International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 38 No. 1 April 2023, pp. 162-169

# *Response Motion Analysis of Trimaran Fishing Vessels on Irregular Waves using CFD*

Richard Benny Luhulima[1], Fella Gasperz[2], Obed Metekohy[3], Helly Simon Lainsamputty[4]

[1]Department of Naval Architecture, Universitas Patimura
Maluku, Indonesia
richardluhulima26@gmail.com

[2]Department of Naval Architecture, Universitas Patimura
Maluku, Indonesia
fella.gsp73@gmail.com

[3]Department of Naval Architecture, Universitas Patimura
Maluku, Indonesia
bobmetekohy2710@gmail.com

[4]Department of Naval Architecture, Universitas Patimura
Maluku, Indonesia
hellylines@gmail.com



***Abstract*—Ships must have good performance and economic value. The purpose of this research is to investigate the motion characteristics of trimaran fishing boats using Computational Fluid Dynamics simulations. The findings of this research are intended to improve a basic basis for the operation of trimaran fishing boats at the Fishing Ground. ANSYS AQWA describes trimaran ship motion response simulation effectively. For a wave direction angle of $135^0$, the trimaran's roll motion reaction is 10.131deg. With a pitch motion response of $6.593^0$ at wave direction of $135^0$, the Trimaran ship boasts the highest pitch motion response. The trimaran is excited by the wave direction angle of $135^0$. Because of the trimaran's enormous cross section at that angle. The $135^0$ wave direction angle is also crucial for trimaran ship operations.**

***Keywords*—Trimaran Fishing Vessel's, Response Motion, Roll, Pitch.**

## I. INTRODUCTION

Maluku Province as a province that has such a large ocean area, naturally has a wealth of various fish and non-fish resources that have the potential to be managed and developed as income or foreign exchange earner for the region and the country. With a potential of around 3.03 million tons per year or 30.76 percent of the national potential, Maluku deserves to be the center of national fisheries management. (DKP Prov. Maluku, 2016). The management of the Maluku seas has been approved by the central government through the Ministry of Maritime Affairs and Fisheries (KKP) to be included in the national strategic program for the 2018–2020 period. This was approved at a Limited Cabinet Meeting chaired by President Joko Widodo in Jakarta on 21 February 2017.

Results of research by the World-Wide Fund (WWF), an international non-governmental organization that deals with issues concerning conservation, research and environmental restoration. The observation results show that the islands in Maluku waters have become very abundant fish resources, this is because the coral reefs there are well maintained. Broadly speaking, Maluku has become the largest fish "headquarters" in the world, but unfortunately it cannot be managed properly so that many fish in Maluku waters are stolen and their habitat destroyed by foreign fishermen.

Fishermen must be equipped with strong knowledge in viewing maps of distribution and migration of fish so that they can detect fishing grounds well, because so far it is still manual or traditional by looking for foam, floating objects, seabirds and following the movements of dolphins. - Dolphins, FADs and other aids. The nature of the fish (fish behavior) which is not stagnant and often migrates and the seasons that change frequently have a great impact on fishing activities by fishermen.

One of the strategic studies is the development of fishing vessels. This study is a technological and scientific study by utilizing shipping technology and fisheries potential for local and national progress. Based on the condition of the waters in Indonesia, especially Maluku, the problem is the operation of fishing vessels on fishing grounds which are still vulnerable. So that an optimal ship operational study is needed.

The majority of fishermen decide not to go out to sea when there are severe sea conditions. This is not because there are no fish on the fishing grounds; rather, it is to prevent marine mishaps in extreme weather conditions. This, of course, has an effect on the income and well-being of fishermen when there are severe sea conditions. A vessel with a trimaran hull might be used as a purse seine rather than a vessel with a monohull in order to catch fish. The fact that the inhabitants of Maluku have always been acquainted with the form of a ship with a straightforward type 3 hull in the shape of a "semang ship" lends credence to the claim that this is the case. As a consequence of advancements in marine technology, ships with multiple hull types, such as catamarans (ships with two hulls) and trimarans (ships with three hulls), are being widely used [1]. The reason for this is because vessels that have more than one hull are superior in terms of stability and efficiency than those that just have one. In the context of the application of a fishing vessel, the most important consideration is connected to the seakeeping performances of the vessel in the sea water of Maluku. Having said that, more research on the hydrodynamic properties, such as seakeeping and motion performances, is also very important. To this day, there have only been a limited number of instances in which multi-hull fishing boats designed to combat the aforementioned challenges have been built.

