(IOTC-WPTT-2005-)

Study on affect of Japanese tuna prices on targeting practices and CPUE of tuna longline fisheries

- Case study for yellowfin tuna (Thunnus albacares) & bigeye tuna (Thunnus obesus) in the Indian Ocean -

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Abstract

We investigated how Japanese tuna prices affect on targeting practices and CPUE in tuna longline fisheries. As a case study we examined yellowfin tuna and bigeye tuna exploited by Japanese and Taiwanese tuna longline fisheries in the Indian Ocean using the data after 1980. As a result, no significant affects were found except one case. The situation seems to be opposite before & after 1980 due to the supply situation, hence more affects are expected before 1980.

CONTENTS

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The original draft was prepared for the 3rd WPTT (2001) but not presented. This is the revised version.

1. Introduction

1.1 Background

Tuna fisheries are driven by market incentives, hence economic behaviors of fishers would normally cause them to target fish on higher priced species which thus affect also CPUE (Sakagawa, 1987; Nishida and Fluharty, 1999). Because of this tendency, there have been occasional discussions on the affects of the Japanese tuna prices over the Generalized Linear Model (GLM) analyses for the CPUE standardization in the past IPTP and IOTC meetings (Anon, 1998 and 2000). Hence in these meetings, it has been recommended to consider incorporating 'tuna price' as one of factors in the GLM or other statistical analyses. Upon these recommendations, this paper attempts to examine how the Japanese tuna prices affect targeting practices and CPUE (hooking rates) of tuna longline fisheries.

1.2 Hypothesis

The hypothesis in our study is that tuna price affect targeting practices (represented by species compositions) which affect nominal CPUE that further affect its standardized CPUE and abundance indices by GLM and other statistical methods. The time lag effect up to 5 years is concurrently examined. Fig. 1 shows the schematic diagram of this hypothesis. To investigate this hypothesis, we will examine yellowfin tuna and bigeye tuna in the Indian Ocean as a case study. There might be difficulties to represent the targeting practices by species compositions (SC) because SC is also sometimes influenced by levels of abundance. Due to such uncertainties we only focus on affects with high correlations.

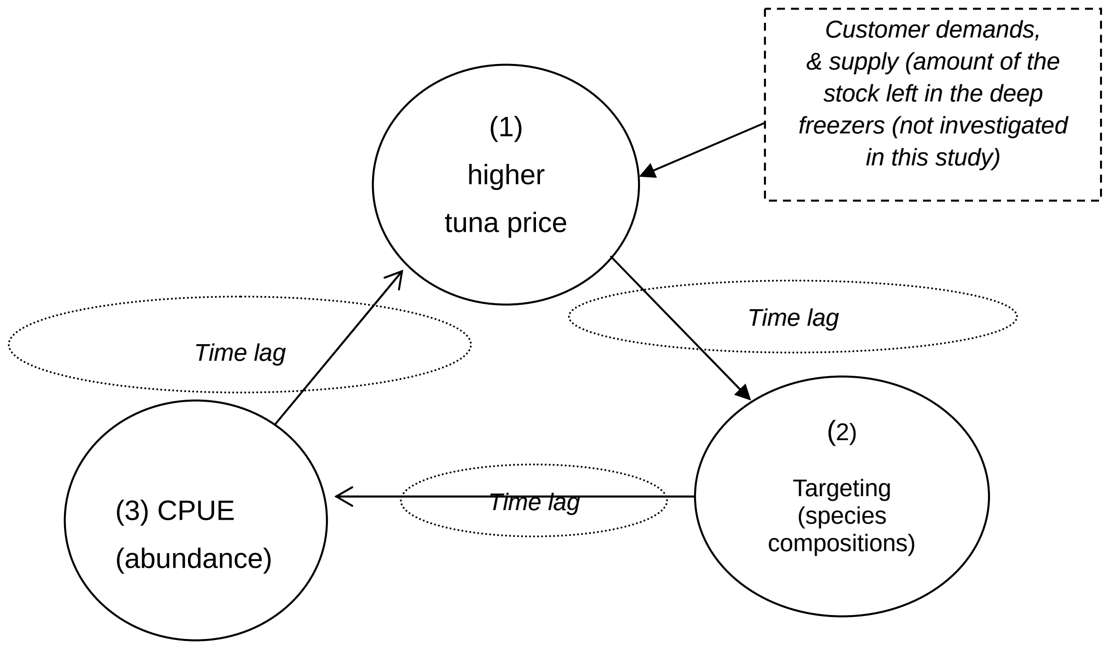
In addition to these factors, customer demands & supply (amount of the stock left in the deep freezers) are also important factors affecting the tuna prices as shown in our hypothesis in Fig. 1. However we did not included these factors for this time. Thus there might be some limitations in interpreting our results due to lack of the demand-supply information.

1.3 Tuna price situation before and after 1980

Frozen tuna are brought to Japan every 2-3 months from fishing grounds in the three Oceans by the transshipment boats which became more active after 1980. After frozen tuna are brought to Japan by transshipment boats, they are kept in deep freezers which will be released when the prices become higher especially before special holiday seasons in Japan.

Thus it is likely that frozen tuna prices do not strongly influence LL operations after 1980 because the minimum prices are seemed to be secured by this release (supply)-at-high-price system.

On the contrary before 1980 when there are no transshipment boats, tuna prices in Japan strongly affect LL operations. This is because tuna supply (stock) was not stable and secured as supply depended on the LL boats came back to Japan. In addition there was no high performance deep freezers before 1980 as we have now. Thus it was not easy to implement the release-at-high-price system. In our study we use the data after 1980, thus we may not be able to get the clear picture of our hypothesis as depicted in Fig. 1 because it is unlikely that tuna price significantly affect LL operational patterns (targeting practices) hence there are less influences (biases) on CPUE due to the prices.



Time lag	Higher tuna price	Targeting	CPUE(abundance)
t			
t+1			
t+2			
t+3			
t+4			
t+5			

Fig. 1 Schematic diagram of the hypothesis in this study

1.4 Previous study

In the past, Murray *et al* (1992) included the southern bluefin tuna (SBT) prices (*Thunnus maccoyii*) in their fine-scale GLM analyses. They used the annual average frozen SBT port prices in Yaizu tuna fishing port in Japan. But, results showed that SBT price was not statistically significant factor in the GLM analyses. In our study, we attempt analyses by considering following points, which are different from the Murray *et al* 's study:

(a) *To adjust the <u>inflation factor</u> into the tuna prices using the consumer price index (CPI), which was not used in Murray et al (1992) ;*

(b) *To use <u>wholesale fresh & frozen tuna prices in six major cities</u> in Japan, which are considered to be more effective for the tropical tuna fisheries different from the SBT tuna longline fisheries case (reasons to use such fish prices are explained in Appendix A).*

2. Information

Information on tuna wholesale prices, CPI (Consumer Price Index), targeting (species compositions) and CPUE for 20 years from 1980-99* were used in the analyses. Table 1 lists types and sources of the information.

