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The Installation of a Mini Line Hauler on a 9 Gt Handline Tuna Vessel in Southern Malang Sea, Indonesia

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Abstract: The tuna handlines operated by some fishers from Southern Malang in the Indian Ocean can be categorized as a type of static fishing gear. The stability of their small-sized vessels becomes critical when a large-sized tuna is caught by the handline and lifted with the help of a line hauler installed onboard, i.e., the floating angle tolerance may be exceeded. This study aims to determine the angle of inclination of a 9 GT boat when a line hauler is operated onboard. The research was carried out in June 2016 by measuring the principal dimensions of a fishing boat, FV Cahaya 01, in Pondok Dadap Fishing Port, Malang. The principal dimensions are length overall (LOA), length before perpendicular (LPP), breadth (B), and depth (D) Data on the boat's principal dimensions, lines plan, and hull shape were used for the boat's stability calculation. The studied boat's buoyancy center is located at 0.27 m in front of the midship and the TCP is 0.315. The maximum load of the line hauler was 211.253 kg, and the inclination angle during the hauling process was 3.52^0. The installation of the line hauler on the fishing boat creates a new acceptable stability of the boat.

Keywords: Floading angle; Handline tuna vessel; Mini line hauler

Introduction

The stability of a fishing boat is one of the important safety aspects of a fishing operation (Hopper, 1989; Nomura et al., 1977; Papanikolaou, 2014). Ship stability is the ability of the ship to return to its original position after experiencing external forces, such as wind and waves-generated forces (Trang et al., 2025; Zhang et al., 2023). The distribution of loads may modify the boat's center of gravity and also affect the boat's stability. The boat's stability may also be modified when auxiliary machinery is installed and operated to help fishers handle fishing gear and captured fish. Implementing this mini line hauler provides a facilitative solution for fishermen to haul their catch with increased ease and efficiency.

Fishers from Southern Malang, East Java - Indonesia, operate handlines to catch tuna in the Indian Ocean with small-sized boats of 8 - 32 GT. Among the 127 units of tuna fishing boats, 60 units of fishing boats of 12-13 GT. Fishers often find difficulty in lifting big-sized tunas to 200 kg/piece. Therefore, using a mini line hauler is recommended to help the fishers. However, a technical assessment is required before its installation since the line hauler's operation may change the fishing boat's stability, especially related to the flooding angle or angle of inclination. The external forces may be generated from the impulsive movement of the captured fish. Placement of the line hauler on either the starboard or port side of the boat must not cause an intolerable inclination angle. Therefore, an analysis of the angle of inclination due to the operation of the mini-line hauler was carried out. This study aims to determine the angle of inclination of the fishing boat when the mini line hauler is being operated.

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Method

The research was carried out in June 2016 by measuring the principal dimensions of a fishing boat, FV Cahaya 01, in Pondok Dadap Fishing Port, Malang. The principal dimensions are length overall (LOA), length before perpendicular (LPP), breadth (B), and depth (D) (Chrismianto et al., 2018; Yaakob et al., 2015). Different positions and additional onboard loads were simulated to determine the ship stability of the static boat. The quality of fishing boat stability was expressed as hydrostatic parameters, which were calculated by applying naval architecture formulas (Gilmer et al., 1982; Tupper, 2004). The other measured parameters were: trim, draught, load weight, the vertical distance of load weight point (KZ) and the longitudinal distance of load weight point (LZ). Moreover, the fishing boat stability was determined by calculating the righting lever (GZ value) based on Attwood methods (Biran et al., 2013)(). The formula to calculate the GZ is:

$$GZ = BR - BT \quad (1)$$

Which

$$v\ x\ hh_1 = BR\ x\ \nabla \implies BR \frac{v\ x\ hh_1}{\nabla} \quad (2)$$

$$BT = BG\ sin\ sin\ \theta \quad (3)$$

Thus,

$$GZ = \frac{v\ x\ hh_1}{\nabla} - BG\ sin\ sin\ \theta \quad (4)$$

Where,

GZ = righting lever

BR = displacement of buoyancy point horizontally

v = fishing boat volume segment

hh_1 = Movement of segmen Research design and method should be clearly defined.