The purpose of this work is to analyze the seakeeping performances of a trimaran fishing vessel under operating conditions at a fishing field with 3 knots of wind and JONSWAP irregular wave. In this study, the seakeeping calculation that was carried out using ANSYS AQWA was detailed. The relative accelerations of motion, or RAOs, for each variant of a trimaran fishing vessel were detailed under three different sea conditions: heading angle ($90^0$), bow quartering seas ($135^0$), and head seas ($180^0$). The behavior of the fishing vessel may be anticipated as a result of the fact that each direction of the wave offers a specific reaction to the motion of the ship in the form of heave and pitch. These new insights will be of considerable use to the naval architects as they work on the layout of an improved purse-seine ship.

## II. METHOD

Trimaran fishing vessels' seakeeping performance was analyzed with CFD. The investigation is performed at a range of practical ship speeds (v=3 knots). The wave energy that occurs in the waters where ships operate with a 1 m wave heigh is predicted using the irregular wave with JONSWAP spectrum adapted to the conditions of the waters around Maluku Island in Indonesia.

### *A. Ship Model*

CFD solver three-dimensional method uses for seakeeping analysis. The tow hull models are discretized so that they are arranged into small grid that compose the shape of the hull. The Purse seine trimaran hull, i.e with axe-bow and without axe-bow as shown at table 1 and figure 2 will analyses with CFD method.

Tabel 1 Particular Dimension of Trimaran Purse Seine

| Parameter | Unit | Mainhull | Sidehull |
|---|---|---|---|
| $L_{OA}$ | m | 18 | 9 |
| $L_{WL}$ | m | 17.51 | 8.42 |
| B | m | 2.41 | 1.21 |
| T | m | 0.96 | 1.35 |
| Wetted Surface Area | $m^2$ | 35.13 | 12.24 |
| Displacement | kg | 9268.72 | 1860.27 |
| Block Coefficient ($C_B$) | | 0.397 | 0.397 |

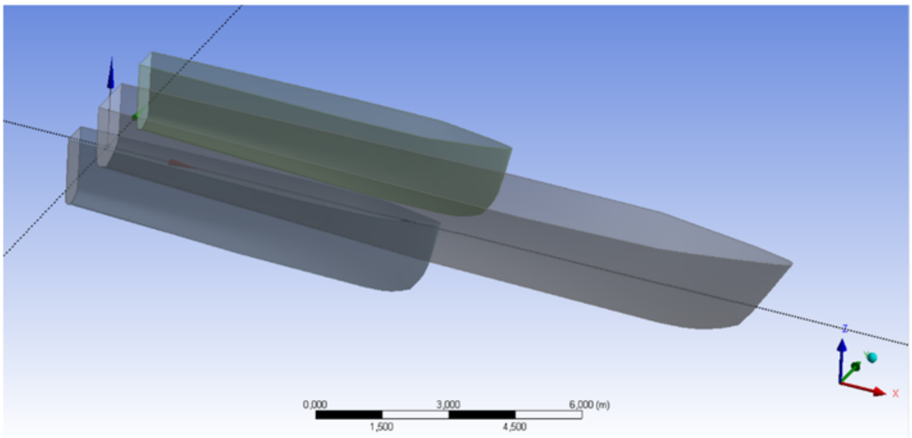



Figure 1 Trimaran Models

*B. Response Motion*

Motion response is obtained by using equation 12, namely by multiplying the RAO square with the wave spectrum to get the motion spectrum response from the ship. Then statistical analysis was performed to obtain the Root Mean Square (RMS) motion of each ship's motion mode, the ship's heave, roll, and pitch. Ship motion RMS is obtained using equation 7 below [8]:

$$RMS = \sqrt{m_0} \tag{1}$$

Where $m_0$ is the area under the spectrum response curve obtained using numerical calculations. The area under the curve can be formulated in the following equation 8 below [8]:

$$m_0 = \int_0^\infty {\omega_e}^0 \; S_\zeta \; d\omega \tag{2}$$

*C. Numerical Simulation*

Mesh generation is a prerequisite for running a trimaran ship simulation. With the use of meshing, numerical simulations may test whether or not a ship's response to waves is accurately modeled. With a minimum element size of 0.1 meters, a wave frequency range of up to 0.353 rad/s, and a total of 28948 elements, as shown in Table 2, the required meshing is both precise and manageable. An explanation of the figure is also included. For clarity, consider Figure 3 as an example of this concept.

