Composition of Skipjack Tuna *(Katsuwonus pelamis L)* Taken by Commercial Fishery from the Northeastern Waters of Indonesia

R. Sala

Department of Marine Science, the State University of Papua
Jl. Gunung Salju, Manokwari 98314, Indonesia. Email: ridwansala@yahoo.com

Abstrak

Penelitian ini bertujuan untuk mengevaluasi perubahan komposisi ukuran cakalang yang tertangkap dan asosiasi yang mungkin ada antara cakalang dan tuna yang lain pada hasil tangkapan di kawasan utara perairan Indonesia bagian timur. Data penelitian ini diperoleh melalui survey lapangan dengan mengambil sampel hasil tangkapan dari perikanan komersial di lokasi penelitian. Dari hasil penelitian ini terungkap bahwa komposisi ukuran cakalang yang tertangkap oleh huhate (pole-and-liner) cenderung stabil dan didominasi oleh ukuran lebih besar dari 2,5 kg. Akan tetapi untuk cakalang yang tertangkap oleh pukat cincin didominasi oleh ukuran yang kurang dari 1 kg, terutama yang tertangkap di perairan sekitar Sulawersi Utara. Hasil penelitian ini juga mendapatkan adanya korelasi yang erat antara ikan cakalang dan tuna ekor kuning yang tertangkap oleh perikanan komersial.

Kata kunci : *cakalang, komposisi ukuran, perikanan komersial, perairan bagian utara kawasan timur Indonesia.*

Abstract

The objectives of this study are to detect the changes in size composition of skipjack tuna, and to examine any association that may exist between skipjack tuna and other tunas taken from the northeastern Indonesian waters. Data were collected through a field survey by taken samples of catch of commercial fisheries in the study areas. Results of the study revealed that size composition of skipjack taken by pole-and-liners tended to be stable over the observation periods and was dominated by size class larger than 2.5 kg. However, there was a tendency of domination of skipjack for size class less than 1 kg, particularly taken by Bitung's purse-seiners fishing around North Sulawesi water. It was also revealed that skipjack taken by the commercial fishery show a strong association with other tuna, especially yellowfin tuna.

Key words : *skipjack, size composition, commercial fishery, northeastern waters of Indonesia*

Introduction

The area defined as the Northeastern Indonesian Waters (NIWs) includes the exclusive economic zone of Indonesia adjacent to the Pacific Ocean. The NIWs are important fishing grounds for skipjack tuna fisheries (Winarso, 2004). Very little effort has been devoted to understanding the skipjack stock structure in the region, although one difficulty that hampers studying on the stock is the lack of historical catch data available especially when the study aims to understand spatial and temporal change in the stock structure overtime (Begg & Waldman 1999). Begg & Waldman (1999) suggested that a rough description of stock structure can be understood by examining catch data. This can be an alternative way of examining stock structure since collecting data by using fishery-independent survey is considerably expensive and time consuming. Catch from commercial fishery can be a source of data when the size composition of fish taken by the fishery is well classified and recorded over time. Available information of historical size composition of skipjack taken from Indonesian waters was briefly presented in Hampton & Williams (2003) which was combined with catch of Philippines fisheries. Differences in fishery characteristics and fishing locations of skipjack fisheries in the two nations may limit the use of the information for specifically understanding stock structure and management of skipjack tuna in NIWs.

Description of size composition of catch taken by fishery is one of useful information that is not only to understand the structure of stock (Begg & Waldman

Diterima / Received : 09-07-2009
Disetujui / Accepted: 07-08-2009

1999) which is vulnerable to the fishing activities, but also to aid the design of suitable management models for targeted species (Begg *et al.,* 1999). It can also be used to detect impact of fishing as a reduced proportion of large fish is often an indicator that the fish stock is heavily exploited (Hampton & Williams, 2003). Furthermore, in term of skipjack stock, since the natural characteristics of this species which is categorized as a highly migratory species, it may, to some extent, affect the size composition of the fish caught in the fishing areas located in the migration path, as the catch in some areas may contain a higher proportion of a particular size than others.

