Problems and technical solutions of capture fisheries in Eastern Indonesian waters

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Abstract. Problems concerning capture fisheries in Eastern Indonesian Waters cover the existing of fishes at sea, continuity of catching activities, the use of fishing gears, safety aspects, market, price and recent situation of pandemic Covid-19. This conditions have the impact on decreasing of economy aspect of local fishermen. The purpose of this research is to develop facility of capture fisheries and other related technical aspects to overcome the existing problems and to keep the continuity of fishing activities. The research started by initial field survey by the authors. In addition, related problems from other references are used as input design parameters. Design process end-up with the blue prints and the design specifications of fishing boats and fishing gears. The research was continued with construction of boats prototype, training for the fishermen and sea trials. The results of research were prototypes and design specifications of several types of fishing boats. Fishing boats with hull configurations (monohull, catamaran and trimaran) and fishing gears specification were fixed due to boat operational aspects. In addition, the results of study concerning safety aspect and ship operation in period of Pandemic Covid-19 are presented in this paper. Recommendations of results of this study are presented for future development of fishing boats for local fishermen.

Keywords: Fishing problems, design and specifications

1. Introduction

There are many kind of fishes in Eastern Indonesian waters where those fishes are caught to fulfil international export as well as domestic consumption. The valuable fishes with high price are exported such as Tunas, Skipjack Tuna, Grouper, Indo-Pacific Spanish Mackerel, Red Snappers, any kinds of shrimps. These fishes, together with pelagic and corral fishes are provided also for domestic consumption. Those fishes are caught by local fishermen and high-scale fishing industry companies. The use of fishing gear depends of kind of fish to be caught. Usually the small scale groups of fishermen use small outrigger canoe or small long-boat provided by outboard engine with 2 or 3 crews. Meanwhile, larger vessels such as purse seiners owned by local person operate 15 to 20 crews and skipjack pole and line operate also 18 to 25 crews.

In fact, there are a lot of problems faced by local fishermen in most eastern Indonesian regions. A survey executed by the authors in early 2020 at several spots in Moluccas regions found the important issues concerning the condition of local fishermen. In addition, the effect of Pandemi Covid-19 give additional misery for the local fishermen. Additional survey for secondary data concerning fish potency in East Indonesian waters resumed several special attention of the life of local fishermen [1]. The effect of pandemic Covid-19 recently affect the economic aspect and welfare of local fishermen in many eastern Indonesian coastal regions. Additional data quoted from the following references give an understanding of real problems faced by the local fishermen.

- The use of simple and single fishing gear such are: hand line, trolling line, drifting net, trammel net, circling net, pole and line gives low catching product by the fishermen
• The use of simple kind of boat such as: outrigger canoe and long boat with outboard engine gives the limitation of catching operations
• The existence of fish at sea is limited due to migration period, sea conditions with strong current and waves and full moon, etc.
• Safety and technical aspects of the fishing boats are not provided
• Difficulties of handling of catching due to availability of local market make the fishermen are not willing to operate their vessels.
• Due to Pandemic Covid-19, some purse seiners and skipjack pole and line do not operate.

Those problems need solutions which relate to many aspects. However, this study concentrated on providing the kind boats and their technical aspects to ensure the continuity of the operation.

2. Literature review
This study correlates with design aspects of small fishing boats. Ship design is an iterative process, particularly at early design stages. The output of the first iteration process should be evaluated, analyzed and modified until the design process satisfies the objectives and requirements. An iterative design process is characterized in the design spiral [9] as shown in Figure 1. The designers begin the design process with the first task then continue the process in sequential steps. When the first iteration (cycle) has finished there will be an evaluation. Then, a second iteration begins and all steps of the cycle are repeated in the same sequence. A number of iterations are needed to reach a satisfactory solution [9], [10]. The design process is divided into several baselines. The first baseline (concept design) generally refers to the activities of a feasibility study. The main objective of this baseline is to clarify the shipowner’s requirements (mission) and translates them into naval architectural and engineering characteristics. During the preliminary design phase, ship design parameters are started to develop such as hull dimensions, hull shape, general arrangement, payload, propulsion plant, structure, etc.. This phase refines the major ship characteristics which affects the cost and ship performance. Control factors such as dimensions, power and deadweight would not be expected to change upon completion of this phase. This process is repeated several times. The results obtained at the end of this phase are used in the next design stage. The design process takes several iterations until the best result is achieved. The next step of design process is to develop the results of parametric studies.

