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PRELIMINARILY RESULTS OF THE RELATIONSHIP BETWEEN CATCH RATIO OF BIGEYE TUNA (*Thunnus obesus*) TO TOTAL CATCH AND DEPTH OF UNDERWATER STRUCTURES OF FADS

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Preliminarily results of the relationship between catch ratio of bigeye tuna (*Thunnus obesus*) to total catch and depth of underwater structures of FADs

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Abstract

The main target species of Japanese purse seine operated in the tropical waters of the Pacific Ocean is skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) consisted of nearly 98 % to their total catch weight and the remaining is bigeye tuna (*Thunnus obesus*) according to logbook. The recent study of the vertical distribution of the three species around drifting FADs (fish aggregating devices) indicates that the skipjack tuna distribute relatively shallower depth layer. A typical FAD consists of floating foundation and underwater structures, which is used-up fishing net. Therefore shortening the length of the underwater structure of FADs (depth of FADs) may be effective to reduce the bigeye tuna catch. Relationship of the species composition of purse seine catch and the depth of FADs was investigated by port samplings and by log book, of 17 sets and 65 sets, respectively from May to June 2007. The analysis was a preliminary because of small sample sizes in both data sets. The clear relationship between the presence/absence of bigeye tuna catch and the depth of FADs was not obtained by generalized linear model (port sampling; Chi-Square 0.11, P = 0.7365 and log book; Chi-Square 2.20, P = 0.1376). It was found that the depth of FADs had no sigfinicant effect on the ratio of bigeye tuna catch to total catch per set (port sampling; $F_{1,4}$ = 2.57, P = 0.1839 and log book; $F_{1,23}$ = 0.19, P = 0.6711). The effects of the depth of FADs for the amount of skipjack and yellowfin tuna catch were also investigated and both the catches were not significant with the depth of FADs.

Introduction

Japanese purse seine operated in the Pacific Ocean tropical waters all year round and the total catch per year of the fishery has stabilized to nearly 230,000 MT in recent five years (Uosaki et al, 2007). The main targets of Japanese purse seine fishery

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operating in the tropical Pacific Ocean are skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) which account nearly 98 % of total catch weight, according to logbook. The remaining catch is bigeye tuna (*Thunnus obesus*) which is non-targeted species and caught mixing with main target species by mainly operation on the floating object including FADs (fish aggregating devices). The fork length of bigeye caught by this fishery is mainly ranged from 30 to 70 cm. To be reduced the small and immature bigeye tuna catch should be effective for efficient use of the resources from the point of view to increase the yield per recruitment and the spawning per recruitment. The recent study of the vertical distribution of the three species around drifting FADs indicates that the skipjack tuna distribute relatively shallower depth layer comparing to yellowfin and bigeye tunas (Matsumoto *et al*. 2007). A typical FAD consists of floating foundation and underwater structures, which is used-up fishing net. Therefore the shortening the length of the underwater structure of FADs may be effective to reduce the small bigeye tuna catch.

In middle May through the end of June 2007, a research on the relationship between the depth of underwater structure of floating objects, mainly FADs, and the ratio of bigeye in the catch was conducted. This investigation was collaborated by Japan Far Seas Purse Seine Fishing Association, two fishing markets (Yaizu and Makurazaki ports), Japan Fisheries Resource Conservation Association and National Research Institute of Far Seas Fisheries, Fisheries Research Agency (NRIFSF, FRA) leaded by Fishery Agency of Japan. This type of collaborative work is recommended in Conservation and Management Measure 2006-01 (WCPFC 2006). The purpose of this report is to verify the relationship between the depth of the underwater structure of FADs and the ratio of bigeye tuna catch to total catch per set. This study is still on going and the results are preliminary.

Methods

Data collection

The species composition in weight and the depth of underwater structure of FADs (it is called as “depth of FADs” hereafter) were investigated by port sampling and by log book from May to June 2007. We tentatively assumed that the depth of underwater structure of natural log was 0 m. The two data sets were analyzed separately. The former data collections were conducted in Yaizu port and Makurazaki port, which are two of the main landing ports of the fishery. The fish market staffs and stuffs of NRIFSF measured the species composition in weight of a well, which is filled with fish from only one set and its depth of FADs is identified by hatch plan. The amount of fish identified and measured were about 1.5 metric tons for each catch. For logbook data, the catch information is taken directly from the logbook and the depth of FADs was given by the purse seiner.

Data analysis

The relationship between the depth of FADs and the ratio of bigeye tuna catch to total catch per set (ratio of bigeye) was analyzed by two steps using the GENMOD and GLM procedure of SAS software (vers. 9.1, SAS Inst., Inc.). The first step is to test the effect of the depth of FADs for the presence/absence of bigeye tuna catch, and the second step is to test the effect for the ratio of bigeye among the sets with positive bigeye catch. The details of the two steps are as follows;

Step 1 *Binomial Generalized Linear Model to model presence/absence of bigeye*
Log [(rate/ (1-rate)] = Intercept + depth of FADs (m) + total catch per set (t)
where the rate is 1 if catch of bigeye is larger than 0, and the rate is 0 if catch of big eye equal to zero. rate ~ binomial (p), link function is logit function.