Several factors may affect composition of skipjack tuna taken from the northeastern Indonesian waters. Those factors include temporal and spatial effects which are induced by stock movement, spawning activities and recruitment, and fishing type (method) effects (Langley *et al*., 2004). The objectives of this study are to detect the changes in size composition of skipjack tuna, and to examine any association that may exist between skipjack tuna and other tunas taken from the northeastern region of Indonesian waters.

Material and Methods

Study Sites and Data Characteristics

Data of landing catch from commercial fishing vessels, grouped by market size from 5 locations, Biak, Manokwari, Sorong, Penambuan and Bitung (see location map, Fig. 1), were used in the present study. The nature of the recorded data was different among these locations in terms of the size classification because buyers (importers) in each location required different market class-size of the fish . Skipjack tuna catch for pole-and-line in Sorong and Penambuan were only grouped into 3 size classes (≤ 1.5, 1.6-2.5 and ≥ 2.6 kg). The catch for purse-seine landed in Manokwari were grouped into 4 size classes (≤ 1, 1.1- 1.5, 1.6-2.5 and > 2.5 kg), and purse-seines' catch for Bitung and Biak were classified into 5 groups with different class intervals, i.e. ≤ 1, 1.1-1.4, 1.5-1.8, 1.9-3.4 and >3.4 kg; and ≤ 0.5, 0.6-1.0, 1.1-2.0, 2.1- 3.0 and >3.0 kg, respectively.

All data were recorded monthly. The length of series data available for this study varied among locations. The shortest data series were for Penambuan and Biak (2 years), followed by the Bitung data (3 years), the Manokwari data (4 years), and the Sorong data (10 years). The latest data available for all locations were for 2002.

For the purpose of analyses, the data classification in each data set were re-arranged in order to enable comparison of size distribution between locations. Manokwari, Sorong and Penambuan data were classified into 3 size groups (≤ 1.5, 1.6-2.5 and ≥ 2.6 kg). Biak and Bitung purse-seine data only had a classification for catch ≤ 1 kg in common, so the data from these locations were classified into two classes (≤ 1 kg and > 1 kg).

Data Analysis

Spatial and Temporal Distribution of Skipjack Catch

In this analysis, the original size classification was used in order to examine details of size distribution of catch for each location and each type of gear. The trends in size composition over time were examined by first converting the original data into proportions and then presented in the form of time series graphs yearly. Judgment on whether proportions of any particular fish size showed a decrease or increase in catch was based on the graphs.

Interaction Between Skipjack Tuna and Other Tunas

A simple linear regression (Grafen & Hails, 2002) was used to test the interaction between skipjack tuna and other tuna species. The analysis aims to find out how the change in number of other tuna correlates to the number of skipjack tuna caught by the pole-and-line and purse-seine fishery.

The presence of association of skipjack with other tuna species was done by examining the regression coefficient. In order to see whether skipjack tuna caught by different fishing types interacts differently with other tuna species, the analysis was done separately for each fishing type. The original data (in metric tons) was used in this analysis. However, since the data distribution was skewed to the left, this was corrected by using a log transformation.

Results and Discussion

Trend of Skipjack Tuna Size Distribution

The results of analyses of trends in size distribution of skipjack were divided into two sections based on fishing methods i.e. purse-seine and pole-and-line.

Purse-Seine Catch

Three histograms of size proportions of skipjack tuna taken by purse-seiners were presented in Fig. 2. Each graph represents each landing location.

Skipjack tuna catch landed in Biak (Fig. 2a), taken by three purse-seiners, showed similar pattern between catch in 2001 and 2002 even though the recorded total skipjack tuna caught in 2002 was about twofold (ca. 5,000 t) higher than in 2001. The catch was dominated by the size class 1.90-3.40 kg which contributed more than 50% of the total catch and very small proportion (ca. 10%) of skipjack tuna size ≤1 kg.

Skipjack tuna landed in Manokwari (Fig. 2b) taken by one purse-seiner tended to be dominated by medium size class (1.60-2.5 kg), with exception of the proportion of size class 1.1-1.5 kg and small size class (≤ 1 kg) that were more dominant in 1998 and 2002 respectively. With respect to the total catch, this change in size composition was not related to the change in total catch. The annual total catch of skipjack taken by the purse-seiner was about 400 t in 1999 and 2000. This figure increased considerably to about 800 t in 2001 and went down again drastically to about 300 t in 2002.