![Figure 1. Design spiral](image-url)

Hydrostatic and stability parameters are considered in this study. The hydrostatics parameter is presented in Figure 1 (a), while stability parameters which covers the vertical centre of gravity (KG), vertical centre of buoyancy (KB), metacentric radius (BM) and initial metacentre (GM) is showed in Figure 2 (b). Basic principle of a ship to be float is weight displacement equals to total weight [11], [12], [13]. This relationship is presented as:

\[ \Delta \geq W \]

where: \( \Delta = \) weight displacement (ton) and \( W = \) total weight of ship (ton)
Figure 2. Hydrostatics and Stability Parameters

\[ \Delta = \nabla \times \gamma \]  \hspace{1cm} (2)

\[ \nabla = L_{WL} \times B \times T \times C_B \]  \hspace{1cm} (3)

where:  
\[ \nabla = \text{volume displacement (m}^3) \]  and  
\[ \gamma = \text{specific weight of sea water (ton/m}^3) \]

\[ L_{WL} = \text{length of waterline (m)}, \ B = \text{beam (m)} \]  \[ T = \text{draft (m)} \]  \[ C_B = \text{block coefficient} \]

Total weight of ship (W) consists of lightweight (LWT) and deadweight (DWT) \[14], [10], [15]. Furthermore, LWT consists of hull, engine and supplements, outfitting and fishing gears and DWT consists of cargo (fish and ice), crew and consumption, fuels, fresh water, luggage and fish bait. The critical condition when the boat is filled with water then the cargo is regarded as total incoming water.

\[ \text{Cargo} = W_{\text{total}} \]  \hspace{1cm} (4)

To ensure the boat is in even condition then the position of longitudinal centre of gravity (LCG) should be aligned to longitudinal centre of buoyancy (LCB).

\[ L_{\text{CG}} = L_{\text{CB}} \]  \hspace{1cm} (5)

In the case where a boat afloat or sink when the incoming water fill the boat up to the deck (H) then:

\[ W_{\text{total}} > \Delta = C_B \times L \times B \times T \times H \times \rho \rightarrow \text{sink} \]  \hspace{1cm} (6)

\[ W_{\text{total}} < \Delta = C_B \times L \times B \times T \times H \times \rho \rightarrow \text{float} \]  \hspace{1cm} (7)

Some formulas concerning stability parameters of boat are described as follows [11], [12].

\[ \text{GM} = K_B + \text{BM} - K_G \]  \hspace{1cm} (8)

\[ \text{BM} = I / \nabla = (L \times B^3 / 12) / (L \times B \times T \times C_B) = B^2 / (12 \times T \times C_B) \]  \hspace{1cm} (9)

where:  
\[ \text{GM} = \text{metacentric height} \]  and  
\[ I = \text{inertia moment to x-axis} \]

\[ \text{GZ} = \text{GM} \times \sin \theta \]  \hspace{1cm} (10)

GZ is lever arm for small angle of inclinations \((\theta < 15^\circ)\)

\[ \text{Moment statical stability} = W \times \text{GZ} = W \times \text{GM} \times \sin \theta \]  \hspace{1cm} (11)

For the case of trimaran fishing boats, the similar principle of hydrostatics and stability of monohull may be applied with consideration of buoyancy force (\(\Delta B\)) and moment (\(\Delta Mr\)) from two outriggers.

\[ \Delta Mr = \Delta B \times l \]  \hspace{1cm} (12)

Figure 3. Trimaran configuration
3. Methodology
In this research several fishing boats were designed, constructed and tested at sea. In addition, those boats were developed at different periods. However, the methodology of the research is similar for those boats which described as follows:

1. **Collecting data base.** The data base of the existing fishing boats owned by local fishermen were collected. The purpose of this task is to get the information concerning their boat as an input for re-designing process.

2. **Re-designing phase.** In this phase, the design process was executed following the standard procedure of ship design. Ship design parameters were determined and evaluated during an iterative process. Some design considerations concerning new concepts were introduced during the process. This concept was introduced in order to gain an added design value.

3. **Developing the ship hull.** The hull form of the fishing boats were developed by using Maxsurf software (Figure 7). In addition, the boat general arrangements were provided for the blue prints. The documents of boat were prepared for the next construction phase. This phase results in design specification of the boats.