Table 2 Meshing Dimension

| | |
|---|---|
| Object Name | *Mesh* |
| State | Meshed |
| **Details of Mesh** | |
| **Defaults** | |
| Global Control | Basic Controls |
| **Mesh Parameters** | |
| Defeaturing Tolerance | 0.1 m |
| Max Element Size | 0.2 m |
| Max Allowed Frequency | 0.353 Rad/sec |
| Meshing Type | Program Controlled |
| **Generated Mesh Information** | |
| Number of Nodes | 2553 |
| Number of Elements | 2286 |
| Number of Diff Nodes | 1203 |
| Number of Diff Elements | 942 |

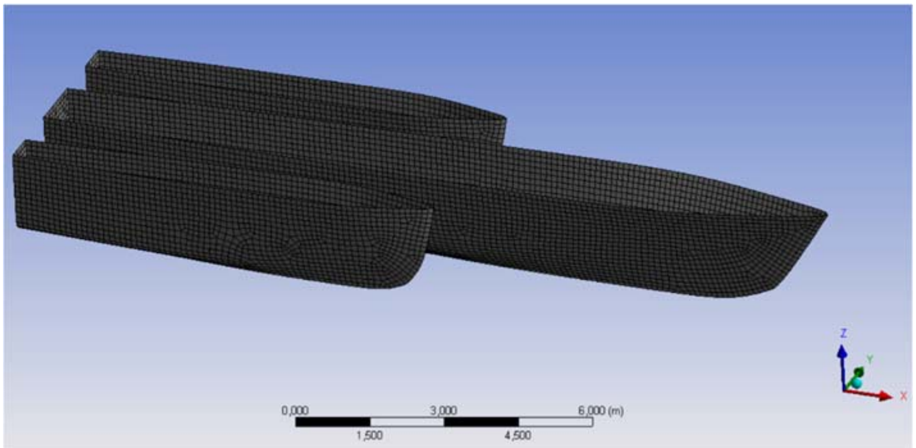



Figure 2 Meshing Trimaran

Setup involves conditioning that takes into account the current water conditions. The inputted price is a constant used often in empirical computations. Numerical computations using ANSYS AQWA and irregular waves with a JONSWAP wave spectrum are shown in Figure 3.4 and Tables 3.3 and 3.4, respectively.

Tabel 3 *set up* irregular wave with JONSWAP Spectrum

| | |
|---|---|
| Name | *Irregular Wave* |
| State | Fully Defined |
| **Details of Irregular Wave 1** | |
| Visibility | Visible |
| Activity | Not Suppressed |
| Wave Range Defined By | Frequency |
| **Wave Spectrum Details** | |
| Wave Type | JONSWAP (Hs) |
| Direction of Spectrum | 180° |
| Wave Spreading | None (Long-Crested Waves) |
| Spectrum Presentation Method | 1D Graph |
| Seed Definition | Program Controlled |
| Number of Spectral Lines Definition | Program Controlled |
| Start and Finish Frequency Definition | Program Controlled |
| Start Frequency | 1,02559 rad/s |
| Finish Frequency | 7,05425 rad/s |
| Significant Wave Height | 1 m |
| Gamma | 3,3 |
| Peak Frequency | 1,75 rad/s |
| Export CSV File | Select CSV File... |
| **Cross Swell Details** | |
| Wave Type | None |

The performance of a trimaran fishing vessel was evaluated using CFD in order to determine how well it maintained its seakeeping capabilities. The experiment is carried out at a range of ship operating speeds, each of which is equivalent to three knots (v = 3). The wave energy that occurs in the waters where ships operate at a wave height of one meter is predicted by making use of the irregular wave spectrum that is suited to the characteristics of the seas in the coastal area of the island of Maluku in Indonesia. This spectrum is suitable for the seas because it is suited to the characteristics of the seas. according to Figure 3, the wave direction angles of $90^0$, $135^0$, and $180^0$ are used.

