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Stability analysis of trawls type traditional fishing boat with modification of eco-friendly fishing-gear on the north coast of Central Java

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Abstract. The prohibition of the use of fishing gear trawls in Indonesia's fishing territory requires fishermen to make replacements of fishing gear against their boats. The replacement of fishing gear on the boat affects the performance of the boat. This study was conducted to determine the extent to which the replacement can be applied to traditional fishing boat Trawls North Coast of Central Java. The study focused on the ring net and gill net as a catch tool. Based on the results of stability and seakeeping analysis, it can be concluded that the replacement of fishing gear is influenced by the loading factor of the used fishing gear equipment. The vessel with the replacement of the ring net and gill net has a stability below the value of stabilities owned by the traditional trawler of Juwana. For the results of motion analysis, the vessel has met the Tello criteria of acceptance of fish ship characteristics for vessels with full velocity and wave as high as 2m. The vessel has the highest rolling value of 3.31 deg, and slamming probability with the greatest value of 2.10% for speed 6 knots and 180 deg heading on head sea condition.

1. Introduction

Regulation of Ministry of Marine Affairs and Fisheries No. 2/Permen-KP/2015 has a big influence that must be resolved soon. Basically a significant change is very difficult to quickly apply. Fishermen need time and solutions of any changes or new rules that affect their lives. One solution that can be done is to impose a transition period and the transfer of fishing gear with other fishing gear according to the characteristics of the ship and of course the permissible fishing gear. In accordance with Ministerial Decree No. KP.KEP.06/MEN/2010 and Ministerial Regulation No. 2/2015 there are 8 (eight) fishing gear that is allowed in Indonesia.

The replacement of fishing gear on the boat affects the performance of the boat itself. The change of fishing gear must prioritize several factors on the vessel which will be very influential when the ship is in sailing condition. Ships must maintain good stability and seakeeping for safety and operational convenience.

In this study it is important to know the extent to which fish gear replacement can be effectively applied to Juwana's traditional Trawl fishing boats. The study focused on gear nets and ring nets as a catch tool. The selection of the gill net for gill net and purse seine for the ring net is based on the catch

target, the operational ease of the net, as well as the habits of the origin of the traditional ship. Researchers will analyze the stability and movement as a result of replacement fishing gear.

The purpose of this research are: to get a good general arrangement and equipment layout to modify the trawler with gill net and ring nets, and getting the changes in stability and seakeeping of the boat due to the replacement of fishing gear type Trawls with ring nets and gill nets.

2. Literature review

Ring net, according to National Oceanic and Atmospheric is a large net that forms walls deployed to catch clumped fish. According to the book Fishing Boat [1], the fish that are the catch of the ring net are "pelagic shoaling species" fish which means the fish must form a gang, close to the surface of the water and it is desirable that the fish gang is high, which means the distance of fish with other fish should be as close as possible.

Gill nets are a type of fishing tool that has long been used but still able to survive until now. The gill net is a rectangular net with the same mesh size. On the top side of the net is equipped with several floats and the bottom is equipped with sinker. The size of fishing vessels of this type of gill nets is very varied from small to large vessels operated in the open sea. Species of fish caught include *tetengkek* (*Megalacpis cordyla*), flying fish (*Cypselurus sp*), mullets (*Mugil sp*), *kuro* fish (*Polynemus sp*), *alu-alu* (*Sphyraena sp*), and mackerel (*Scromberomorus commersoni*).

The mandatory stability requirements of ships shall refer to the standards established by the local Indonesian Bureau of Classification or the Marine Authority such as International Maritime Organization (IMO). Thus the process of stability analysis carried out must be in accordance with IMO (International Maritime Organization) standards [2]. Code A.749 (18) Ch 3 - design criteria applicable to all ships Section A.749 (18), Chapter 3.1.2.3: The area under the curve GZ at oscillation angle 0^o- $30^o \geq 3{,}101$ m.deg, area 0^o- 40^o (deg) $\geq 5{,}157$ m.deg and area 30^o- $40^o \geq 1{,}719$ m.deg. Chapter 3.1.2.2: Maximum GZ value occurring at an angle of 30^o-$180^o \geq 0.2$ m. Chapter 3.1.2.2: angle at the maximum GZ value $\geq 25\ ^o$. Chapter 3.1.2.4: Early GM at $0^o \geq 0.15$ m.