On the contrary to the two other locations, skipjack tuna caught by three Bitung purse-seiners (Fig. 2c) showed a clear trend of the change in size class during 2000-2002. The small size class (≤ 1 kg) has a tendency to dominate the catch. The proportion of this class increased from about 30% in 2000 to about 50% in 2001 and continues to increase to about 90% in 2002. The increase in the small size class was followed by a significant decrease in total catch taken by the three purse-seiners during the periods. Record of the total catch in 2000 was just above 2000 t which decreased during the next two year and reached about 1000 t in 2002.

Pole-and-Line Catch

The data for the three size classes caught by Sorong pole-and-line (area A) showed no clear trend. Fig. 3a displays the distribution of fish size class < 1.5 kg and > 2.5 kg that show strong fluctuation while medium size (1-5-2.5 kg) was relative constant over the 10 years of fishing. Fish size larger than 2.5 kg dominated Sorong pole-and-line catch during the periods with the exception of catch in 1998 where the medium size class was more dominant and in 1999 the proportion of small size fish was higher.

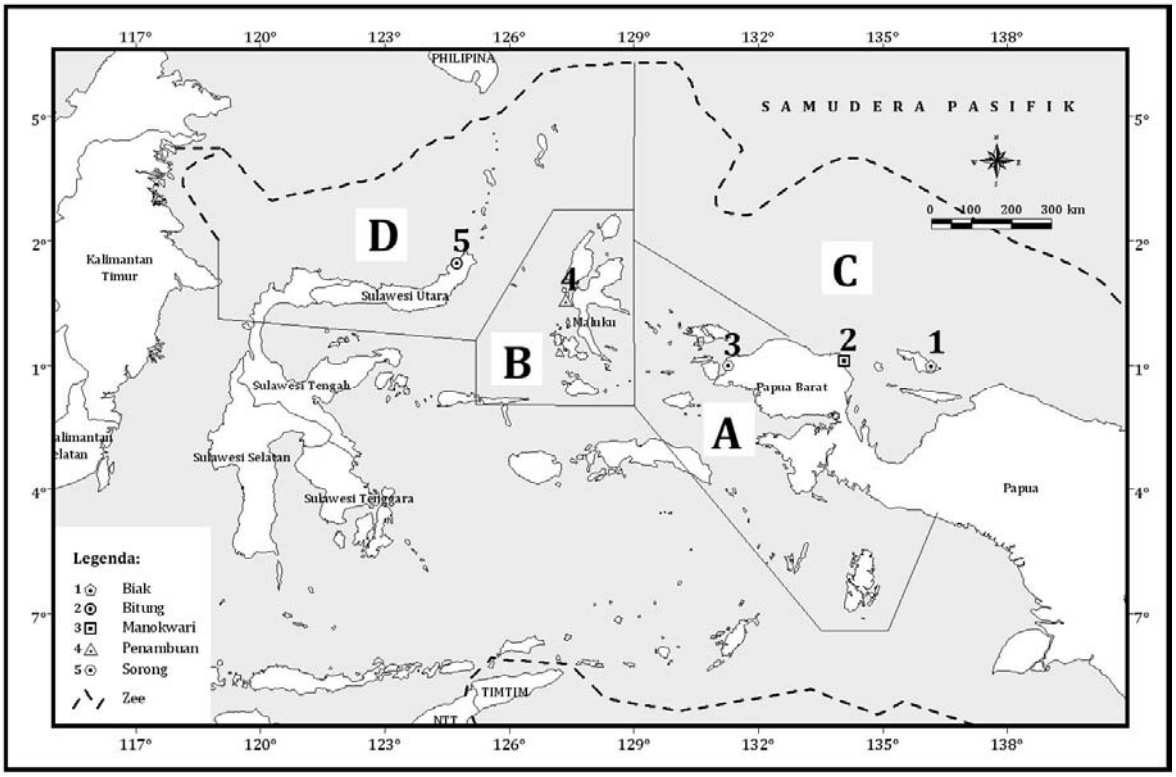

Figure 1. Boundary of locations covered in the present study. Numbers (1,2,..,5) are main fishing bases of skipjack fishing fleets. Letters (A,B,C, and D) are the estimates of fishing areas of the skipjack fishing fleets. In the present study, the NIWs is defined as the region in the northeastern of Indonesia adjacent to Pacific Ocean, including exclusive economic zone of Indonesia.