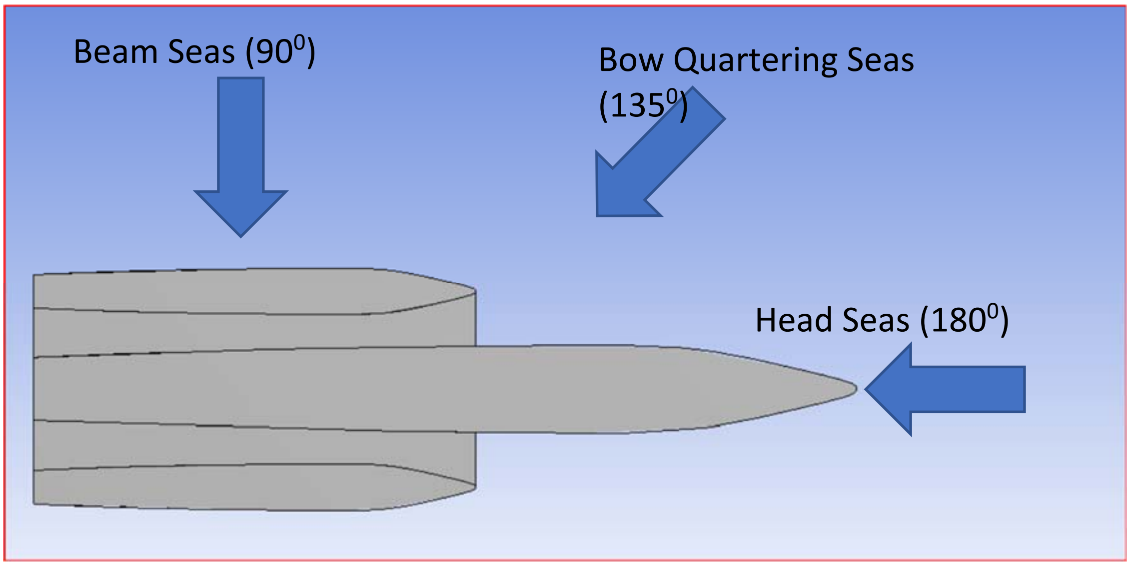
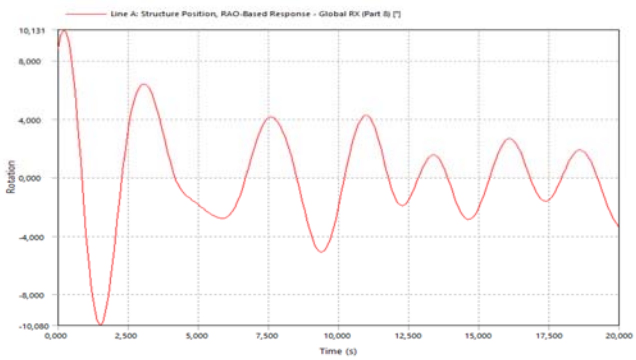



Figure 3 Wave Heading Angle

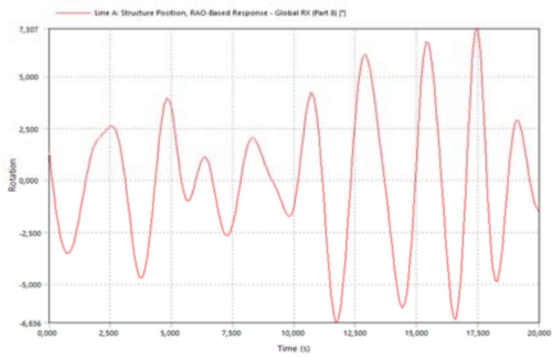
## III. Result and Discussion

### A. Heave Roll

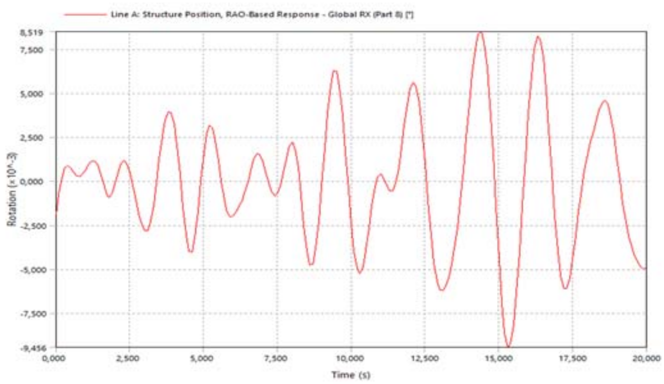
Simulation of a trimaran ship at a wave angle of 90-180 degrees produces a ship roll response. The response of the trimaran ship shows an irregular motion pattern, as shown in Figure 4