Table 1 Types and sources of Information used in this study (1980-99)

Type	Country	Source
Tuna prices (monthly) Wholesale prices of fresh and frozen YFT & BET in the six major cities in Japan (Tokyo, Yokohama, Nagoya, Kyoto, Osaka and Kobe) (**)	Japan	Monthly Statistics on Fishery Commodities' Distribution, Ministry of Agriculture, Forestry and Fisheries, Government of Japan
CPI (monthly) (Consumer price index)	Japan	Monthly statistics of Japan, Ministry of Public Management, Home Affairs, Posts and Telecommunications, Government of Japan
Targeting (species compositions)	Japan Taiwan	IOTC database : 5^{o}x5^{o}/month area based YFT & BET catch and fishing effort (number of hooks)
Standardized CPUE or abundance indices	BET	Japan: Okamoto *et al* (2004) Taiwan : Okamoto *et al* (2004)
	YFT	Japan : Shono *et al* (2005) Taiwan: Wang *et al* (2005)

Note (*): We used the data to 1999 because the original paper was prepared in 2002 when the most recent data were available to 1991 at that time.
Note(**):Reasons why we employ this information are explained in Appendix A.

3. Methods and results

3.1 Estimation of the wholesale tuna prices

Original monthly sales and quantities of yellowfin tuna and bigeye tuna (both fresh and frozen) at the wholesale fish markets in six cities were processed to estimate annual average fish price (six cities combined). Average fish prices were estimated by the weighted average of sales and quantities, which were also adjusted (standardized) by the inflation factor. Estimation procedures are shown in Box 1.

BOX 1 Estimation of quarterly wholesale tuna prices

●Adjustment of inflation

$$(S)_{ymc}=(S')_{ymc}/\ (CPI)_{ym}$$

●Estimated average wholesale tuna price (fresh and frozen of YFT & BET)

$$\hat{(P)}_{y}=\sum_{m=1}^{12}\sum_{c=1}^{6}(S)_{ymc}*(Q)_{ymc}\ /\ \sum_{m=1}^{12}\sum_{c=1}^{6}(Q)_{ymc}$$

, where

y	*: year*
m	*: month*
c	*: city*
(S)	*: adjusted sales by the inflation (CPI)(yen)*
(S')	*: unadjusted (original) sales (yen)*
(P)	*: estimated fish price (yen/kg)*
(Q)	*: quantities of sales (kg)*
CIP	*: consumer price index (1995=1) (see Fig.2 next page)*

Fig. 2 shows the resultant annual trend of the CPI and Fig. 3 shows the estimated annual wholesale fish price of YFT & BET (fresh & frozen) respectively. The CPI shows very gentle increase trend from 1980-99. In general tuna prices show the slight decreasing trends except that frozen BET price dropped sharply after 1991. In general, the prices of fresh YFT and BET are higher than frozen prices especially for BET

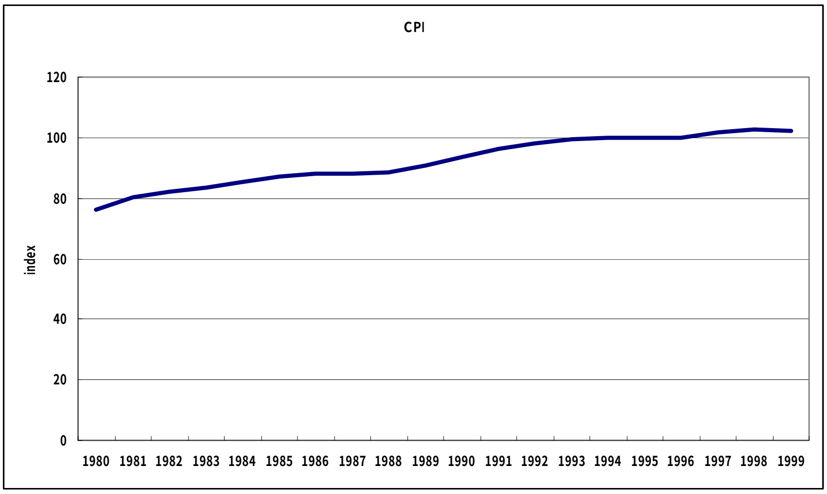
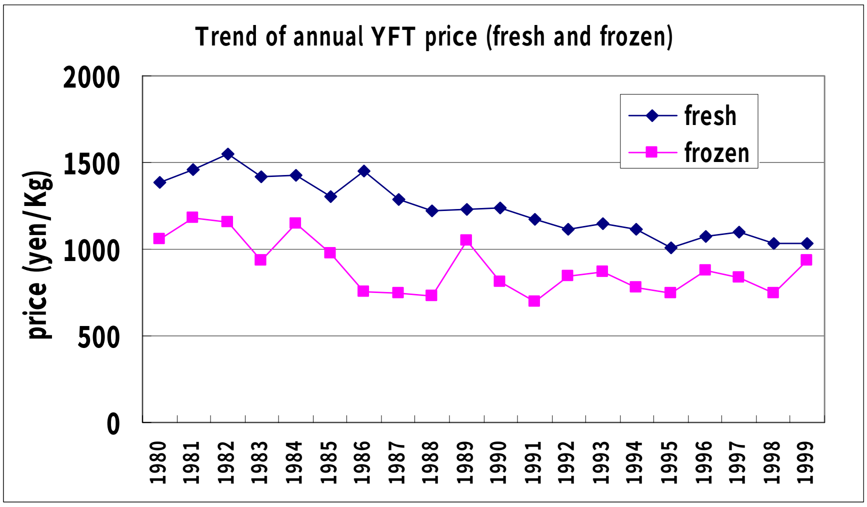


Fig. 2 Trend of annual consumer price index (CPI) in Japan [CPI (1995)=100]



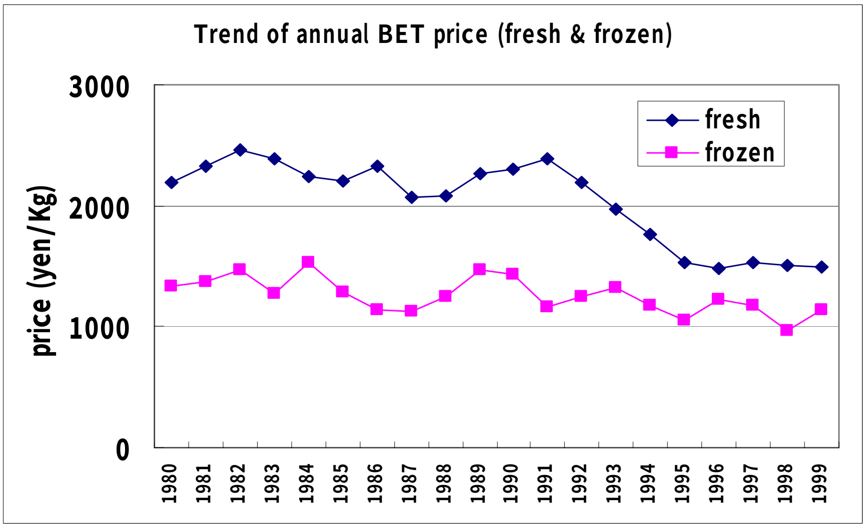
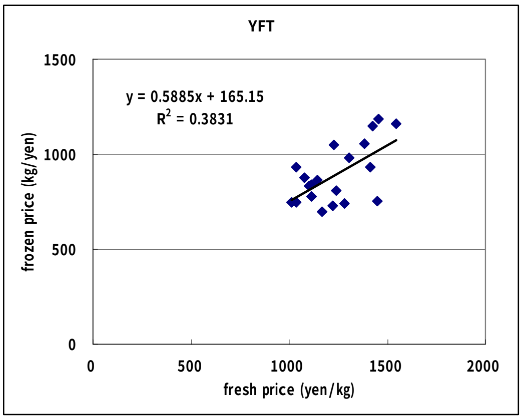