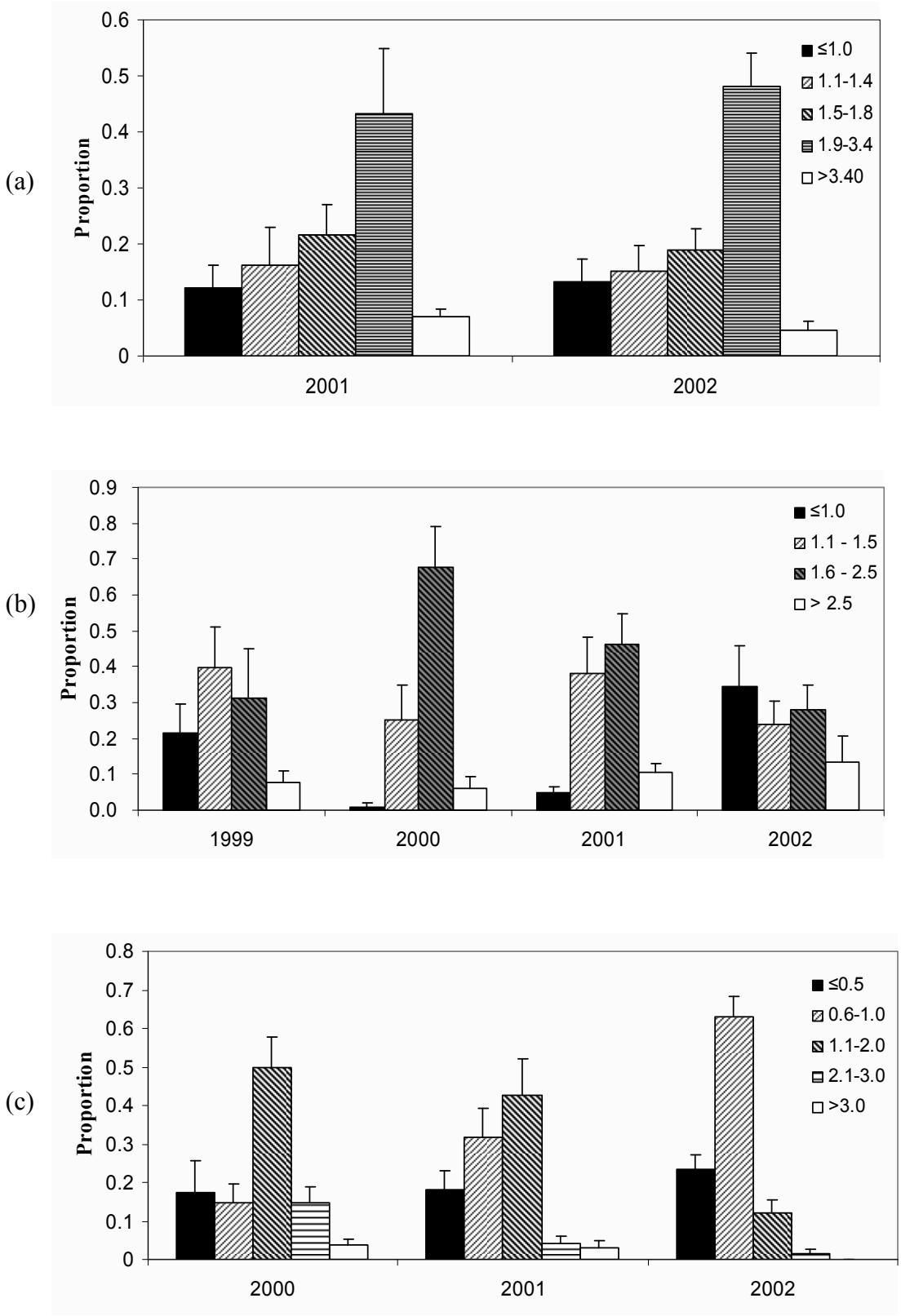

Figure 2. Distribution of skipjack tuna size taken by purse-seiners landed in (a) Biak, (b) Manokwari and (c) Bitung. The histogram shows the mean and standard error of proportion of each size class. The size was measured in kg and each location had a different size classification.