Step 2 *linear model with transforming ratio of bigeye catch out of total by logit transformation*
Log [Ratio of bigeye/ (1- Ratio of bigeye +0.0000001)]
= Intercept + depth of FADs (m) + total catch per set (t)
where Log [Ratio of bigeye/ (1- Ratio of bigeye +0.0000001)] ~ normal(0, σ^2).

The total catch per set was considered as determinant because it was found that the sigfinicant negative relationship between ratio of bigeye and the total catch with positive bigeye catch per set from the logbook data from 1995 to 2007 (GLM, $F_{1, 13477}$ = 2808.50, P < 0.0001). The relationship between depth of FADs and the total catch per set of both data sets had no significant relationship (GLM, $F_{1, 81}$ = 0.26, P = 0.6122).

In addition to above analyses as base case study, the following analysis was also made to test sensitivity of the results. The natural log data was omitted to remove the effect of floating object which the depth of under water structure is 0m.

The effects of the depth of FADs for the amount of catch of skipjack tuna and yellowfin tuna were examined by general linear model using the GLM procedure of SAS.

Results

The species composition and the depth of FADs of 17 purse seine sets (13 cruises) and 65 purse seine sets (nine cruises) were collected from port samplings and log books, respectively, from May to June 2007 (Table 1). The fishing locations were showed in Fig. 1. The sample of the port sampling covered 2.0 % of a well in average. The ratio of bigeye of the port sampling was from 0 to 0.243, and of the logbook was from 0 to 0.200 (Fig. 2). The numbers of absence of bigeye catch were 10 and 39 sets, respectively. The depth of FADs of each data set distributed from 25 to 75 m and from 0 to 50 m, respectively (Fig. 2).

The results of generalized linear model were showed in Table 2. Clear relationship between the presence/absence of bigeye tuna catch and the depth of FADs was not found by generalized linear model from both data sets (port sampling; Chi-Square 0.11, P = 0.7365 and log book; Chi-Square 2.20, P = 0.1376). It was found that the depth of FADs had no sigfinicant effect on the ratio of bigeye tuna catch to total catch per set (port sampling; $F_{1,4} = 2.57$, P = 0.1839 and log book; $F_{1,23} = 0.19$, P = 0.6711). The data set omitted the natural log data was showed in Table 3.

The effects of the depth of FADs for the amount of skipjack and yellowfin tuna catch were also investigated and both the catches were not significant related with the depth (Tables 4, 5).

Discussions

In respect of the step 1, Cleridy *et al.* (2007) indicated that FAD's underwater structure depth had the largest effect on bigeye tuna catch, however our results did not indicate such effect on the depth of FADs in both data sets. One possible explanation of the different conclusion is probably due to the small sample size used in this analysis. However, Cleridy *et al.* (2007) also suggested the strong effect of fishing location (latitude, longitude) for the presence of bigeye tuna catch and indicated the actual magnitude of the gear effects must be viewed cautiously. The effect of fishing location and season should be considered in our model in further study.

With regard to the step 2, the depth of FADs is not significant in both data sets (Table 2). Pooling all observation does not affect the analysis because the general result has no change (Table 2, 3).

It is also necessary to verify the extent of the impact on the catch technique for skipjack and yellowfin tuna. Although the P-value (0.084) of yellowfin catch in the log book was near the critical value (0.05), there is no significant relationship between the depth of FADs and catches of skipjack and yellowfin tuna.

Acknowledgement

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References

1. Cleridy E. Lennert-Cody, Jason J. Roberts, Richard J. Stephenson. 2007. An analysis of gear effects on the presence of bigeye tuna (*Thunnus obesus*) in the catches of the purse-seine fishery in the eastern Pacific Ocean. DOCUMENT SAR-8-09c. IATTC Working group to review stock assessments 8th meeting. La Jolla, California (USA). 7-11 MAY 2007

2. WCPFC 2006. Conservation and management measure 2006-01. Conservation and management measures for bigeye and yellowfin tuna in the western and central Pacific Ocean. Third regular session. Apia, Samoa. 11-15 December 2006.

3. Matsumoto, T., K. Satoh, Y. Semba and M. Toyonaga. (in press). Study on swimming behavior of small bigeye, yellowfin and skipjack tunas around drifting FADs to develop mitigation measures for the incidental catch of juvenile bigeye and yellowfin tunas. PFRP Newsletter.