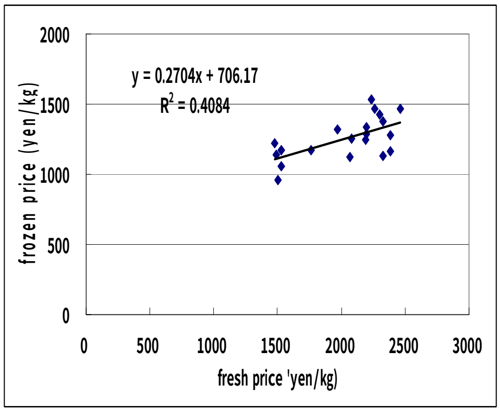
Fig. 3 Annual trends of estimated wholesale YFT & BET price (fresh & frozen)

3.2 Relationships among fish prices

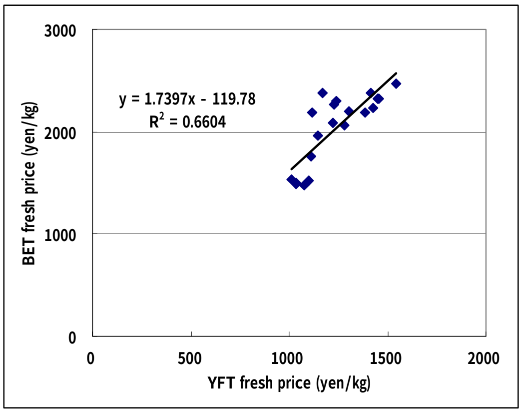
Fig. 3 indicates that there are some degrees of correlations among fish prices. We now check such correlations in advance in order to understand how these prices are related and affect targeting and CPUE in our study. Fig. 4 shows the relationships.



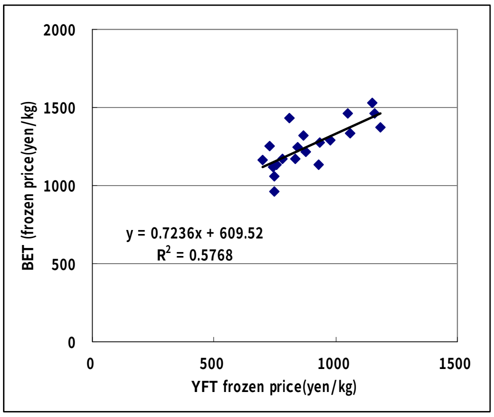
(a) YFT fresh vs. frozen price



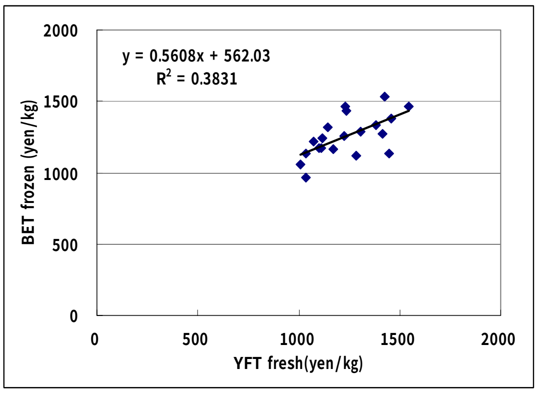
(b) BET fresh vs. frozen price



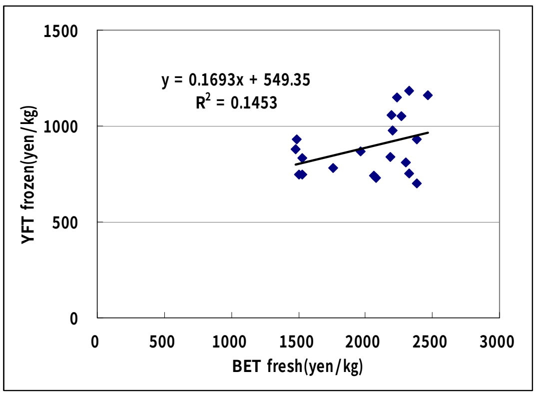
(c) YFT vs. BET fresh price



(d) YFT vs. BET frozen price



(e) YFT fresh vs. BET frozen price



(f) BET fresh vs. YFT frozen price

Fig. 4 Relationships among tuna prices.

Generally most of the fresh tuna are consumed at high rank restaurants while the frozen tuna is sold at supermarkets. In addition fresh tuna needs to be quickly sold. Thus when there is a shortage of the fresh tuna, fresh tuna prices rapidly increase and the price of frozen tuna will also increase. That is the reason why the fresh tuna has been a leader of the price. Although the market of the fresh tuna and frozen tuna is different, there is some degree of the positive relation between the prices as shown in Fig. 4 (a) & (b). But for the frozen tuna, they can be used to control the quantity of the tuna in the market as they are frozen and can be kept for a fairly long period in the deep freezers. Similarly the import tuna prices are also led by the fresh (then frozen) tuna price (Izawa, 2003).

In addition, other relations between various fresh vs. frozen prices, there are also different levels of positive correlations as shown in Fig. 4 (c) – (f). These correlations in our analyses later imply that fresh & frozen prices will similarly influence both targeting and CPUE as they are positively correlated each other. Hence when we interpret the results we need to keep this fact in mind.

3.3 Study area

For the studied area for the targeting and CPUE, we use the data from the major fishing grounds of YFT & BET for Japanese and Taiwanese LL fisheries in the tropical waters shown in Fig 5.

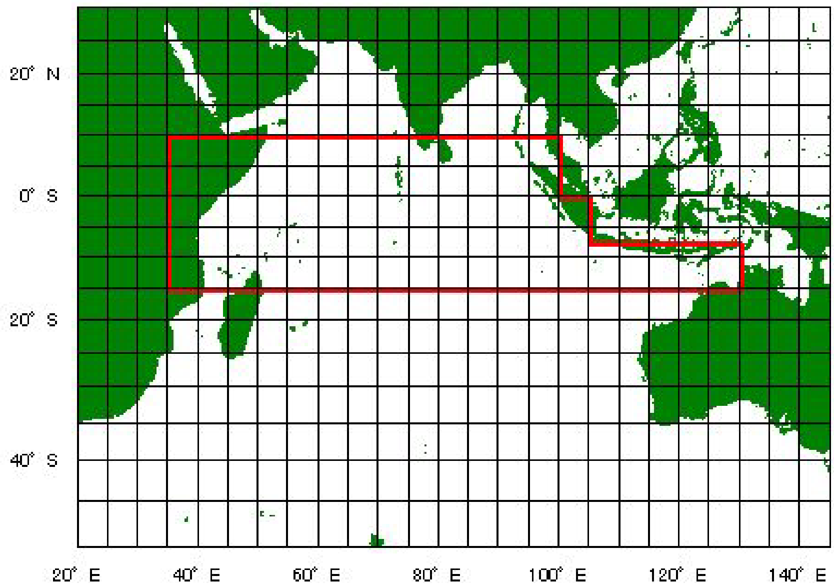
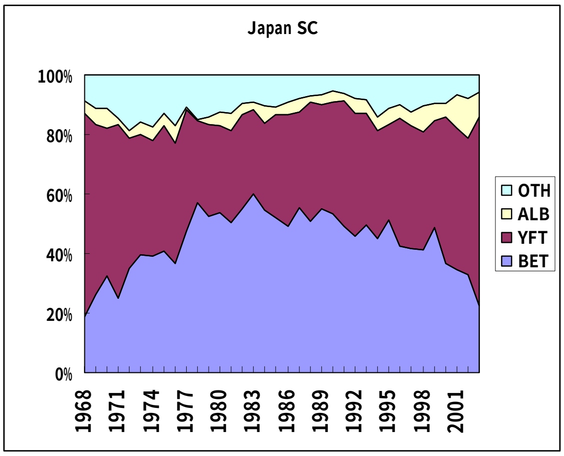