(b)

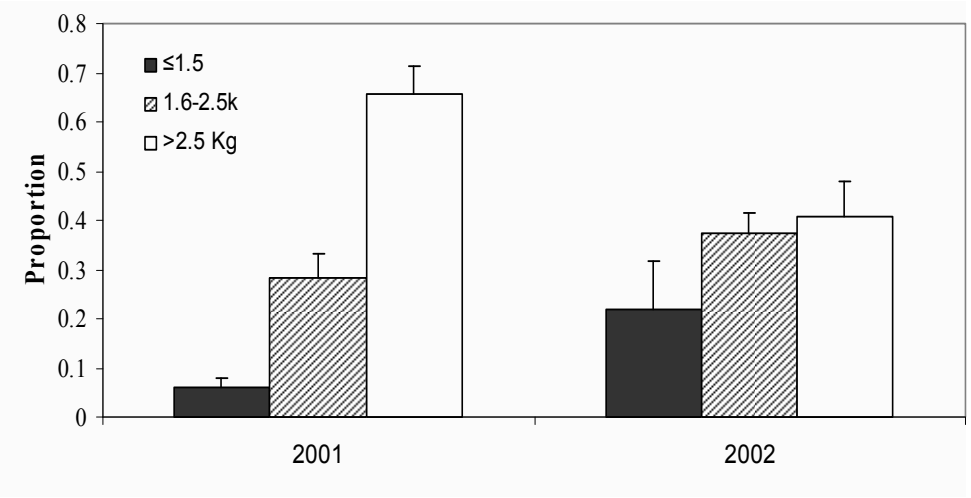

Figure 3. Distribution of skipjack tuna size taken by pole-and-liners landed in (a) Sorong and (b) Penambuan. (The histogram shows the mean and standard error of proportion of each size class. The size was measured in kg weight).

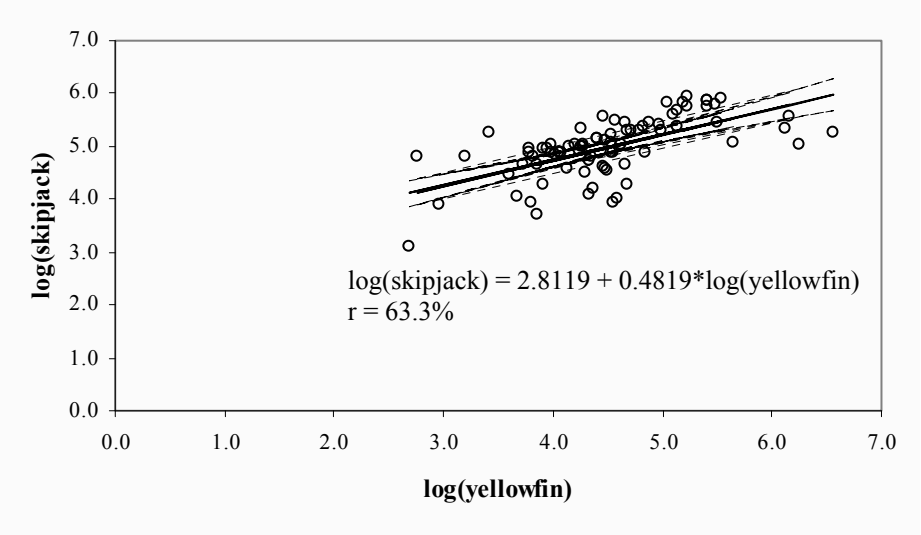

Figure 4. Correlation between skipjack and yellowfin caught by purse-seine fishery in the NEIWs. (o) represents the observed-log(skipjack); the line (-) represents the prediction line produced by regression model and 95% confidence intervals.

The recorded total skipjack tuna caught by the pole-and-lines showed significantly decreased trend from about 8000 t in 1996 to about 3000 t in 2000 before increasing slightly (about 3,500 t) in 2002. This trend of decreasing total catch was reflected by decreasing in fishing effort (vessel units). The total catch data for 1993-1996 was provided by 40 vessels while for 1997 was only 38 vessels and even lesser (17 vessels) for 2001-2002.

