Trim by Head from 0.358 to 1.118 could increase the vessel stability. Thus, the addition of the trim by head as much as 0.76 will be potential to increase safety during fishing operations. Nevertheless, the arrangement of goods and catch placement onboard is also needed to maintain the vessel stability.

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