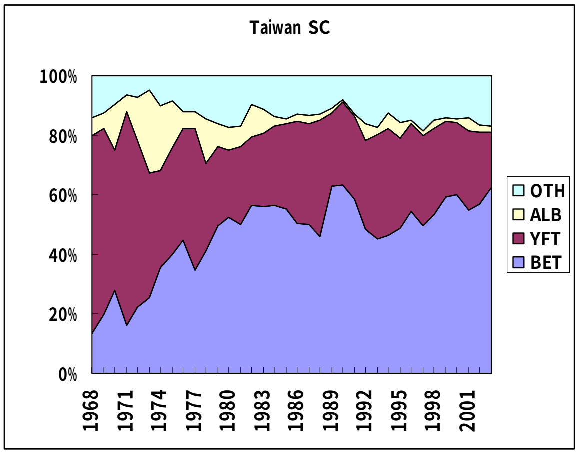
Fig. 5 Study areas

3.4 Targeting

It will be difficult to represent the targeting practices in LL operations. We assume that species compositions roughly reflect the targeting species. In this connection, we use annual average species compositions of YFT and BET as indices of the targeting. Figs. 6-7 show species compositions for (a) all species and (b) YFT & BET respectively (in the Indian Ocean?).

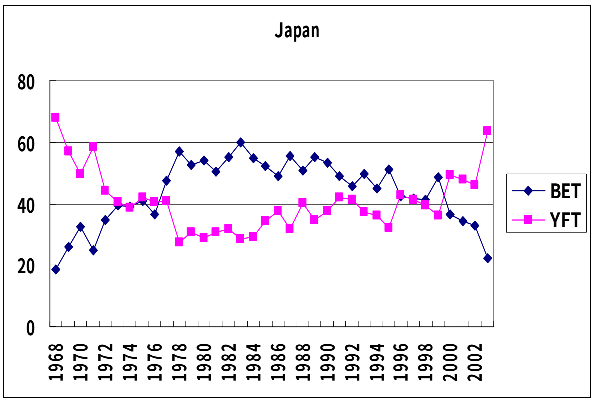


(a) Japan LL

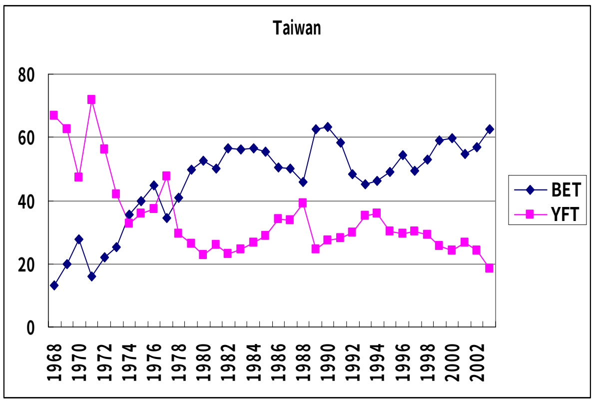


(b) Taiwan LL

Fig.6 Trend of annual species compositions in the total catch (in weight).



(a) Japan



(b) Taiwan

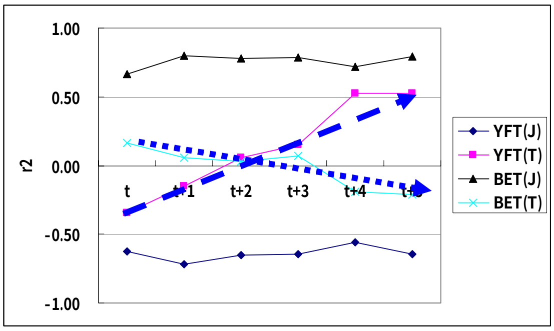
Fig.7 Trend of annual species compositions of YFT & BET in the total catch (in weight) based on Fig. 6.

(Note: these data are used in the analyses)

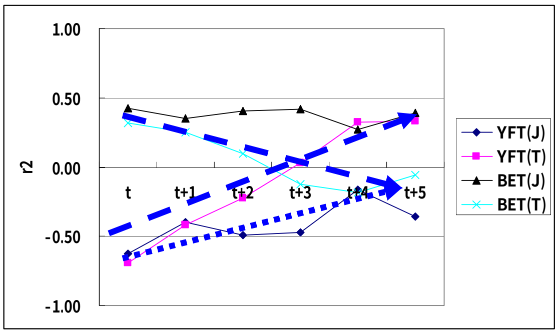
To understand how tuna prices affect targeting practices, we use the simple correlation analyses between tuna prices vs. YFT & BET species compositions (targeting) using the SAS program (SAS, 2004). For YFT & BET species compositions we used the data obtained in Fig. 8. In the analyses time lag effect for 0-5 years are examined. Table 2 shows the results of the correlation analyses and Fig. 8 depicted these results. Table 4 (page 13) summarizes all the results on affects of YFT & BET price on targeting and CPUE. In summary, YFT price (both fresh & frozen) strongly affect to target on YFT and less BET in Taiwanese LL, while BET price (both fresh & frozen) weakly affect to target less on YFT in Japanese LL.

Table 2 Results of correlation analyses between YFT/BET prices vs. species compositions

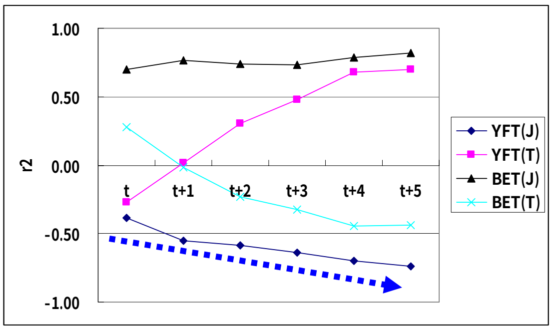
	Species compositions																							
Species	YFT												BET											
country	Japan						Taiwan												Taiwan					
price	t	t+1	t+2	t+3	t+4	t+5	t	t+1	t+2	t+3	t+4	t+5	t	t+1	t+2	t+3	t+4	t+5	t	t+1	t+2	t+3	t+4	t+5
YFT(fresh)	-0.63	-0.72	-0.65	-0.65	-0.56	-0.65	-0.35	-0.15	0.06	0.15	0.53	0.53	0.67	0.80	0.78	0.79	0.72	0.80	0.17	0.06	0.03	0.07	-0.19	-0.21
YFT(frozen)	-0.62	-0.40	-0.49	-0.47	-0.16	-0.36	-0.69	-0.42	-0.22	0.03	0.33	0.33	0.43	0.35	0.40	0.42	0.27	0.39	0.31	0.25	0.10	-0.12	-0.18	-0.05
BET(fresh)	-0.38	-0.55	-0.59	-0.64	-0.70	-0.74	-0.27	0.02	0.30	0.48	0.68	0.70	0.70	0.76	0.74	0.73	0.79	0.82	0.27	-0.02	-0.23	-0.33	-0.45	-0.44
BET(frozen)	-0.41	-0.36	-0.50	-0.49	-0.35	-0.74	-0.43	-0.22	0.04	0.33	0.74	0.52	0.57	0.47	0.50	0.55	0.42	0.68	0.40	0.23	-0.08	-0.36	-0.62	-0.33