In the study of ship movement, the movement under consideration is a movement that can only be responded by the ship, namely rolling, heaving, pitching [3]. The seakeeping fruits are evaluated by adjusting the seakeeping criteria standards depending on the type of vessel. In this study, the standard seakeeping used is the standard criterion [4] contained in table 1.

Table 1. Seakeeping criteria for fishing boat.

No	Criteria	Value
1	Green water deck	5% (prob)
2	Slamming	3% (prob)
3	Propeller emergence	15% (prob)
4	VA at Bridge	0.2 g (rms)
5	LA at Bridge	0.1 g (rms)
6	VA at work deck	0.2 g (rms)
7	LA at Work deck	0.1 g (rms)
8	Roll	6^o (rms)
9	Pitch	3^o (rms)

The ship movement response to regular waves is expressed in RAO (Operator Amplitude Response), where RAO is the ratio between ship's amplitude of movement (either translation or rotation) to wave amplitude at certain frequencies. The RAO movement's response to translational motion is a direct comparison between the amplitude of the ship's movement (Z0) with wave amplitude ($\zeta 0$) (both in unit length) as shown in equation (1).

$$RAO = \frac{Z_0}{\zeta_0} \quad \text{(m/m)} \quad (1)$$

While the rotational motion is the ratio of the amplitude of the rotational motion (in radians) with the wave inclination which is the multiplication of wave numbers, kw = ω2 / g with wave amplitude as shown in equation (2).

$$RAO = \frac{\theta_0}{kw\,\zeta_0} = \frac{\theta_0}{(w^2/g)\zeta_0} \quad \text{(rad/ rad)} \quad (2)$$

In fact, the waves at sea are random waves so the ship's response to the regular waves expressed in the RAO cannot describe the ship's response to the real state of the ocean. To obtain a motion response of ships against random waves can be described by the response spectrum [5] and [6]. Probability of slamming can be calculated using equation (3).

$$Nw = \frac{1}{2\Pi}\sqrt{\frac{2m_{OR}}{2m_{2_R}}} \text{ x } Pr\ (slamming) \quad (3)$$

where:

$Pr\ (slamming) = exp^{-y}$

y = $\frac{T^2}{2_{mo_S}} + \frac{V_{cr^2}}{2m_{2S}}$

T = draught of ship

V_{cr} = velocity threshold 0,093 $(gl)^{1/2}$

Nw = intensity of s*lamming* per second

Mor = area under curve spectrum response moment in zero 0

M_2r = area under curve spectrum response moment 2nd

Probability of deck wetness can be calculated using equation (4).

$$Pr\ (deck\ wetness) = exp^{-f} \quad (4)$$

where:

f = $\frac{T^2}{2_{mo_S}}$ = effective Freeboard

T = draught of ship

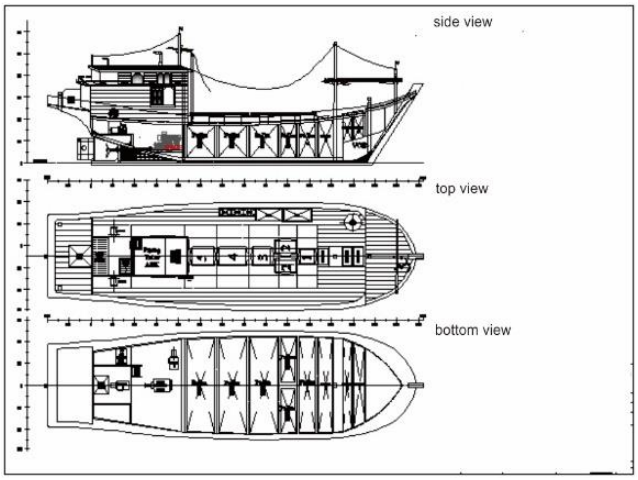
Mor = area under curve spectrum respon moment in zero 0

3. Results and discussion

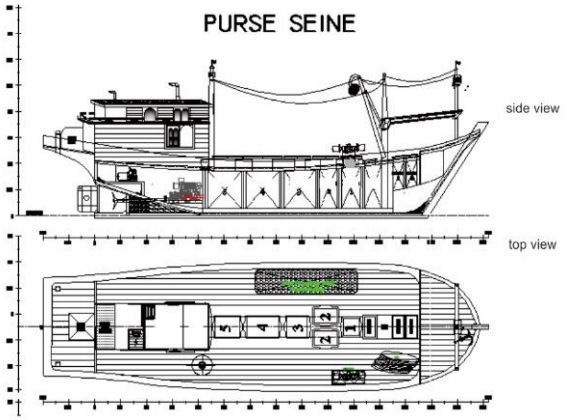
This study used four (4) variations or changes to the general plan layout of each type of fishing gear used in accordance with the loading of the fishing gear equipment [7, 8]. Given the replacement of fishing gear on a fishing boat will cause a change of ship's center of gravity which will affect stability.