4. **Developing boat template.** The output of this task is to find a boat template provided for developing the boat. This is a standard procedure to construct the real boat with the hull material of Fibreglass Reinforced Plastic (FRP).

5. **Construction of real boat.** This task was executed with the aid of boat template. There will be many boats produced by this method.

6. **Sea trial.** This task was executed in order to evaluate results of design in the sea.

7. **Training project.** This task was executed in order to train the local fishermen and boat builders. The implementation of this project is the local boat builders have been developing their products.

4. Results and discussion

4.1. Unsinkable tuna long-boat
The unsinkable tuna long-boat was designed, constructed and operated due to demand of local fishermen to solve their problem of safety [16], [17]. Many accidents occur at sea affected by open sea harsh conditions which end-up with the loss of life and boats at sea. Additional fishing gears such as gill net and bottom vertical line will increase the catching product instead of hand line and trolling line. The unsinkable tuna long-boats were designed and constructed at ship construction workshop, Faculty of Engineering Pattimura University. Sea trial of the boats proved the positive results in safety and increasing the catching product (Figure 5). The training programs were executed for local fishermen and boat builders to product their own boats. The specification of the boats are:

- Length overall L\textsubscript{OA}: 8.05 m; length of waterline L\textsubscript{WL}: 7.60 m; beam B: 1.08 m; draft T: 0.39 m
- Three boats the same dimensions and configurations which is 1.5 GT.
- The hull material of Fibre Glass Reinforced Plastic (FRP).
- Capacity: fish payload 0.7 ton, ice 0.35 ton (ratio ice/fish: 0.5)
• Total volume: 4.37 m$^3$, volume of solid boxes: 0.623 m$^3$ (14.3 %)
• Prime mover: Outboard engine 25 (speed 12 knots) or 40 HP (speed 15 knots)
• Autonomy: 50 nautical milles with 2 crews
• Fishing gears: hand line, trolling line and additional small gill-net and bottom vertical line
• Fishing grounds: Banda Sea, Ceram Sea and other Moluccas waters
• Floating and stability test
  o At upright condition, full load, the boat still afloat
  o At capsized condition the boat still afloat

Figure 5. Unsinkable tuna long-boats

4.2 Multi-purpose fishing boat
The design of this boat is based on principal design of fishing boat [18] as well as principal design of other commercial ships [14], [18]. The main requirements of this kind of boat is designing the ship arrangement to fulfil the operation of multi-fishing gears. This boat was designed and constructed together with group of fishermen partner [19]. This boat were designed and constructed together with a group of local fishermen at the Faculty of Engineering Pattimura University (Figure 6). Multi fishing gears will be applied in this boat. However, this project is hold temporaly d due to the financial aspect during the period of Pandemic Covid-19. The specification of the boat are:
• Length overall $L_{OA}$: 8.50 m; length of waterline $L_{WL}$: 8.12 m; beam B: 1.20 m; draft T: 0.50 m
• Block coefficient $C_B$: 0.63; prismatic coefficient $C_P$: 0.77; midship coefficient $C_M$: 0.81
• Capacity: fish payload 1.50 ton, ice 0.75 ton (ratio ice/fish: 0.5)
• Gross Tonnage: 2.3 GT
• The hull material of Fibre Glass Reinforced Plastic (FRP).
• Prime mover: Outboard engine 40 HP
• Autonomy: 50 nautical milles with 3 to 4 crews
• Fishing gears: hand line, trolling line, vertical bottom line, gill net, trammel net.
• Fishing grounds: Banda Sea, Ceram Sea and other Moluccas waters

4.3. Mobile fish platform
This platform was designed and constructed in order to be applied as prototype for the local fishermen. Problems with small catching product from the traditional fishing platform (bagan) was implemented with introduction of mobile platform. The benenifit of mobile fish platform is application of several fishing gears, cathing operation in many places and any times. Basic design of this fishing platform is
based fishing boat design [18] as well as principal design of other commercial ships [10], [14], [18]. Typical hull configuration of fish platform is two-hull vessel (catamaran). The main requirements of this kind of boat is designing the ship arrangement to fulfil the operation of multi-fishing gears. Additional mechanical equipment are provided to this platform to ensure good operation (Figure 7). Other requirements of input design are: netting area should greater than 63 m$^2$, service speed when operation is about 2.5 knots where normal speed is greater than 6 knots.

