

学位論文題名

Study on boat characteristics and safety of small purse seine fishery in North Sulawesi, Indonesia

(北スラウェシ（インドネシア）における小型旋網漁船の特徴と操業安全性)

学位論文内容の要旨

Indonesia is the largest archipelago country in the world comprising of over 18,000 islands and a combined coastline of about 81,000 km. The North Sulawesi province is a part of the Republic of Indonesia provinces, and has a huge potential in fisheries and maritime. Indeed, the North Sulawesi province has the potential for a sustainable fishery resource. It has been counted for 1,400,000 tons/year and a potential maximum sustainable yield (MSY) of 1,800,000 tons/year (BPS Statistics Province of North Sulawesi 2009). According to the Department of Marine and Fisheries of North Sulawesi Province (2010), the utilization of marine fisheries resources is 315,469.320 tons/year, which is equivalent to about 17.52% of potential MSY. In 2010, it was established that the total number of households fisheries in North Sulawesi was 19,204 units. This accounted for 6,251 units of non-motorized boats, 14,222 units of out-board engines and 671 units of fishing boats with in-board engine. Moreover, the total number of fishing boats was 21,144 units and the estimated number of purse seiner was between 450 and 550 units (BPS Statistics Province of North Sulawesi, 2010). This is due to the fact that majority of fishing efforts in North Sulawesi province is categorized as small scale with the characteristics of traditional capture technology, insufficient skills, limited support to capital and investment, and inadequate of management skills.

The Transportation Department of Indonesia, as the party which holds authority application of Safety of Life At Sea (SOLAS), has to give examination of the construction of hull, machinery and electricity board to the Bureau classification of Indonesia (BKI). Accidents of fishing boat often cause loss of lives and huge economic damages. This has proved that the implementation of government regulations and policies are insufficiently applied for the fishing industry. It also demonstrates that safety rules applying for the fishing industry are inadequacy and amateurish. Marine accidents often occur on the sea due to the lack of controls on the ships in particular including the ship stability. Further, the fishing boat has heavy and complicated duties in waters. Thus, it needs to keep high stability due to the concerns about the safety of the fishermen during fishing operations. Fishing boat accidents in North Sulawesi province generally occurs 1 - 2 times per year. In fact, when the traditional shipbuilders build fishing boats, they never get any supervision until the boats are completed. This is one of the factors that the fishing boats cannot apply for the fishing operation.

There are two types of small purse seiners in North Sulawesi. Those are in-board engine and out-

board engine. The fishing operation of each purse seiner is fairly different. In the case of purse seiner with in-board engine, fishing operations of release and carry of nets are doing on the back side of the boat, while those operations in the out-board engine are doing on the right side of the boat. According to the term of one fishing navigation for the boat with out-board engine, it is merely one night. On the other hand, the term of the fishing navigation for the boat with in-board engine is about 5-7 days.

The experiments were carried out in the waters of Bitung, Manado and Molibagu in North Sulawesi. And I engaged 20 subjective purse seiners; 10 boats in Bitung, 4 boats in Manado and 6 boats in Molibagu. The boats were subjected for observations, calculations and analyses on 3 different conditions, namely;

- Condition 1 : the boats are loaded with nets, engine and equipment used fishing operations;
- Condition 2 : add crew, oil and ice block to the first condition (Condition 1);
- Condition 3 : add fish and reduced oil to the second condition (Condition 2).

The objectives of the study are as follows:

- a. To clarify the characteristics of hull design,
- b. To determine the stability and safety,
- c. To make clear the characteristics of the rolling motion during fishing operation.

Generally, the purse seiners built by traditional local shipbuilder in North Sulawesi did not have a body plan. So all of the boats used in this study were needed to measure boat form and to make molded plan. After accumulating fundamental data and drawing the boat form, I carried out calculations about hydrostatic parameters of the boats. In this study cluster analysis was used to estimate segment characteristics of the purse seiners. To estimate the characteristics of the rolling motion in the time/frequency domain simultaneously, I applied the wavelet analysis for the rolling motion of the purse seiners under the fishing operation. In the calculation, I used the continuous wavelet transform (CWT) with the Morlet function.