4. Uosaki, K., H. Okamoto and K. Satoh, 2007 National Tuna Fisheries Report of Japan. WCPFC. Scientific Committee Third Regular session. 13-24 August 2007, Honolulu, Hawaii.

Table 1. Number of cruise and set, operation location, depth of under water structure of FADs (m) (depth of FADs), coverage of measurement to total catch per set (measurement coverage).

Data set		port sampling	log book
Number of cruise		13	9
Number of set	Total	17	65
	FADs	14	26
	Log	3	39
operation	Latitude	9°32′ N - 0°46′ N	10°38′ N - 1°21′ S
	Longitude	141°50′ E - 150°40′ E	136°38′ E - 154°32′ E
depth of FADs (m)		25.0 - 75.0	0.0 - 50.0
measurement coverage (%) (avg (SD))		2.0 (1.6) (%)	-
total catch per set (t)		20 - 220	5 - 200

Table 2. Bigeye tuna (*Thunnus obesus*). Results of 2-step generalized and general linear model of the data sets of (A) port sampling and (B) log book. The step 1 and 2 test the influence of the depth of underwater structure of FADs for existence or non-existence of bigeye tuna, and for the ratio if it is not zero, respectively.

		parameter	DF	Estimate	Chi-Square (step 1) / F (step 2)	P
(A) port sampling	Step 1	Intercept	1	-0.5426	0.19	0.6670
		total catch	1	0.0062	0.67	0.4141
		depth of FADs	1	0.0087	0.11	0.7365
	Step 2	total catch	1	0.0086	0.75	0.4360
		depth of FADs	1	2.7813	2.57	0.1839
		Error	4			
(B) log book	Step 1	Intercept	1	1.1234	5.24	0.0221
		total catch	1	-0.0135	1.48	0.2241
		depth of FADs	1	-0.0245	2.20	0.1376
	Step 2	total catch	1	-0.0107	14.76	0.0008
		depth of FADs	1	0.0023	0.19	0.6711
		Error	23			

Table 3. Bigeye tuna (*Thunnus obesus*). Results of 2-step generalized and general linear model of the data sets of (A) port sampling and (B) log book. The step 1 and 2 test the influence of the depth of underwater structure of FADs for exsistence or non-existence of bigeye tuna, and for the ratio if it is not zero, respectively. The data with natural log operation was omitted.

		parameter	DF	Estimate	Chi-Square (step 1) / F (step 2)	P
(A) port sampling	Step 1	Intercept	1	-2.3102	0.85	0.3570
		total catch	1	0.0059	0.49	0.4855
		depth of FADs	1	0.0493	0.87	0.3521
	Step 2	total catch	1	0.0157	1.86	0.2664
		depth of FADs	1	0.1603	3.13	0.1748
		Error	3			
(B) log book	Step 1	Intercept	1	3.3795	3.61	0.0574
		total catch	1	-0.0609	2.77	0.0959
		depth of FADs	1	-0.0527	1.74	0.1877
	Step 2	total catch	1	-0.0122	-0.62	0.5515
		depth of FADs	1	-0.0009	-0.07	0.9437
		Error	9			

Table 4. Skipjack tuna (*Katsuwonus pelamis*). Results of general linear model for (A) port sampling and (B) log book, which test the influence of the depth of underwater structure of FADs (depth of FADs) to skipjack tuna catch.

	Source	DF	F	P	Parameter estimate
(A)	port sampling				
	depth of FADs	1	0.010	0.927	-0.081
	Error	15			
(B)	log book				
	depth of FADs	1	0.070	0.794	-0.054
	Error	63			

Table 5. Yellowfin tuna (*Thunnus albacares*). Results of general linear model for (A) port sampling and (B) log book, which test the influence of the depth of underwater structure of FADs (depth of FADs) to yellowfin tuna catch.

	Source	DF	F	P	Parameter estimate
(A)	port sampling				
	depth of FADs	1	0.540	0.475	-0.053
	Error	15			
(B)	log book				
	depth of FADs	1	3.070	0.084	-0.103
	Error	63			