Result and Discussion

The simulation and installation of the mini line hauler were performed on the smallest fishing boat, which is 9 GT. The boat was selected with the assumption that the stability of the larger boats is less affected by the installation of the line hauler (Fadillah et al., 2019b; Hutauruk, 2013; Paroka, 2018; Susanto et al., 2011). The specifications of the studied fishing boat are presented in Table 1. The ratio among the principal dimensions of FV Cahaya 01 was comparable to some fishing boats studied by (Özkaya et al., 1999; Susanto et al., 2011). These studied boats share common ratios of the principal dimensions (Table 2).

The general arrangements of the fishing boat FV Cahaya 01 before and after the installation of the line hauler and hydraulic power pack are presented in Figure 1. The line hauler was placed in the port and starboard sides. The center buoyancy of the studied boat is located at 0.27 m in front of the midship. The tons per centimeter (TPC) of the boat was 0.315 or every extra load of 315 kg will increase the draft by 1 cm. Since the weight of the line hauler is 100 kg, its installation onboard will cause an increase in the draft by 0.35 cm. The hydrostatic curve of the boat shows that the altering of the moment to change trim one centimeter (MTc) is 3 tons per 5 cm, therefore, the weight of the line hauler does not significantly change the MTc (Figure 2).

Table 1. Specifications of FV Cahaya 01 from Southern Malang, East Java

Information		
Name	:	Cahaya 01
Build	:	2010
Material	:	Wood
Length Over All	:	14.32 meter
Length between Perpendicular (LPP)	:	12.34 meter
Breadth (B)	:	3.18 meter
Breadth Water Line (BWL)	:	3.04 meter
Depth (D)	:	1.20 meter
Draught (d)	:	0.95

Table 2. Various Main Dimension Ratio of Static Gear

Ratio	Darmawan et al. (1999)	Sutanto et al. (2011)	FV Cahaya 01
LPP/B	4.14 – 15.64	3.98	3.88
LPP/D	10.15-12.50	10.34	10.28
B/D	0.78-2.39	2.60	2.65
D/d		1.25	1.26

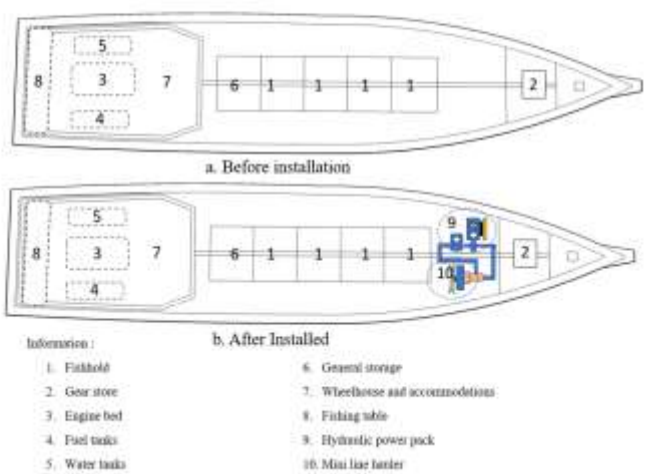

Figure 1. General arrangements of FV Cahaya 01

The hauling process of tuna captured on board a fishing boat must be calculated since this process gives a load to the fishing boat. When two entities interact, they exert forces that are equal in magnitude and opposite in direction, according to Newton's third law (Özkaya et al., 1999). The force that is released due to the tuna trying to escape gets a reaction with the same magnitude but in the opposite direction; the tuna will pull one side of the boat but will be held back by the buoyant force and the stability of the boat. Conversely, when the mini hauler starts to haul the catch, it will also cause a force in the opposite direction, which causes one side of the ship to be pulled down. The force that arises due to the tuna trying to escape and the force arising from the mini hauler pull seems to be a load with a certain weight placed on one side of the boat.