Laying of equipment above deck or change of layout of general plan baracu at Indonesian Fish Shipowner from BPPI. The following is a drawing of the ship's general plan layout plan after reconstruction of the fishing gear and auxiliary equipment on the deck. Figure 1(a) shows the general arrangement of trawl at Juwana area, figure 1(b) shows the arrangement after changed using ring net and figure 1(c) shows the arrangement after changed using gill net. Figure 2(a) shows the general arrangement of trawl at Tegal area, figure 2(b) shows the arrangement after changed using ring net and figure 2(c) shows the arrangement after changed using gill net. Figure 3(a) shows the general

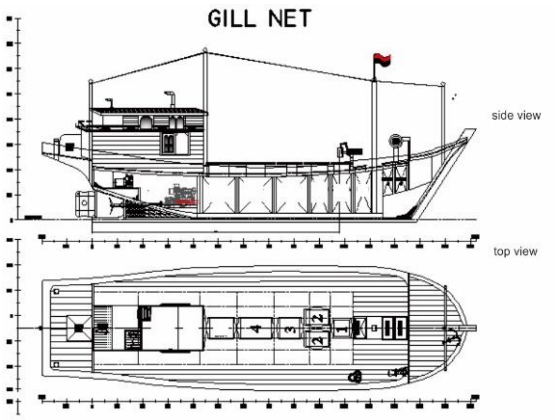
arrangement of trawl at Batang area, figure 3(b) shows the arrangement after changed using ring net and figure 3(c) shows the arrangement after changed using gill net.



(a) General arrangement of trawl at Juwana area



(b) The arrangement after changed using ring net



(c) The arrangement after changed using gill net

Figure 1. The ship's general plan layout plan after reconstruction at Juwana area.

The calculation of ship stability performed in this study analyzes the 3 conditions of each model that have been made, in accordance with IMO A.749 (18) Chapter 3.5. As for the 3 conditions are:

1) Condition I: Represents a ship condition before departing from port to fishing ground. Under these conditions, the vessel in a consumable charge state is empty.
2) Condition II: The ship is already on the fishing ground. In this condition, the ship has been given additional cargo ship (mackerel) 50%.
3) Condition III: The ship is still on the fishing ground. In this condition, the boatload (mackerel) is 100%.