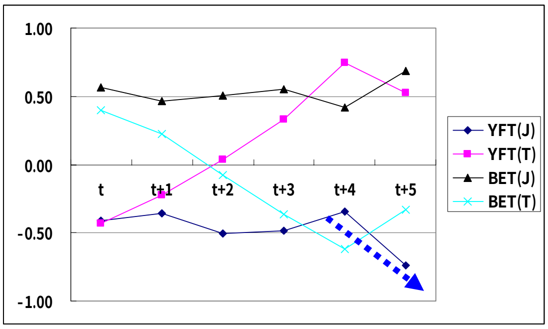
(a) YFT fresh price



(b) YFT frozen price



(C) BET fresh price



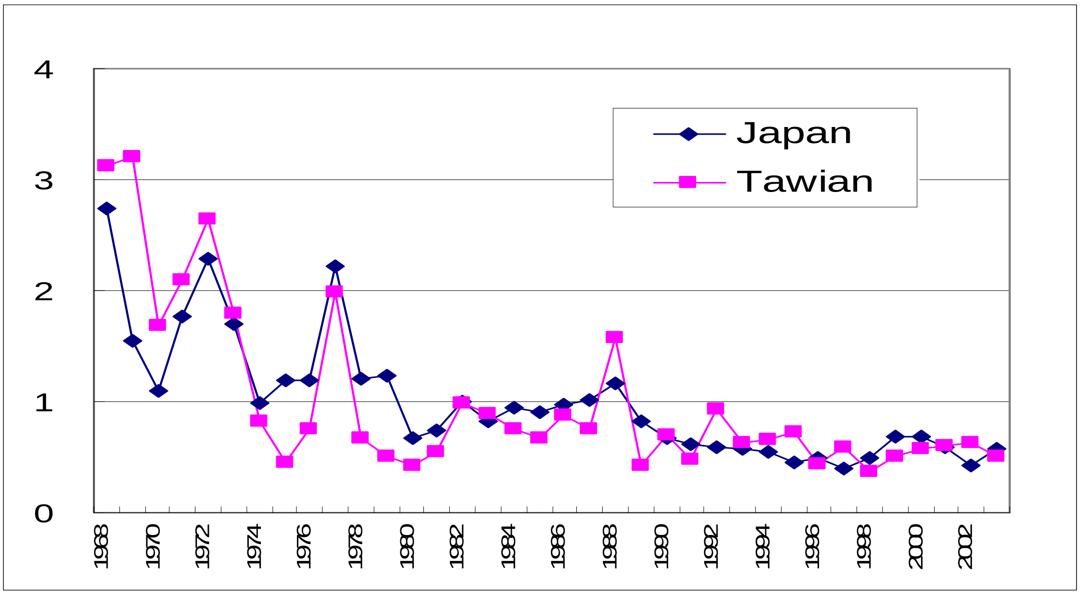
(d) BET frozen price

Fig. 8 Time lag trends of r^2 between YFT/BET prices vs. species compositions

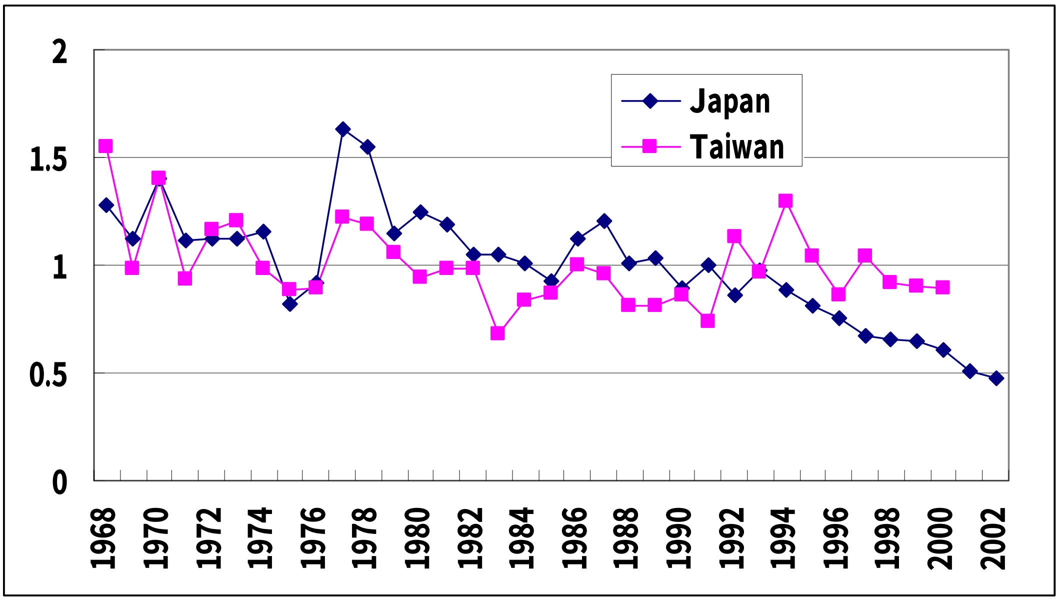
Note *increasing trends of r^2 imply that LL likely tends to target more on YFT or BET as prices become higher and vice versa.*

3.5 CPUE

To investigate how tuna prices affect CPUE, we used the abundance indices estimated based on standardized CPUE. Fig. 9 represent those for YFT and BET (Japan & Taiwan) respectively.