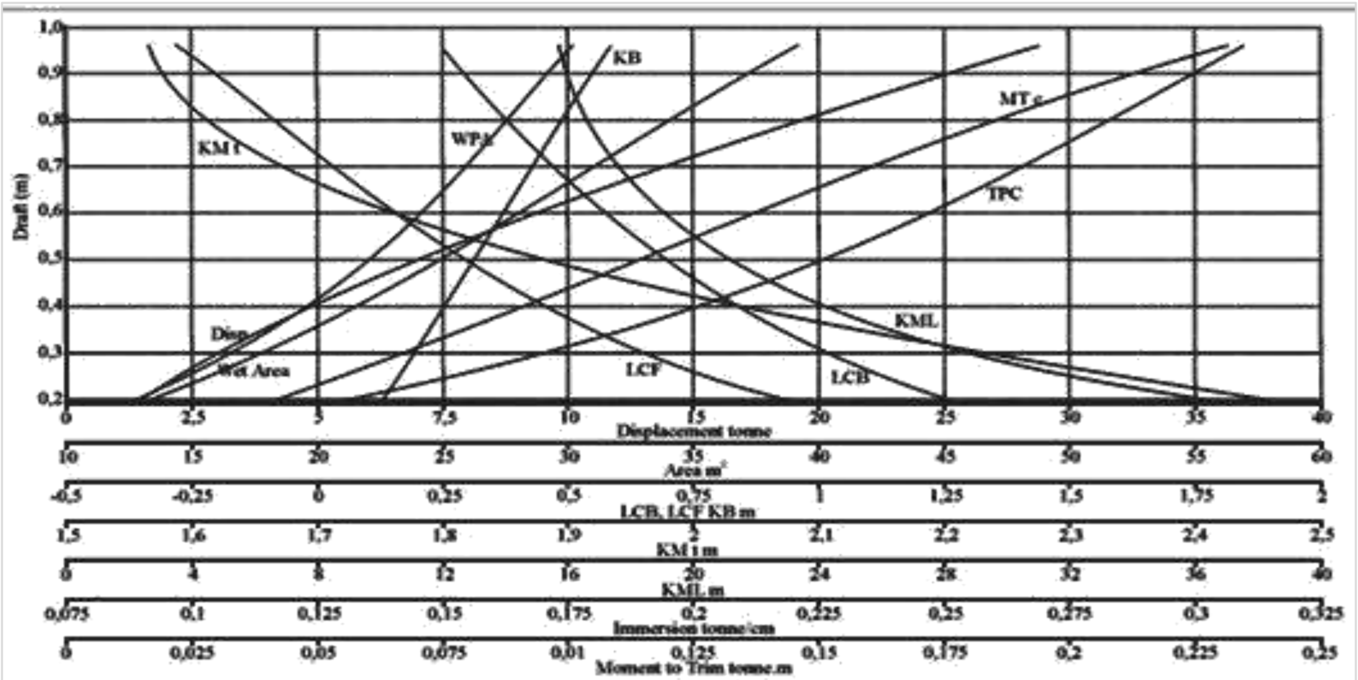

Figure 2. The hydrostatic curve of FV Cahaya 01 (software simulation)

The movement of the tuna in the water will produce additional load to the boat. If the weight of a tuna of 210 cmFL is 139.28 kg (Wudianto et al. 2003) and the line hauler was operated at a pump speed of 1600rpm after the reduction gear mechanism (1:10) then the load from swimming fish and line hauler operation became 171.43kg. If the total weight of three fishers onboard is 180 kg then the total load becomes 211.253kg (Table 3).

Table 3. Loads during Hauling Process

Tuna length (cm FL)	Swimming tuna (kg)	Load generated by line hauler operation at 3 levels of pump speed (kg)			Fishers (kg)	Total load at 1600 rpm (kg)
		400 rpm	1000 rpm	1600 rpm		
30	0.04	0.002	0.05	0.008	180	180.001
60	0.67	0.038	0.94	0.151	180	180.151
90	3.78	0.212	5.30	0.847	180	180.874
120	12.85	0.721	1.803	2.885	180	182.885
150	33.24	1.865	4.662	7.460	180	187.460
180	72.25	4.053	10.133	16.212	180	194.212
210	139.28	7.813	19.533	31.253	180	211.253

The operation of the line hauler for handling a tuna of 210 cmFL will cause an inclination angle of 3.52^0. This condition is still considered safe because the maximum GZ of 0.334 m occurs at an angle of 42.4° with an initial GM value of 0.640 m.