(a) Heading Angle $90^0$




(b) Heading Angle $90^0$




(c) Heading Angle $180^0$

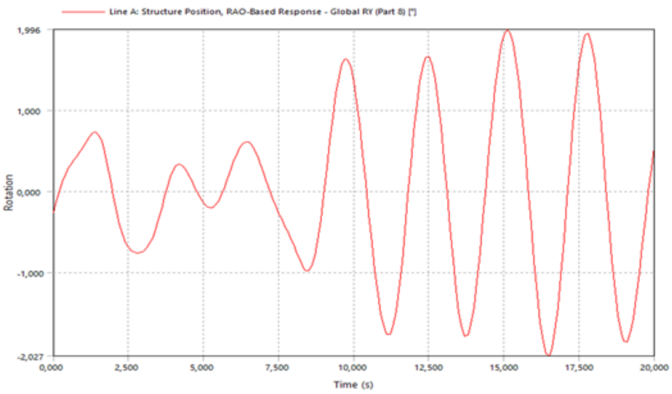
Figure 4 Ship Roll Motion Response with variations in wave direction angles

Figure 4(a) depicts the Roll motion of the trimaran fishing vessel when the wave direction is $90^0$, with the maximum value of $10.131^0$ occurring at 0.4 seconds. Furthermore, the ship's roll response with a direction of $135^0$ has the largest value of $7.307^0$ at 17.5 seconds as shown in Figure 4(b). The response to a roll motion with a wave direction of $180^0$ on a trimaran fishing vessel is -0.009456 deg occurring in the second -15.6 as shown in figure 4(c).

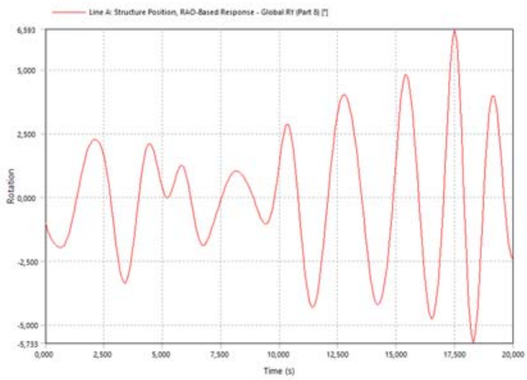
The greatest roll response of trimaran fishing boats occurs in the wave direction with an angle of $90^0$. This is due to the large cross-sectional area facing the incoming wave direction and short moment arms. This causes an external force in the form of a wave to easily move the trimaran fishing boat in response to the roll motion. On the other hand, at low tide, the wave direction of $180^0$ gives a smaller response to the motion of the trimaran fishing boat than in other wave directions, this is more due to the longer moment arm of the trimaran fishing boat which corresponds to the length of the ship and requires a large force. to give the ship movement so that the response given to the incoming waves is very small

*B. Pitch*

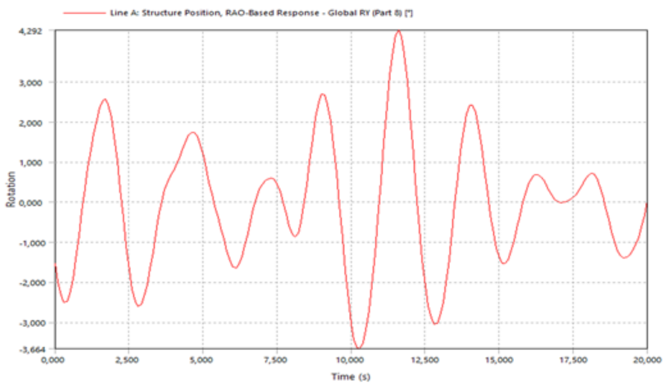
Trimaran fishing vessel 0n pitch motion was produced by the simulation at wave angle between $90^0$ and one $180^0$. As may be seen in Figure 5, the response motion of the trimaran ship has random motion.