(a) YFT (Japan: Shono *et al* 2005 and Taiwan: Wang *et al* 2005)



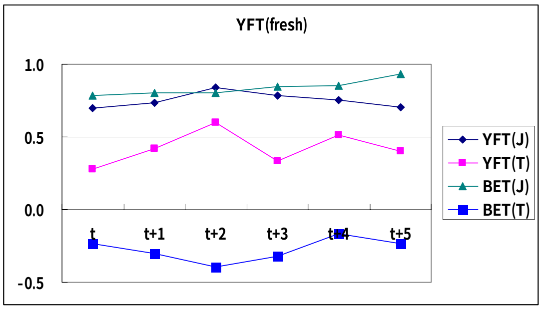
(b) BET (Japan: Okamoto *et al*, 2004 and Taiwan: Okamoto *et al*, 2004)

Fig. 9 Annual trends of abundance indices standardized CPUE

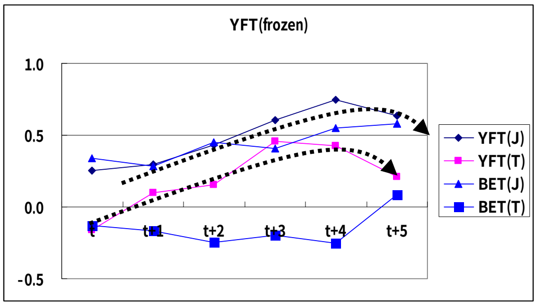
To understand how tuna prices affect CPUE (abundance indices), we also use the simple correlation analyses between tuna prices vs. YFT & BET using the SAS program (SAS, 2004). For YFT & BET CPUE (abundance indices) we used the data appeared in Fig. 9. In the analyses time lag effect for 0-5 years are also examined. Table 3 shows the results of the correlation analyses and Fig. 10 depicted these results. Table 4 summarizes all the results on affects of YFT & BET price on targeting and CPUE. As a consequence, YFT frozen price strongly affected YFT CPUE (both Japan & Taiwan) and BET (both fresh & frozen) price affect BET (Taiwan).

Table 3 Results of correlation analyses between YFT/BET prices vs. CPUE (abundance indices)

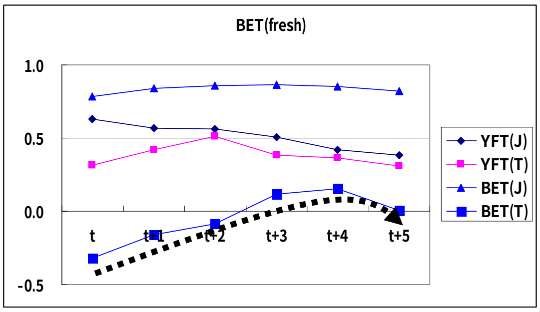
	YFT												BET											
	Japan						Taiwan						Japan						Tawain					
time lag	t	t+1	t+2	t+3	t+4	t+5	t	t+1	t+2	t+3	t+4	t+5	t	t+1	t+2	t+3	t+4	t+5	t	t+1	t+2	t+3	t+4	t+5
YFT(fresh)	0.696	0.736	0.837	0.783	0.753	0.702	0.277	0.419	0.598	0.336	0.513	0.402	0.785	0.800	0.801	0.843	0.853	0.931	-0.234	-0.305	-0.392	-0.319	-0.165	-0.232
YFT(frozen)	0.254	0.296	0.434	0.608	0.746	0.637	-0.161	0.099	0.156	0.456	0.427	0.212	0.340	0.281	0.448	0.408	0.550	0.582	-0.133	-0.165	-0.248	-0.200	-0.253	0.087
BET(fresh)	0.629	0.568	0.560	0.503	0.419	0.380	0.318	0.420	0.514	0.381	0.363	0.311	0.783	0.837	0.860	0.863	0.851	0.823	-0.323	-0.163	-0.086	0.119	0.157	0.003
BET(frozen)	0.397	0.181	0.280	0.446	0.547	0.330	0.124	0.037	0.212	0.344	0.537	0.113	0.450	0.452	0.593	0.639	0.611	0.550	-0.253	-0.186	-0.010	-0.015	0.237	0.250



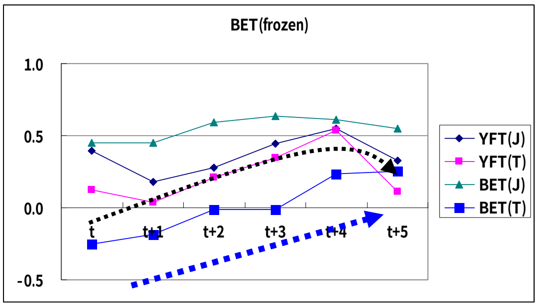
(a) YFT fresh price



(b) YFT frozen price



(C) BET fresh price



(d) BET frozen price

Fig. 10 Time lag trends of r^2 between YFT/BET prices vs. species CPUE (abundance indices)

Note *y- axis represents r^2*

increasing trends of r^2 imply that LL likely tends to target more on YFT or BET which increase CPUE as prices become higher and vice versa.

Table 4 summarizes all the results on affects of YFT & BET price on targeting and CPUE.

Table 4 Summary of affect of YFT & BET price on targeting and CPUE.

	[A] tuna price (if the price [A] increased, targeting & CPUE will be affected as in	[B] Species examined by country	Affect on targeting			Affect on CPUE	
			[C] Degrees of the affect : absolute values of slopes of the regression line 5-9 : weak 9- : strong	[D] Degree of the affect and species affected after fish price of [A] increased.	[E] Time lag effect (how long does the affect continue ?)	[C] Degrees of the affect : slope of the regression line 5- 9 : weak 9- : strong	[D] How CPUE of [B] will be affected if tuna prices [A] go up?
(a)	YFT fresh	YFT(J)	1.2	no significant affect		2.7	no significant affect
		YFT(T)	18.6	Strong (YFT)	0-5 years	0.7	
		BET(J)	1.2	no significant affect		1.8	
		[3] BET(T)	-7.4	Weak (target less on BET)	0-4 years	1.4	
(b)	YFT frozen	[2] YFT(J)	5.9	weak (YFT)	1-4 years	13.0 (first 4 years)	CPUE increased for the first 4 years probably due to targeting practices but from the 5th year it drops sharply probably due to over fishing effect.
		[1] YFT(T)	21.7	strong (YFT)	0-5 years	15.3 (first 4 years)	
		BET(J)	-1.1	no significant affect		5.6	weadk
		[3] BET(T)	-9.6	Strong(target less on BET)	0-4 years	2.5	no significant affect
(c)	BET fresh	YFT(J)	-6.5	weak (YFT)	0-5 years	0.7	
		YFT(T)	20.0	(inverse affect)		-5.0	
		BET(J)	2.0	no significant affect		-1.0	
		BET(T)	-14.1	(Inverse affect)		12.4 (first 4 years)	CPUE increased for the first 4 years probably due to targeting practices but from the 5th year it drops sharply probably due to over fishing effect.
(d)	BET frozen	YFT(J)	-4.6	no significant affect		5.6 Weak	no significant affect
		YFT(T)	22.7	(Inverse affect)		11.3 (first 4 years)	The reason is unknown why YFT (T) was affected as BET (frozen) price increased. It may be apparent correlation?
		BET(J)	1.4	no significant affect		4.5	no significant affect
		BET(T)	-18.4	(Inverse affect)		10.8	CPUE increased continuously probably due to effect of the targeting practices.

3.6 Summary

In our correlation analyses we have sometimes negative correlations but we focused on the increase or decrease trends in time lag series. If there are signs of increase or decrease trends we consider that there are responses according to tuna prices. Based on the results how tuna price affect on targeting and CPUE (Table 4), the only consistent & relatively strong affect observed in terms of our hypothesis (Fig. 1) is the case [1] in Table 4, i.e., YFT frozen price affect targeting (more to YFT) in Taiwanese LL (0-5 years) which further affect their CPUE to 4 years. For the case [2], it also satisfy the hypothesis except a weak affect in targeting. For other cases, there are no results consistently affecting both targeting & CPUE which satisfy our hypothesis.