Discussion

The stability of a fishing boat during tuna hauling is influenced by dynamic forces generated by the tuna's resistance and the line hauler's operation, as dictated by Newton's third law. A 210 cm tuna (139.28 kg) exerts force while escaping, countered by the boat's buoyancy and stability mechanisms. Combined with the line hauler's load (operating at 1600 rpm post-gear reduction) and three fishers (180 kg), the total load reaches 211.253 kg. This results in a boat inclination of 3.52°, well within safe limits. The vessel's stability is ensured by a maximum righting lever (GZ) of 0.334 m at 42.4° and an initial metacentric height (GM) of 0.640 m, indicating sufficient resistance to capsizing. Despite dynamic operational loads, the calculated parameters confirm that the boat maintains structural integrity and safety during hauling. Thus, under the specified conditions, the interaction of forces does not compromise stability, validating the operational feasibility of the hauling process (Fadillah et al., 2019a; Gudmundsson, 2009; O'Doherty et al., 2020).

The other aspect of using a mini line hauler is the biological aspect of the catch which is Tuna. Biological factors influencing tuna quality include species, age, size, sexual maturity, and the presence of parasites or diseases, while non-biological factors encompass capture methods, handling techniques, cooling processes, and storage conditions (Irianto, 2008). Tuna meat exhibits a color spectrum ranging from pink to dark red, attributed to the higher myoglobin content in its muscle tissues compared to other fish species. This distinct pigmentation is further influenced by abundant blood supply and a greater proportion of red muscle fibers (Starling et al., 2005).

Before death, tuna experience elevated levels of metabolic byproducts, such as lactic acid, which accumulates during strenuous struggling upon landing and retrieval. To prevent the degradation of fatigued muscle tissue, lactic acid must be promptly eliminated (Irianto, 2008). Failure to mitigate this accumulation can result in adverse quality changes, including a shift in appearance from translucent to cloudy, textural softening, and the development of a bitter flavor profile (Lemasson et al., 2018). These parameters are critical for buyers evaluating tuna suitability for sashimi. The implementation of mini haulers to accelerate retrieval in handline fisheries has been shown to enhance tuna quality. By reducing prolonged struggling, this method minimizes excessive oxygen depletion and lactic acid accumulation in red muscle tissues, thereby preserving sensory and structural integrity.

Conclusion

The installation of the mini line huler in the fishing boat onboard the FV Cahaya 01 creates a new stability and generate an inclination rate of 3.52o that is considered safe for handling tuna of 210cmFL. Therefore, the use the mini line hauler is recommended for larger fishing boats operated in the coastal waters of southern Java. The implementation of mini haulers to accelerate retrieval in handline fisheries has been shown to enhance tuna quality. By reducing prolonged struggling, this method minimizes excessive oxygen depletion and lactic acid accumulation in red muscle tissues, thereby preserving sensory and structural integrity.

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References

Biran, A., & Lopez-Pulido, R. (2013). *Ship Hydrostatics and Stability* (Second Edi). Elsevier Science.

Chrismianto, D., Manik, P., & Rindo, G. (2018). Study comparative of stability performance between PVC fishing boat and wooden traditional fishing boat. *IOP Conference Series: Materials Science and Engineering*, *403*(1). https://doi.org/10.1088/1757-899X/403/1/012002

Fadillah, A., Manullang, S., & Irvana, R. (2019a). Stabilitas, Hambatan Dan Olah Gerak Kapal Ikan Multi Purpose Net/Line Hauler 20 Gt Berdasarkan Kajian Ukuran Dan Bentuk Kasko Kapal. *Marine Fisheries : Journal of Marine Fisheries Technology and Management*, *10*(2), 117–128. https://doi.org/10.29244/jmf.v10i2.29313

Fadillah, A., Manullang, S., & Irvana, R. (2019b). Stabilitas, Hambatan Dan Olah Gerak Kapal Ikan Multi Purpose Net/Line Hauler 20 GT Berdasarkan Kajian Ukuran Dan Bentuk Kasko Kapal. *Marine Fisheries: Journal of Marine Fisheries Technology and Management*, *10*(2), 117–128. https://doi.org/10.29244/jmf.v10i2.29313

Gilmer, T., & Johson, B. (1982). *An Introduction to Naval Architecture*. Naval Institute Press.