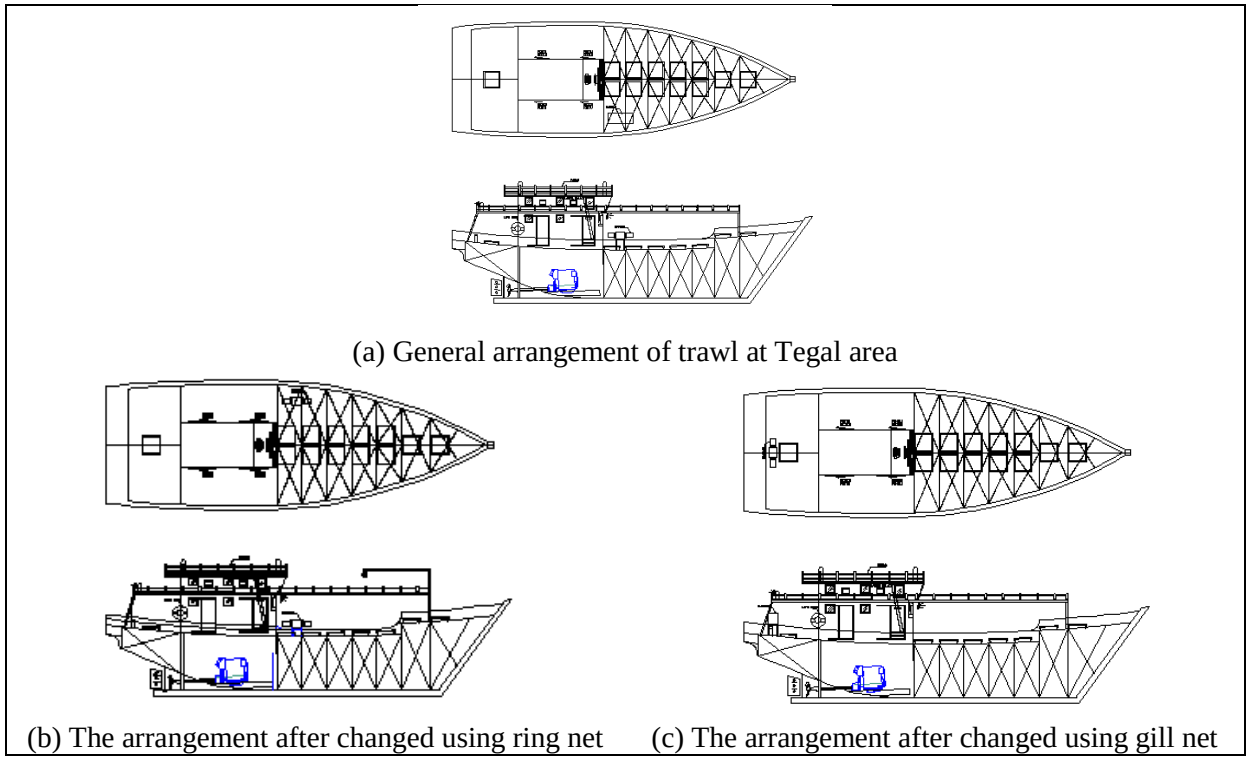


Figure 2. The ship's general plan layout plan after reconstruction at Tegal area.

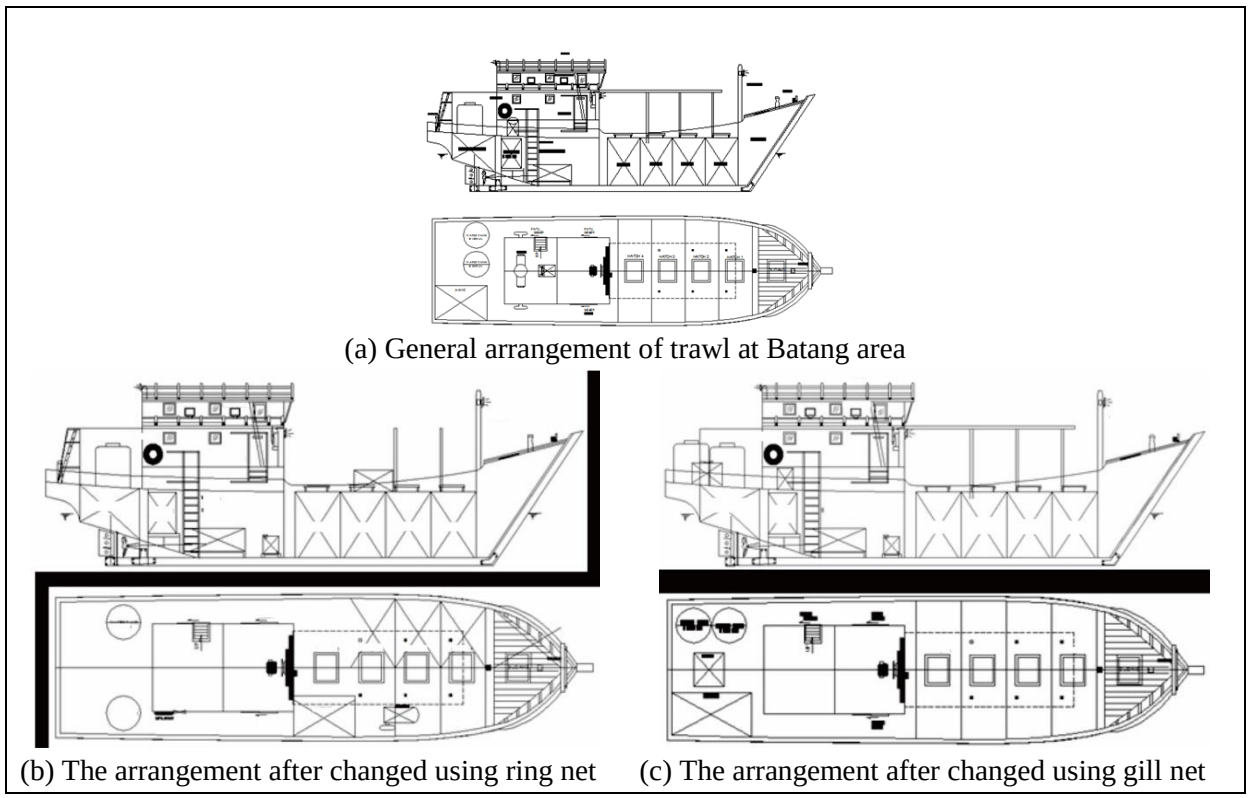


Figure 3. The ship's general plan layout plan after reconstruction at Batang area.