4. Discussion

4.1 General

In our analyses we use species composition as indices for targeting practices of LL, as we consider that if fishermen want to target a certain species, they will make every effort (change gear configuration or change fishing location, and so on) to maximize the catch composition. However when abundance of other species changed, species composition will be affected and in this regard we expect large uncertainties in results. Under such circumstances we focus on results showing clear, robust and consistent trends, which are considered to satisfy our hypothesis, i.e., tuna price affect target (species compositions) which further affect CPUE. As a result there is only one such case satisfying the conditions, i.e., YFT (frozen) price significantly affect to target on YFT (Taiwan) to 5 years, which further increase their CPUE(AI) up to 4 years. For other cases, there are weak correlations and trends, but we put reservations to accept them due to possible apparent correlations caused by uncertainties.

Based on results of the analyses, it was found that in general after 1980 tuna prices affect more on Taiwanese LL (targeting & CPUE) than those in Japanese LL. This is because Taiwan LL likely pays more attention on the prices than in Japan LL as they need to sell their majority of the catch to Japan. That is why there is another interesting observation as in case [3] in Table 4, i.e., when YFT (fresh & frozen) price goes up in Japan, targeting to BET becomes lower in Taiwan LL up to 5 years. This trend was relatively strong and it is understandable because in such situation Taiwanese LL naturally target more YFT and less on BET.

The reason why Japanese LL likely don't pay much attention on prices is that as explained before, frozen tuna of the Japanese LL sent to Japan by the transshipment boats can be kept in the deep freezers until the prices go up hence minimum prices are likely secured under such release-at-high-price system.

Japanese LL has increased the fishing operation in the waters off South Africa (Area 3 in Fig. 5) for yellowfin tuna since 1990s, and the targeting in terms of species composition has reflected this change of operation (Fig.10). However, since Area 3 data has not been used in this study, the correlations and trends has not been investigated and might be worthwhile to look into in the future.

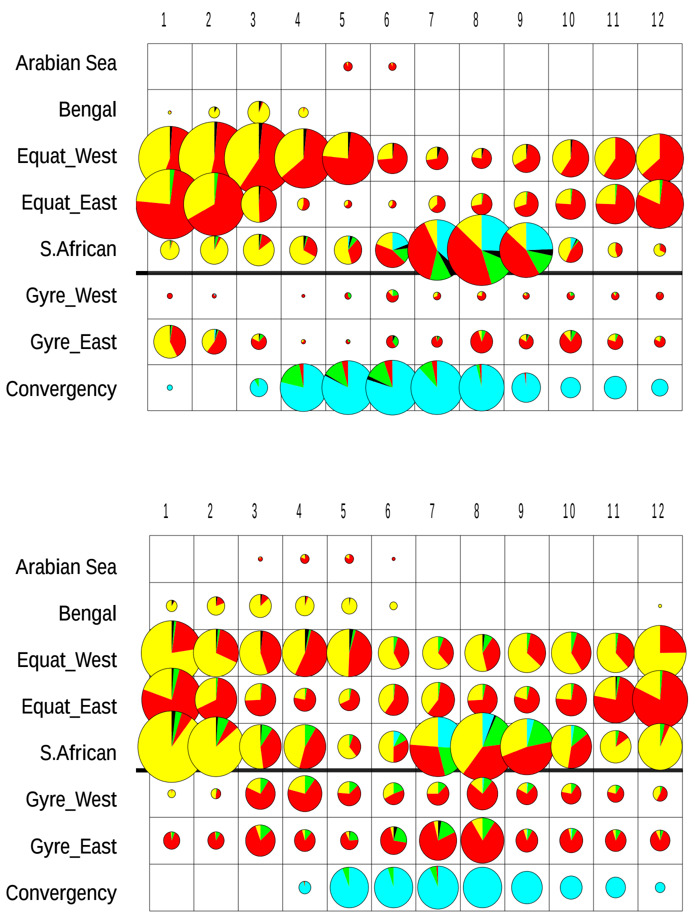


Fig. 11 Species composition of Japanese LL in 1986-1990 (upper panel) and in 1998-2002 (bottom panel). Yellow indicates yellowfin tuna and red indicates bigeye tuna.

4.2 Tuna price

In our analyses we used average tuna prices in six major cities which were considered as an adequate approach because each city had tendencies of their favorite tuna hence their prices are different. If we used one fixed price in one city, we might have some levels of biases in the results. In addition we standardized tuna prices by incorporating the deflator using the customer price index (CPI) which also contributed to reduce biases in our analyses.

We now discuss about the relationships between fresh and frozen tuna prices. Generally most of the fresh tuna are consumed at high rank restaurants while the frozen tuna is sold at supermarkets. In addition fresh tuna needs to be quickly sold. Thus when there is a shortage of the fresh tuna, fresh tuna prices rapidly increase and the price of frozen tuna will also increase. That is the reason why the fresh tuna has been a leader of the price. Although the market of the fresh tuna and frozen tuna is different, there is some degree of the positive relation between the prices as shown in Fig. 4 (a) & (b) (page 7). But for the frozen tuna, they can be used to control the quantity of the tuna in the market as they are frozen and can be kept for a fairly long period in the deep freezers. Similarly the import tuna prices are also led by the fresh (then frozen) tuna price (Izawa, 2003).

In our study we use both fresh and frozen tuna prices to expect the similar and consistent results because both prices are positively correlated. As a result we actually had such consistencies in the results.

The tuna price used in this study is for the three Oceans, i.e., the price for the Indian Ocean tunas has not been separated for calculation of correlation with Indian Ocean tuna catches. Based on information from the Taiwanese industry, the price is a little different by Oceans (*it seems the price of Pacific bigeye tuna is higher than the other two oceans*). The magnitude of difference is unknown yet. If it is small or the trend is consistent among years, then this factor could be ignored in the analysis..

4.3 Index for targeting

There might be no differences in operational costs to catch YFT and BET although BET price is always higher than YFT price. Thus, we expected strong affect of BET prices on targeting in our analyses because LL tends to catch higher priced tuna (BET). But we could not see such responses at all. This might be caused by different stock sizes and status of the stocks between two species. In fact YFT stock size is about 5 times larger than BET stock size and the BET stock level is the over fishing state last 10 years (Nishida *et al*, 2004), while the status of YFT stock is the around MSY level in recent years. This means that even LL fisheries try to target BET they can not catch so much BET due to less available BET resources. Thus species compositions may not be able to reflect the real situation of the targeting practices (Okamoto, 2005). This is because even there were high effort to target BET, species composition of BET will remain same or become less.

To improve this problem, other indices for targeting such as <u>(BET price)x(CPUE), (fishing effort)x(BET price)x(CPUE), (fishing effort)x(BET price)</u> and etc. might be more effective indicators as they include more realistic factors relating to the targeting practices. If the differences of the prices between YFT & BET were large we may need to replace from BET price to the difference of the prices between YFT & BET. They might be more effective & realistic indices to present the targeting situation. These newly proposed indices need to be evaluated.

The fishermen care about total benefit from the fishing operations. It may happen that, even for a species the market price is lower but is more abundant which means easier to have a high catch, fishermen will target on that species to get overall higher total benefit (=lower price multiply by higher catch). For example, price of yellowfin tuna was always lower than bigeye tuna. But during recent years, the difference between the two species has become smaller (Fig.12) and the yellowfin stock keeps more abundant than bigeye, this phenomenon may attract fishermen shifting their target species. Therefore, the trend of difference in price of the two species might be considered further in the future as a target index.