Gudmundsson, A. (2009). *Safety practices related to small fishing vessel stability*. FAO. Retrieved from https://openknowledge.fao.org/handle/20.500.14283/i0625e

Hopper, A. G. (1989). Design of small fishing vessels. *Fisheries Research*, *7*(1–2), 192. https://doi.org/10.1016/0165-7836(89)90021-0

Hutauruk, R. M. (2013). Perhitungan Stabilitas Kapal Perikanan Melalui Pendekatan Ukuran Utama Dan Koefisien Bentuk Kapal. *Perikanan Dan Kelautan*, *18*, 49–61. Retrieved from https://festiva.ejournal.unri.ac.id/index.php/JPK/article/view/1792

Irianto, H. E. (2008). Teknologi Penanganan Dan Penyimpanan Ikan Tuna Segar Di Atas Kapal. *Squalen Bulletin of Marine and Fisheries Postharvest* *and Biotechnology*, *3*(2), 41. https://doi.org/10.15578/squalen.v3i2.140

Lemasson, A., Hall-Spencer, J., Kuri, V., & Knights, A. (2018). Changes in the biochemical and nutrient composition of seafood due to ocean acidification and warming. *Marine Environmental Research*, *143*. https://doi.org/10.1016/j.marenvres.2018.11.006

Nomura, M., & Yamazaki, T. (1977). *Fishing Techniques*. Japan Internasional Cooperation Agency (JICA).

O'Doherty, T., & Mason-Jones, A. (2020). The development of marine energy extraction. *Journal of Marine Science and Engineering*, *8*(5), 2019–2020. https://doi.org/10.3390/JMSE8050321

Özkaya, N., & Nordin, M. (1999). *Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation* (Second). Springer.

Papanikolaou, A. (2014). *Ship Design: Methodologies of Preliminary Design* (First). Springer Netherlands.

Paroka, D. (2018). Karakteristik Geometri dan Pengaruhnya Terhadap Stabilitas Kapal Ferry Ro-Ro Indonesia. *Kapal: Jurnal Ilmu Pengetahuan Dan Teknologi Kelautan*, *15*(1), 1–8. https://doi.org/10.14710/kpl.v15i1.17272

Starling, E., & Diver, G. (2005). *The Australian Tuna Handling Manual: a Practical Guide for Industry*. Seafood Service Australia.

Susanto, A., Iskandar, B. H., & Imron, D. M. (2011). Stabilitas Statis Kapal Static Gear Di Palabuhanratu (Studi Kasus KM PSP 01) The Static Stability of Static Gear Fishing Boat in Palabuhanratu (case study of KM PSP 01) Oleh. *Marine Fisheries*, *2*(1), 65–73. https://doi.org/10.29244/jmf.2.1.65-73

Trang, N. T. H., Mitsuyuki, T., Hirakawa, Y., Sadakata, K., & Nakamura, Y. (2025). Experimental and Numerical Study on the Seakeeping Performance of a Wind-Powered Generation Ship Considering Boom Configurations. *Journal of Marine Science and Engineering*, *13*(3), 412. https://doi.org/10.3390/jmse13030412

Tupper, E. C. (2004). *Introduction to Naval Architecture: Formerly Muckle's Naval Architecture for Marine Engineers* (Fourth). Elsevier Science.

Yaakob, O., Hashim, F. E., Jalal, M. R., & Mustapa, M. A. (2015). Stability, seakeeping and safety assessment of small fishing boats operating in southern coast of Peninsular Malaysia. *Journal of Sustainability Science and Management*, *10*(1), 50–65. Retrieved from https://jssm.umt.edu.my/wp-content/uploads/2015/06/5.pdf

Zhang, C., Zhang, W., Qin, H., Han, Y., Zhao, E., Mu, L., & Zhang, H. (2023). Numerical Study on the Green-Water Loads and Structural Responses of Ship Bow Structures Caused by Freak Waves. *Applied Sciences*, *13*(11), 6791. https://doi.org/10.3390/app13116791