![Figure 6. Multi-purpose fishing boat](image1)

This boat were designed and constructed at the Faculty of Engineering Pattimura University. The specification of the boat are:

- Length overall $L_{OA}$: 10.10 m; length of waterline $L_{WL}$: 9.91 m; beam overall $B_{OA}$: 8.00 m; beam $B$: 0.90 m; draft $T$: 0.50 m; deck height $H$: 1.00 m.
- Block coefficient $C_B$: 0.63; prismatic coefficient $C_P$: 0.77; midship coefficient $C_M$: 0.81;
- Weight displacement 9.40 tons and netting area 67 m$^2$.
- Capacity: fish payload 2.30 ton, ice 1.15 ton (ratio ice/fish: 0.5)
- The hull material of Fibre Glass Reinforced Plastic (FRP).
- Prime mover: Outboard engine 2x40 HP, electrical power: 10 kVA with winch power 5 kVA
- Autonomy: 25 nautical milles with 5 to 6 crews and fishing ground is near the islands
- Fishing gears: lifting net, gill net, bottom fish trap, vertical bottom line

![Figure 7. Mobile fish platform](image2)

4.4. Multi-purpose trimaran
This boat was designed to overcome the problem of local fishermen such as the application of single fishing gear with low catching capacity. The application of trimaran-type hull is to allow the boat still operate at ‘certain wave condition’ where compared to its counterpart monohull. Basic design of this multi-purpose trimaran boat is based fishing boat design [18] as well as principal design of other commercial ships [10], [14], [18]. The boat was designed and operated by the authors [20] and [21]. The unique of this boat is the use of multi-fishing gears to keep the continuity of operation by the fishermen. Multi-purpose fishing boat trimaran was constructed together with a company partner which was involved with research fund (Riset Unggulan Kemitraan IV- 2004) (Figure 80. The specifications of the boat are:
- Length overall $L_{OA}$: 10.84 m; length of waterline $L_{WL}$: 10.00 m; beam $B$: 0.90 m; draft $T$: 0.60 m; deck $D$: 0.90 m, beam overall $B_{OA}$: 4.65 m; length outrigger $L_{OUT}$: 5.64 m; diameter outrigger: $d_{OUT}$: 0.25 m with Gross tonnage: 4.3 GT
- Capacity: fish payload 2.0 ton, ice 1.0 ton (ratio ice/fish: 0.5)
- The hull material of Fibre Glass Reinforced Plastic (FRP) and wood.
- Prime mover: Outboard engine 40 HP
- Autonomy: 50 nautical milles with 4 to 5 crews
- Fishing gears: hand line, trolling line, vertical bottom line, gill net, trammel net.
- Fishing grounds: Banda Sea, Ceram Sea and other Moluccas waters

4.5. *Tuna long-boat trimaran*
This boat was designed, constructed and operated due to the requirements of catching tuna fish at open or harsh sea condition. The ability of this boat to exist at harsh sea condition make it is favourable for the fishermen. The unique of this boat is fast and can resist in wave condition (Figure 9). Previous works by the author to designed and constructed the boat as prototype were applied for many local fishermen to construct their similar boats [22], [23]. Additional fishing gears such as gill net and bottom vertical line will increase the catching product instead of hand line and trolling line. The specification of the fishing boat are:
- Length overall $L_{OA}$: 9.80 m; length of waterline $L_{WL}$: 9.30 m; beam $B$: 0.80 m; draft $T$: 0.50 m; deck $D$: 0.85 m, beam overall $B_{OA}$: 4.06 m; length outrigger $L_{OUT}$: 4.60 m; diameter outrigger: $d_{OUT}$: 0.16 m and Gross tonnage: 2.0 GT
- Capacity: fish payload 0.9 ton, ice 0.45 ton (ratio ice/fish: 0.5)
- The hull material of Fibre Glass Reinforced Plastic (FRP) and wood.
- Prime mover: Outboard engine 25 HP with the speed of 14 knots
- Autonomy: 50 nautical milles with 2 to 3 crews
- Fishing gears: hand line, trolling line, gill net and vertical bottom line
4.6. Solution in pandemic covid-19