Data of skipjack tuna catch grouped by size class taken by Penambuan pole-and-liners was available for 2001-2002. Distribution of catch from large size class dominated the catch in 2001 (Fig. 3b). This composition changes slightly in 2002 with some increase in proportion of small and medium size class and decrease in large size class. The catch was taken by 22 pole and liners with the total catch was about 700 t and 350 t in 2001 and 2002 respectively.

The analyses on the size composition have provided some insight into the current status of skipjack tuna stock which is vulnerable to fishing activities. Based on the composition analyses, two distinctive

regions can be recognized where different proportions of skipjack tuna are caught. In the eastern part (areas A,B, and C), based on data from the pole-and-line fishery of Sorong and Penambuan, as well as data from Biak and Manokwari purse-seines, composition of catch was more abundant for sizes larger than 1.5 kg; while in the western part (area D), based on Bitung purse-seines catch, for the small size (≤ 1.0 kg) was more dominant. The size composition of skipjack tuna in the western part agrees with the size composition of skipjack tuna for the Indonesian and Philippine fishery presented in Hampton and Williams (2003), in which the dominant size fell between 20-40 cm length for data 1997-2001 and remained unchanged when looking at the composition of skipjack tuna for the two countries since 1980s (Langley *et al.,* 2004), in which most dominant was size of less than 30 cm (Babaran, 2006). While no detailed information about the source of data used in the analysis, It can only be suspected that most of the data was most likely sampled from the Philippine purse-seine operating in the adjacent waters of Bitung purse-seine fishing grounds. It may also be suspected the small skipjack caught from western part of NIWs resulted from local recruitment in the tropical fishing grounds (Arai *et al*., 2005).

The attempt to investigate the size composition of skipjack tuna from each specific location in the study area revealed that for pole-and-line catch, the size was dominated by large size class (> 2.5 kg). This can be seen clearly for Sorong pole-and-line fishery (area A) that had a long series of historical data with exception of the catch in 1999, in which the size <1.5 kg was more dominant. The large proportion of small skipjack in 1999 may be caused by a large amount of recruitment after El Nino 1997-1998 (Hampton & Williams , 2003; Langley *et al.,* 2004); recruitment to the fishery will be delayed by 6-12 month after El-Nino events (Lehodey Submitted to FAO).

The similarity of size composition between Sorong and Penambuan pole-and-liners may possibly be due to the sharing of the same stock between pole-and-liners in the two locations, since they are adjacent to each other. Variability of size composition by year may be due to a difference in yearly recruitment or may also be caused by the dynamics of the stock in terms of immigration to (or emigration from) the areas. This, however, needs to be confirmed by further research through, for example, tagging experiments.

In contrast to the pole-and-line catch, the size distribution of skipjack tuna taken by purse-seine at the two fishing bases, Biak and Bitung, (area C and D, respectively) showed significant differences in the proportion of size classes between the two areas. There was a tendency of the fish in area D to be dominated by small size (≤ 1 kg). If this catch represented the stock of skipjack tuna, it may be suspected that area D has become locally-highly exploited due to the development of local purse-seine fishery in the area and the presence of Philippine purse-seiners since 1990 (Naamin *et al.,* 1996). Another possibility is that the purse-seiners in that area may be highly dependent on the local recruitment. Recruitment from outside the area, before entering that area during their migration from WPO, might have been taken by other fishery (ie. Philippines purse-seines) since the fishery deployed FADs (fish aggregating devices) around northern Sulawesi water (Naamin *et al.,* 1996)

Association between Skipjack Tuna and Other Tuna Purse-Seine Catch

The regression analysis for interaction between skipjack tuna and other tuna was conducted on data from purse-seine fishery that landed their catch in Biak and Bitung (area C and D). The relationship between number (biomass) of skipjack tuna and other tuna (represented by yellowfin tuna) taken by purse-seiner was found to be strong; the increase in log(yellowfin) tended to be followed by the increase in log (skipjack) with a correlation coefficient shown in Fig. 4. The regression coefficient (*b*) ranged between 0.3480 and 0.6158 with a mean of 0.4819 in log scale. When converted to the original scale, these figures represented the ratios of skipjack and yellowfin caught by purse-seine fishery which ranged between 2.23 and 4.13 t with the mean of 3.03 t of skipjack for every metric ton of yellowfin. This finding confirms the percentage of skipjack in the total catch based on the interview with purse-seine fishermen, where skipjack accounted for about 80% of the total catch. Due to data limitation, this analysis however cannot reveal whether particular size of the skipjack tend to interact with particular size of yellowfin.