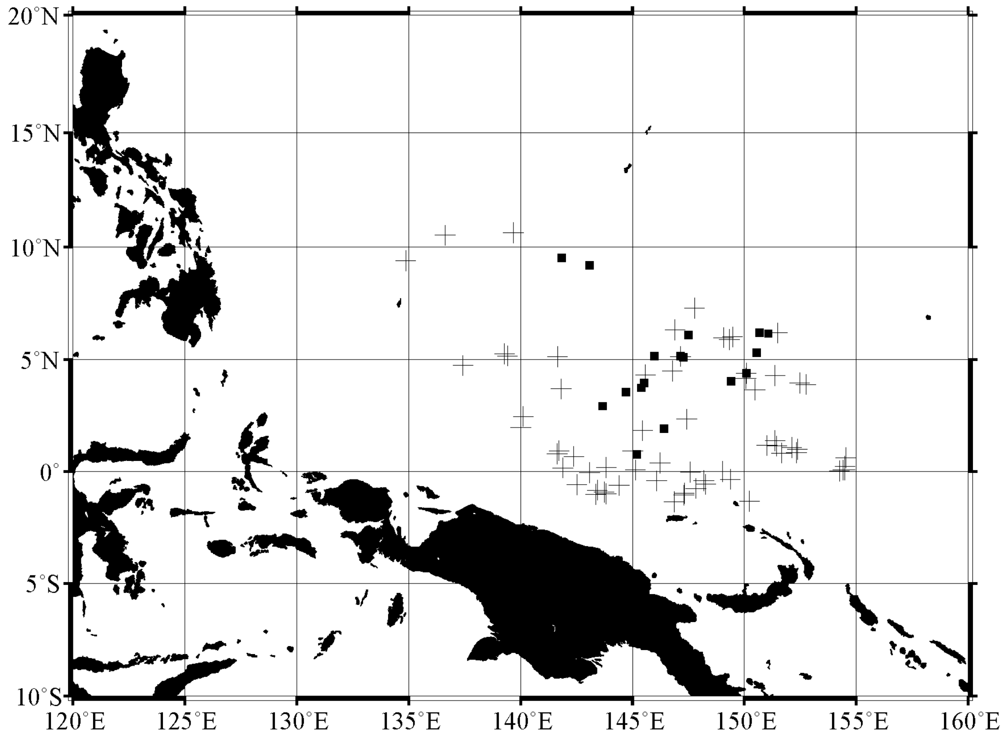

Fig. 1 Location of operation of Japanese purse seine. Solid square (■) and cross (+) show the positions of data set of port sampling and log book, respectively.

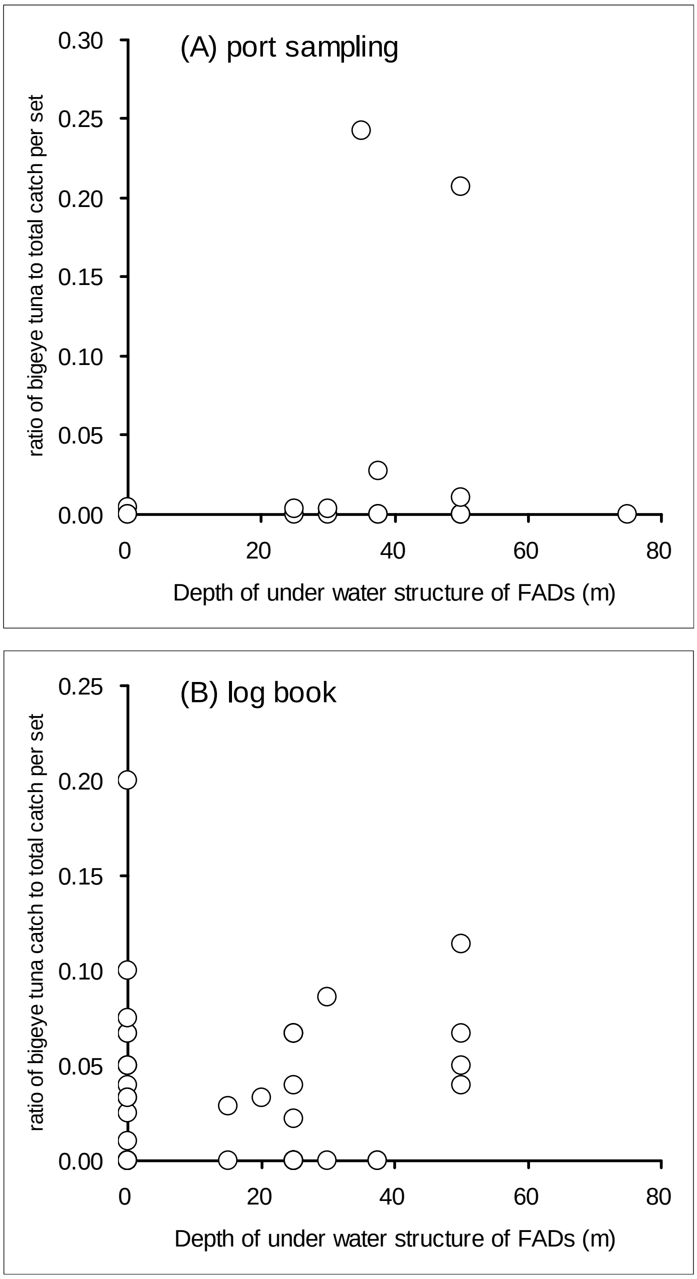

Fig. 2 The relationship between depth of underwater structure of FADs and the ratio of bigeye tuna catch to total catch per set of (A) port sampling and (B) log book.