The stability of the ship can be determined by looking at the ship's static stability curve. The stability curve shows the value of the control arm (righting arm) at different angle values. A comparison of the GZ value of the vessel with each capture device and loading conditions is carried out to determine the best loading conditions owned by the ship and the layout model that best meets the criteria of stability acceptance based on IMO. The comparison of stability analysis results for trawling boats in Juwana, Tegal, and Batang areas and all layouts with change of fishing gear in each condition are shown in figure 4, figure 5 and figure 6.

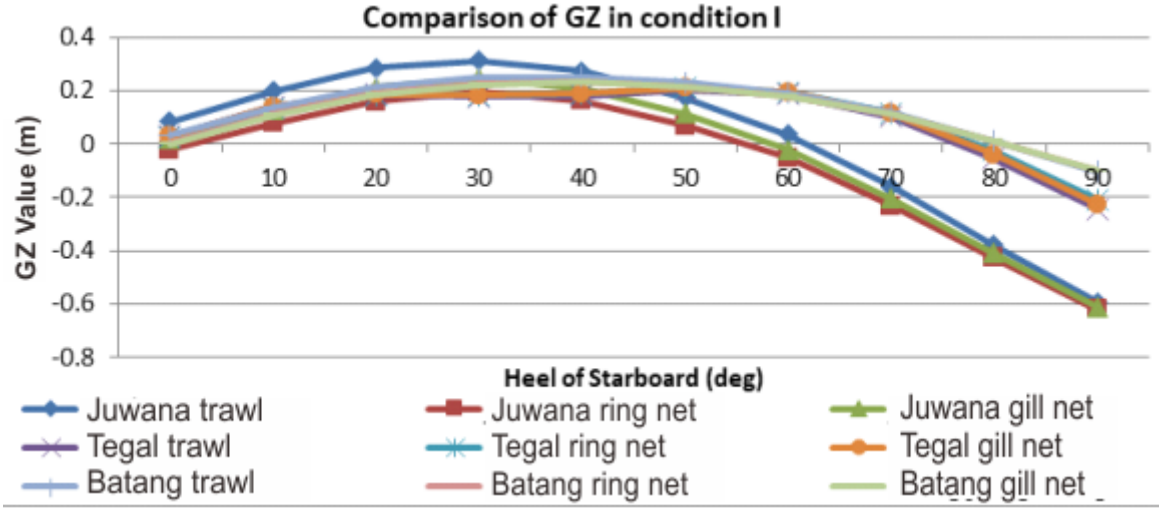


Figure 4. Comparison of GZ value in condition I.

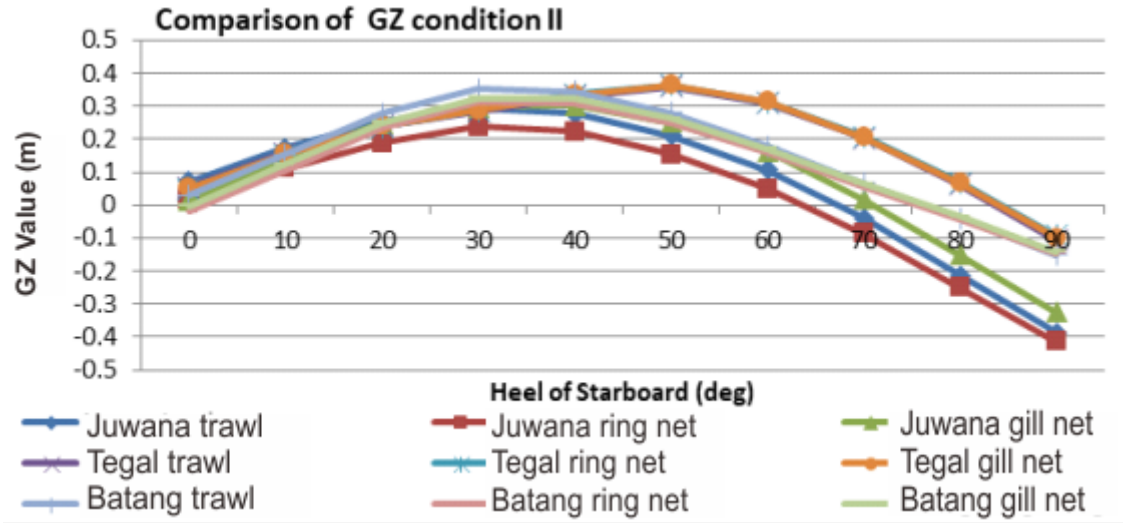


Figure 5. Comparison of GZ value in condition II.