Pole-and-Line Catch

The regression analysis based on catch data of Sorong and Penambuan (area A and B) pole-and-liner fishery showed similarity with the results based on purse-seine data above. The correlation coefficient

was 86% which indicated a very strong relationship between number of skipjack tuna biomass and yellowfin biomass caught by pole-and-line fishery (Fig. 5). The regression coefficient was 0.759 (in log scale) with confidence interval 0.682 - 0.837 or when converted to the original scale became 5.75 t with the confidence intervals 4.81 - 6.87 t in which this explain the number of skipjack tuna biomass in every metric ton of yellowfin caught. These figures were marginally higher than those of purse-seine catch. However, these figures were in agreement with the information gathered from the pole-and-line fishermen, who reported that the composition of skipjack tuna was about 80% from the total catch. And like purse-seine data, the result from the analysis of pole-and-line data cannot explain whether particular size of the skipjack tends to interact with particular size of yellowfin.

The presence of other tuna species together with skipjack catch has been well known. Especially when fishing around FADs, the catch usually is mixed with other tuna species (Wild & Hampton, 1994; Hampton & Bailey, 1999), particularly small yellowfin and small bigeye (MRAG Americas Inc, 2002). Dayaratne (1994) reported the catch of driftnet in the South of Sri Lanka, consists of 62-94% of tuna which was dominated by skipjack and yellowfin. In this study, a strong correlation was also found between skipjack and other tuna, especially with yellowfin tuna in aggregated monthly catch data, both for pole-and-line fishery and purse-seine fisheries operating in Northeastern Indonesian waters. The composition of yellowfin in the catch was about 25% from the total monthly catch for pole-and-line and about 15% from the total catch of purse-seine fishery. However, it is still unclear whether the two species form of composite school (Wild & Hampton, 1994) or whether they school by species and integration in the fishing ground was only stimulated by food as diets for all small size tuna caught under FADs were found to be similar (Menard *et al.,* 2000; Tanabe, 2001).

The present study has made use of data from commercial fishery in order to understand the skipjack stock in the Northeastern of Indonesian waters. There is some limitation of this study due to incomplete data/information provided by fisheries in that region. This study has not included data for pole-and-line fishery operating in Bitung because the fishing industry there was unwilling to provide data, and searching for supported published-literatures about pole-and-line catch in the area found no result. This has limited a comprehensive interpretation of the results, as the pole-and-line catch in these areas may have different characteristics from pole-and-line catch landed in Sorong and Penambuan and/or purse-seine catch landed in Bitung. Moreover, data from several locations used in the present study span only over a short time period of 2 years. Therefore, with exception of the catch for pole-and-line in Sorong where data on catch composition was available for 10 years, the change in catch distribution for other locations can only be interpreted as a change in the short term.

A continued investigation of catch composition dynamics in the tuna fishery in the investigated region will be important and may provide information of the change in skipjack stock structure over time due to the fishing and environmental impact. More attention should be paid to the location that indicated a high proportion of pre-spawning skipjack tuna found in the catch area (i.e. Area D). In order to perform a more comprehensive study on this species using commercial data, fishing log books that were introduced by the Indonesian government must be filled out during the fishing operation and made available to scientists.

Conclusion

The size composition of skipjack taken from the northeastern waters of Indonesia tended to be stable over the period of study and dominated by fish size larger than 2,5 kg, with exception for skipjack taken from water around North Sulawesi, in which fish size less than 1 kg were more dominant. In addition, there was a strong association between skipjack and yellowfin tuna.

Acknowledgements

We wish to thank the two Anonymous Reviewers for their very useful suggestions to improve the paper. Data and information for this research were taken from various sources. I would like to thank to the owners and staff of PT. Usaha Mina Sorong, PT. Usaha Mina Labuha, PT. Mitra Mas, PT.Ratatotok, PT. Biak Mina Jaya, PT. Inter Galaxy, PT. Ramoi, and PT. Karya Teknik Utama for allowing the author to have access to part or whole data and information available at the companies. Thanks also to purse-seiners' crews and pole-and-liners' crews for providing data and information during the survey. Lastly, I appreciate support and help from local governments during the survey.