This study is concluded as follows:

1. The measurement and field observation showed that the sizes of the purse seiners made by traditional shipbuilders vary widely and do not have standard sizes. The small-sized boats are used in Bitung, because the fishing ground is closer to the fishing base before 2000. On the other hand, the large-sized boats are used in Molibagu and Manado, because the fishing ground is far from the fishing base. The sizes of small purse seiners in North Sulawesi can be classified into three groups: small, medium and large. Typical ship form under water line is slim and has a conventional round hull with a long bar keel. Ship form at the front perpendicular (FP) is a V-shaped hull, while that of the midship to the after perpendicular (AP) has a round shaped hull (U-shaped hull). Fishermen prefer such model which adapted for the fast speed because they want to arrive at the fishing base as soon as possible.
2. The GM values of the small purse seiners in North Sulawesi agree with the standard stability criteria issued by the IMO. However, the maximum GZ values on a half of the boats are extremely lower than the standards. According to the increase in loading on the deck (condition 3), the stability of purse

seiners became worse. Then for the stability criterions (C1 with 26 m/s wind speed) about a half of the purse seiners are lower than the standard. This indicates that many purse seiners are unsuitable for fishing operation under rough weather condition. Practically, most purse seiners in North Sulawesi are conducting fishing operation under such stability conditions. To improve the poor stability of the purse seiners in North Sulawesi, I recommend fishermen to reduce the load on the upper deck, and to place catches into the fish hold.

3. In the fishing operation, the wavelet power increased when the boat direction crossed to the wave directions or the boat was in hauling process. Especially, rolling angle increased when the boat getting across the wave direction. The purse seiners in North Sulawesi had the same characteristics of the rolling motion. As the weather condition affects the rolling angle and motion of purse seiners during fishing operations, I suggest reducing the surface area of structure above on the deck like a bridge as much as possible.

This study presents valuable information about characteristics and safety of the small purse seine fishery in North Sulawesi, Indonesia. Then, I expect that the government, fishermen, and traditional shipbuilder will utilize this information to make a small purse seiner for improving the livelihoods of fisheries communities. Furthermore, to improve safety during fishing operations, I suggest that the subjected purse seiner Manado1 will be a good sample in order to develop new purse seiner. Because Manado1 is small, and has a slim around hull and the rounded shape. Furthermore, this purse seiner is also classified as a fast boat, so it is approved by fishermen who want to return to the fishing base as soon as possible. This boat has a good stability with inferior gravity position. Main cause is that the purse seiner does not have bridge on upper deck. Then, I suggest the purse seiner without bridge should be adopted to improve the stability of small purse seiner. Actualization of good stability is best way to improve the safety of the purse seiners in North Sulawesi, Indonesia.

学位論文審査の要旨

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(北スラウェシ (インドネシア) における小型旋網漁船の特徴と操業安全性)

インドネシア，北スラウェシ州の旋網漁業は，地元造船所で建造される木製の小型漁船で営まれている。全漁船に占める旋網漁船の隻数は 7.6%と少ないが，漁業生産においては 44%を占める主要漁業である(2009 統計)。これら旋網漁船は地元の造船所で建造されるため，船体図面等はなく，また船体規模は材料に依存する。インドネシアにおいては，漁船海難に関する統計調査も行われておらず，また生産手段である漁船の船体形状，復原性能と操業時の船体運動特性等に関する調査・研究も，ほとんど実施されておらず，漁船漁業の安全対策については造船所，漁業者，及び行政のいずれも実施していない状況にある。こうした実態の中，小型旋網漁船の安全性を向上させることを目的に，北スラウェシ，Manado, Bitung, Molibagu の 3 地域を対象に，20 隻の小型旋網漁船の船型計測，復原性試験を実施した。さらに，7 隻の小型旋網漁船の実船実験を行い，操業実態と船体運動の動揺特性を明らかにした。

得られた成果は以下の通りである。

- 2) 旋網漁船の大きさに統一性はないが，一般に船型は瘦せ型で，長いバーキールの円形形状を有する。水面下の船型は，船首垂線(FP)では V 字形状，中央垂線(∞)から船尾垂線にかけては平坦な船底部と U 字形状を有する。
- 2) クラスタ分析により，3 地域の漁船の船型分類を行い，特性を明らかにした。Bitung と Manado, Molibagu に大別され，主要因は船長であった。船長は，漁場と漁港との距離に大きく依存する。
- 3) 船体規模が小さい Bitung の旋網漁船は総じて復原力も悪い。操業中の横傾斜を，乗組員の配置位置を変えることで平衡を維持しながら操業しており，操業時の危険な実態が明らかとなった。船長が短い漁船では，ブリッジを設置することで重上昇から復原性能の低下が顕著になることからブリッジレスが船体重心を低くし安全性向上につながる事を示唆した。
- 4) 操業時の横揺れ運動の周波数/時間領域における動揺特性を，Wavelet 解析により明らかにした。旋網操業中で横波状態になる過程と揚網過程で Wavelet 係数が大きくなる。特に横傾斜も大きい横波状態は危険な状態となる。

以上の結果は，北スラウェシにおける旋網漁船の復原性能と実操業中に変化する船体運動の動揺特性を実験的に明らかにしたもので，漁業者，造船業者及び行政機関へ旋網漁業の実態と旋網漁船の安全性に関する情報を提供し，小型旋網漁船の安全性改善に大きく寄与するものと判断される。よって審査員一同は申請者が博士 (水産科学) の学位を授与される資格のあるものと判定した。