Comparison of some GZ arm graphs to the three conditions presented above indicates that the best stability or value of the highest IMO acceptance criteria for each ship loading condition as well as the modeling of the layout of the respective equipment occurs in the third condition. Condition when the ship is in the fishing ground area. In this condition, the boatload (mackerel) is 100%.

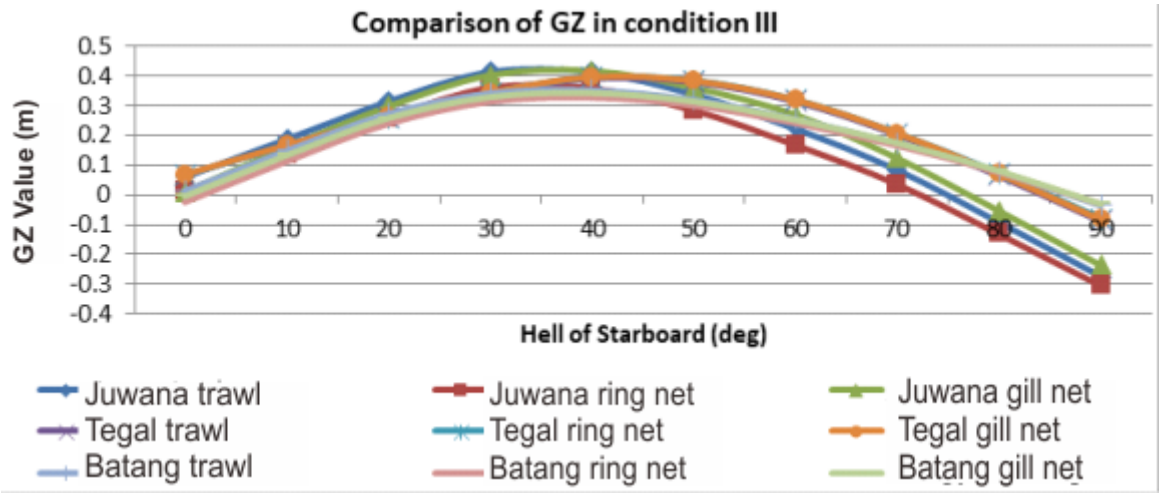


Figure 6. Comparison of GZ value in condition III.

The stability of the vessel with the replacement of fishing gear has a stability value that is still below the stability value that owned by the Juwana's traditional trawl boat of KM *Sumber Mino Mulyo* and Batang MV *Barokah Rezeki*. For the largest GZ arm values on boats with the addition of fishing gears are boats with gill net gear for Juwana boat, and ring net for Tegal and Batang boat.

4. Conclusions

A general plan of good equipment layouts for modifying trawlers with gill nets and ring nets can be done taking into account the weight of the apparatus, the weight of the apparatus is adjusted to keep the vessel's point of weight balanced transversely and without extreme trim. Of the 8 layouts that have been analyzed then obtained the best results of the layout to 4 of each substitute fishing gear. The 4th layout has an arrangement with equipment and load points located backward to the rear of the stern with a LCG nets below 5.2 m, and LCG from a total of 5.47 m vessels for ring net and 5.74 m for gill nets, and a TCG valued at 0.02 m to the left of the girder ship's deck center.

Stability analysis of vessel with replacement of fishing gear equipment with three conditions has met IMO acceptance standard. The value of area under GZ curve at oscillation angle 0º- 30º > 3.101 m.deg, area 0º - 40º > 5.15 m.deg and an area of 30º - 40º > 1.719 m.deg. As well as the maximum GZ value occurring at an angle of 30º - 180º > 0.2 m, the angle at the maximum GZ value > 25º, and the initial GM score at 0º > 0.15 m. However, there is a Layout that does not meet the IMO stability acceptance parameter, which is the first Layout plan of ring net. GZ arm values at 30 deg or more less than 0.2 m or only have a value of 0.194 m. Analysis of ship movement has fulfilled the Criteria of Admission of fish ship characteristics for vessels with full speed and wave as high as 2 m vessel has the highest rolling value of 3.31°, and probability slamming with the greatest value 2.10% for vessel velocity 6 knot and corner 180 deg heading head sea.

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