Pandemic Covid-19 brings some additional problems for the local fishermen, particularly for a ship with many crew on board such as purse seiner and skipjack pole and line [1]. Discussion with the ship owners and related institution staffs were concluded that some ships did not operate because they can not fulfil the Covid-19 protocol. Meanwhile, some owners operate their ships to meet the Covid-19 protocol by spending additional money. The decisions were made by the authors and shipowners to re-arrange the vessel’s general arrangement and additional mechanism. The purse seiner should be provided with the mechanical winch and systems in order to reduce the amount of crew on board. This scenario could increase the amount of catching with additional money for the systems. There should be re-arranged fishing seats on board to keep the distance of crew on board. For example: the process of re-arranging the crew on board after discussion with the owner CV Yora as the counterpart of Faculty of Engineering Pattimura University. The discussion end-up with reducing of 12 crews at normal condition (Figure 10.a) to 8 crews (Figure 10. b) in order to keep social distance on board. The result of sea trial showed reducing of catching capacity about 25 % per each trip. However, this drawbacks may be overcome with extending the ship operation period. This study is still continued in the future for the economic aspects.

Other fishing boat considered in this study was purse seiner. This kind of fishing boat operates a lot of crews on board which are 18 to 22 persons (Figure 11. a). The big amount of crews relates to the need of human power to operate the circling net manually. During the Pandemic Covid-19 most boats stop operating. Some owners operate their boats when all protocol covid-19 was fulfilled. This situation needs additional money for this issue. The solution was made after discussion with head of local fishery board and boat owners. The application of mechanism system could reducing the amount of crew on board (Figure 11.b). Besides, this system could be used for another fishing gears such as bottom long line and gill net. However, it needs further study to confirm re-design results in the future.

The operation of small fishing boats as explained in sub-section 4.1 to 4.5 do not need Protocol Covid-19. This is due to the few crew operate on board and the social distance is fulfilled. Some ship owners follow the Protocol Covid-19 as performed by our counterpart CV Yora such as spraying the disinfectant liquid on board, health test for the crew before boarding and after the trip in order to get the sailing permit and when the boat arrive at other ports the crew stay on board. This procedure spend additional money even so, there was still the profit gained by the company. Future study is required to evaluate this economic aspect of operating the fishing boat.

(a) Normal condition
Figure 10. Skipjack pole and line
Figure 10. Skipjack pole and line (continued)

(b) Covid condition

(a). The existing purse seiner

(b) Redesign mechanized purse seiner
4.7. Discussion
Problems concerning the operation of fishing boats in Eastern Indonesian waters were implemented by introducing some new-design boats. Some benefits may be gained from the study includes:

- The application of multi-fishing gears for the new-design boat contribute to keep cathing operation for several kind of fishes.
- Safety aspect of small fishing boats was implemented by introducing solid boxes on board and application trimaran-type of boat instead of monohull.
- The application of mobile fish platform with multi-fishing gears may increase the cathing amout where this boat may operate at any places and any times.
- The record of catching products obtained form the boats operated by the fishermen have proved the suceedull of new design
- Technically those boats and their mechanisms are provided however, other aspects are still become obstacles for the fishermen which are preservation of catching product, harsh sea conditions, the existence of fish at sea, market and price.
- Solution of operation fishing boat during Pandemic Covid-19 was performed at initial stage for two kind ship, which are skipjack pole and line dan purse seiner

5. Conclusion and recommendation
Some conclusions may be drawn from this study concerning the existence of new-small fishing boat for local fishermen.

- Those ships that had been designed, constructed and operated by the local fishermen for some periods which means that the ships are accepted by users.
- The design specification of fishing boats fulfils the requirements for the operation process at sea where the dimensions, configuration and kind of fishing gears may be operated in a good way.
- The application of multi-fishing gears give opportunities for fishermen to continue their operation for other kind of fish
- The design specification provided for any kinds of fishing boat were used by the fishermen when attending training process executed by the Faculty of Engineering Pattimura University.
- It needs some periods to re-arrange purse seiner and skipjack pole and line in order to meet the protocol Covid-19 applied on board.

Meanwhile, the recommendations were made for future study include:
Re-arrange of purse seiner and skipjack pole and line should be considered in a good way to ensure the crew can work safely on board
Main problems which still influence fishermen life are the existence of market, price and product preservation

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