References

Arai, T., A. Kotake, S. Kayama, M. Ogura & Y. Watanabe. 2005. Movements and life history patterns of the skipjack tuna *Katsuwonus pelamis* in the western Pacific, as revealed by otolith Sr:Ca ratios. *Journal of the Marine Biological Association of the United Kingdom* 85(5):1211-1216

Babaran, R.P. 2006. Payao fishing and its impacts to tuna stocks: a preliminary Analysis. WCPFC-SC2-2006/FT WP-7

Begg, G. A., K. D. Friedland & J. B. Pearce, 1999. Stock identification and its role in stock assessment and fisheries management: an overview. *Fisheries Research* 43(1-3): 1-8.

Begg, G. A. & J. R. Waldman, 1999. An holistic approach to fish stock identification. *Fisheries Research* 43: 35-44.

Dayaratne, P. 1994. Observations on the species composition of the large pelagic fisheries in Sri Lanka. Proceeding of The 5th Expert Consultation on Indian Ocean Tuna, Mahe, Seychelles, 4-8 October, 1993, PTP, Colombo (Sri Lanka), IPTP Collect.

Grafen, A. & R. Hails. 2002. Modern statistics for the life sciences. Oxford University Press Inc. New York. 351 p.

Hampton, J.& K. Bailey, 1999. Fishing for tunas associated with floating objects: Review of the western Pacific fishery. *Special Report. Inter-American Tropical Tuna Commission* 11: 222-284.

Hampton, J. & P. Williams, 2003. The western and central Pacific tuna fishery: 2001 overview and status of stocks. Oceanic Fisheries Programme, Tuna Fisheries Assessment Report No.4. Noumea, New Caledonia, The Secretariat of the Pacific Community.**:** 42 p.

Langley, A., J. Hampton & P. Williams, 2004. The western and central Pacific tuna fishery: 2002 Overview and Status of Stocks. Tuna Fisheries Assessment Report No. 5. Noumea, New Caledonia, Secretariat of the Pacific Community.**:** 49 p.

Langley, A., M. Ogura & J. Hampton., 2004. Stock assessment of skipjack tuna in the western and central Pacific Ocean. SCTB16 Working Paper SKJ–1: 43 p.

Lehodey, P. (Submitted to FAO). Impacts of the El Niño Southern Oscillation on tuna populations and fisheries.

Menard, F., B. Stequert, A. Rubin, M. Herrera & E. Marchal, 2000. Food consumption of tuna in the Equatorial Atlantic ocean: FAD-associated versus unassociated schools. *Aquatic Living Resources* 13(4): 233-240.

MRAG Americas Inc. 2002. Review of Ecosystem bycatch issues for the Western and Central Pacific Region, paper prepared for Prepcon3 for the Western and Central Pacific Fisheries Commission, Philippines, November 18-22.

Naamin, N., C. P. Mathews & D. Monintja, 1996. Studies of Indonesian tuna fisheries, Part 1: Interactions between coastal and offshore tuna fisheries in Manado and Bitung, North Sulawesi. Scientific Papers from the Second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, 23-31 January 1995., Shimizu, Japan, FAO Fisheries Technical Paper.

Tanabe, T. 2001. Feeding habits of skipjack tuna *Katsuwonus pelamis* and other tuna *Thunnus* spp. juveniles in the tropical western Pacific. Fisheries Science; 67: 563–570

Wild, A. & J. Hampton. 1994. A review of the Biology and fisheries for skipjack tuna, Katsuwonus pelamis in the Pacific Ocean. Interactions of Pacific Tuna Fisheries: Paper in Biology and Fishery. Proceeding of First FAO Expert Consultation on Interaction of Pacific Tuna Fisheries, 3-11 December 1991, Noumea, New Caledonia., FAO Fisheries Technical Paper. Rome.

Winarso, B. 2004. Analisis managemen “waktu” pada usaha penangkapan ikan tuna/cakalang dengan sistem rumpon di Kawasan Timur Perairan Indonesia. ICASERD Working Paper No. 30.