(a) Heading Angle $90^0$




(b) Heading Angle $135^0$




(c) Heading Angle $180^0$

Figure 5 Ship Pitch Motion Response with variations in wave direction angles

In the direction wave of the $90^0$ shown in Figure 5(a) with the largest value of the pitch movement response is -2.027 deg at the 16th second. The ship's pitch response with a direction of $135^0$ has the largest value of $6.593^0$ at 17.5 seconds as shown in Figure 5(b). Furthermore, the pitch movement response on the trimaran boat was $4.292^0$ which occurred in the 2nd minute as shown in Figure 5(c).

The biggest pitch response of trimaran fishing vessels occurs in the direction of the wave with an angle of $135^0$ (bow quartering seas) as shown in Figure 3.18. This is due to the large cross-sectional area facing the incoming wave direction and short moment arms. This causes the external force in the form of waves to easily move the trimaran fishing boat in response to the pitch movement, besides that the streamlined shape of the bow makes it easy for the boat to nod (pitch). Conversely, at low tide the wave direction is $90^0$ (beam seas) and the pitch response of the trimaran fishing boat is smaller than in other wave directions, this is more due to the longer moment arm of the trimaran fishing boat which corresponds to the length of the boat and requires a large force so that the response the pitch given to the incident wave is very small

## IV. CONCLUSION

The response simulation of trimaran ship motion can be described very well by using ANSYS AQWA. The response of the roll motion on the trimaran and has the greatest value of $10.131^0$ at 0.4 seconds with a wave direction angle of $135^0$. Furthermore, the Trimaran ship has the greatest pitch motion response, which is $6.593^0$ at 17.5 seconds with a wave direction of $135^0$. In general, the wave direction angle of $135^0$ degrees gives a large excitation force to the trimaran. This is due to the fairly large cross section of the trimaran at that angle. In addition, the angle of the $135^0$wave direction needs special attention because it is a critical point for trimaran ship operations.

## V. ACKNOWLEDGMENT

The author would like to thank Pattimura University for providing access to the Ship Modeling Laboratory so that this paper can be completed properly

## REFERENCES

[1] Taggart, R. 1980. *Ship Design and Construction*. New York: The Society of Naval Architects and Marine Engineers;

[2] Schneekluth, V. Bertram. 1998. *Ship Design for Efficeincy and Economy* (second edition). Reed Educational and Professional Publishing Ltd . Great Britain;

[3] Anderson, J.D., Jnr, 1995, Computational Fluid Dynamics, The basics with applications, McGraw-Hill International Editions.

[4] Maxruf Manual, 2018.

[5] Bhattacharyya, Rameswar (1978). Dynamics of Marine Vehicles. John Wiley and Sons. USA.

[6] Couser, P R, Wellicome, J.F., Molland, A F. (1998), "An Improve Method for the Theoretical Prediction of the Wave Resistance of Transom-Stern Hulls Using A Slender Body Approach", *International Shipbuilding Progress*, Vol. 45, No. 444.

[7] Hughes, G (1954), "Friction and Form Resistance in Turbulent Flow and a Proposed Formulation for Use in Model and Ship Correlation", *Trans INA*, Vol. 96.

[8] Kurultay, A.A.: 2003. Sensitivity analysis of the seakeeping behavior of trimaran ships. MSc Thesis, Naval Postgraduate School, Monterey, California (USA) (2003).

[9] Luhulima R.B, Utama, I.K.A.P. Selecting Mono- And Multi-Hull Passenger Vessels For Moluccas Waters: Resistance/Powering And Seakeeping Evaluation. The 13th International Conference on QiR, 25-28 June 2013. Jogjakarta. Indonesia (2013).

[10] Luhulima R. B, Sutiyo, I Ketut Aria Pria Utama. 2017. An Investigation Into The Correlation Between Resistance and Seakeeping Characteristics of Trimaran at Various Configuration and with Particular Case in Connection with Energy Efficiency. International Symposium on Marine Engineering (ISME) October 15-19, 2017, Tokyo, Japan

[11] Molland, A.F., Utama, I K A P., and Buckland, D. (2000), "Power Estimation for High Speed Displacement Catamarans", *The second Regional Conference on Marine Technology for Sustainable Development in an Archipelago Environment, Proc. MARTEC'2000*, Surabaya, Indonesia, 7- 8 September 2000.

[12] Tello, M., Ribeiro E Silva, S., Guedes Soares, C., 2011. Seakeeping performance of fishing vessels in irregular waves. Ocean Eng. https://doi.org/10.1016/j.oceaneng.2010.12.020