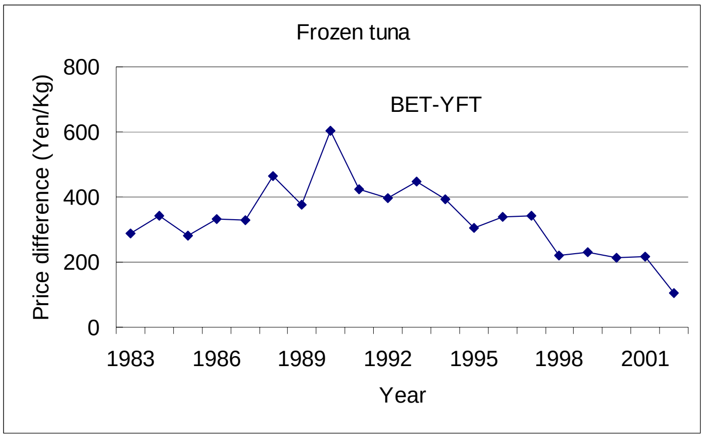


Fig. 12 Difference of frozen tuna price for bigeye and yellowfin tunas in Japanese markets

At last, we also need to consider the fisheries regulations because they will influence targeting practices. In the Indian Ocean there are no strict regulations at present, thus we don't have to tackle this factor now. However, there are the agreements between Japan and Taiwan made in 1995, i.e., the total frozen import from Taiwan to Japan should be less 99,000 tons. This agreement might affect targeting practices in some extent.

4.4 Seasonality

LL fishing operational patterns highly vary by season. But in our study we did not include the seasonal factors. Thus for the future study we need to consider the affect of tuna prices including seasonal factor especially in the situation before 1980. Before 1980 there are no transshipments bringing tuna to Japan every few months nor the release-at-high-price systems. Hence, it is considered that tuna prices before 1980 much more affected LL operational patterns (Sakagawa *et al*, 1987). As tuna prices vary by season due to seasonal fresh tuna fisheries in Japan, which affect frozen tuna prices in addition to the factors of holidays (high demand period), we need to incorporate seasonality in the future study.

4.5 Affect of supply and demand

As indicated in Fig. 1, demands by customers and supply (stock levels left in the deep freezer including those by imports) are also considered to affect the tuna prices significantly. In our study these factors were not used. As such information are available more complicated analyses by incorporating the classical supply-demand econometric models can be conducted to understand the broader relationships among supply (stock), demand, targeting and CPUE in the future study.

5. Conclusions

5.1 General

Since 1980 frozen tuna have been gradually brought to Japan every 2-3 months from fishing grounds in the three Oceans by the transshipment boats, they were stored in deep freezers. Then, frozen tuna have been released when the tuna price became higher. Thus it is likely that tuna price have been weakened to affect LL operations after 1980. But before 1980 when there were almost no transshipment boats nor efficient deep freezers, it is likely that tuna prices in Japan strongly affect LL operations because such the release–at–high -price scheme could not be implemented easily. In our study we used the data after 1980. That is why we have only one case showing the strong influence of YFT prices on operations (targeting and CPUE) of Taiwan LL.

Under such circumstances, we can attempt the GLM analyses including fish prices using available data (Nishida & Izawa, 2005) in the future, i.e., there are tuna prices available from 1961 to now although the data before 2000 are not computerized, But we need to consider that the price data before and after 1980, which may affect GLM results differently. Before 1980 we expect significant effects of fish prices on the GLM CPUE standardization, while for after 1980, we may not have such pictures, i.e., not significant effect as observed in the southern bluefin tuna analyses (Murray 1992) and also results obtained in this study. In this connection, if results of our study are reliable, even using the data after 1980 YFT prices, results of the GLM analyses for the Taiwan LL CPUE probably show the statistical significant levels. Furthermore we can test the effect of the seasonality by the GLM analyses by adding the seasonal factors.

Based on the above discussion we realize that we actually can conduct the multivariate statistical tests if fish prices are significant factors in the CPUE standardizations by looking at the ANOVA table after we run the GLM. In our study we examined such effect for each variable by the correlation analyses. In this sense GLM analyses will provide overall picture on the affects of prices synthetically considering all relevant factors.

5.2 Remarks to use tuna price statistics

When tuna price data are used in numerical and/or statistical analyses, for example, for the CPUE standardization by GLM, following remarks are important:

- Use fresh and/or frozen tuna prices as the representative tuna price statistics in Japan.
- As tuna prices are different among cities (or landing ports) in Japan, try to use tuna prices in major 6-10 cities to represent average situation.
- Apply the inflator to standardize tuna prices using consumer price indices (CPI).
- Apply the exchange rates (US$-Japan yen) to standardize tuna prices (Izawa, 2003).

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(Unlisted references will be provided upon request to the first author)

Appendix A : Reasons to adopt fresh and frozen wholesale prices in six major cities in Japan

(1) Reasons to use fresh and frozen fish prices as parameters

Major econometric analyses on the demand and supply of fishery commodities have been made in terms of the price decision by the quantity supplied. Theoretical backgrounds that the quantity demands are adjusted by the prices, because catch is restricted by nature and the whole quantity ought to be supplied to the market. However, since the quantity of frozen tuna supplied can be adjusted by changing the stock according to the prices, there is a possibility that the prices can decide the quantity supplied, and that the prices can affect the production plans, i.e., fishing patterns, etc. Figure 1 shows a decrease in the landing of yellowfin tuna with a drop in the price（all the prices in the figures are real prices deflated by Consumer Price Index for 1995=100.

Figure1. Changes in wholesale price and landing of frozen Yellowfin tuna

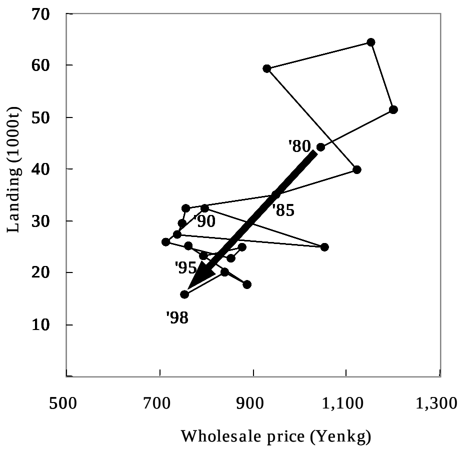
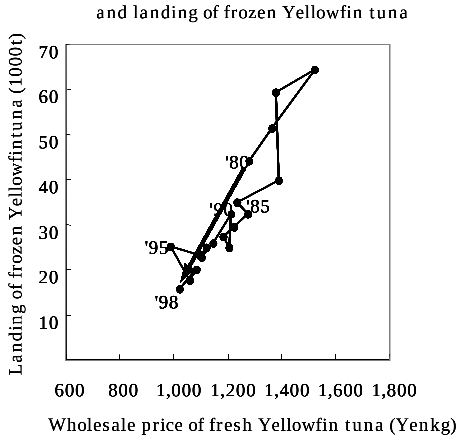


Figure 2 suggests that, with a lowering of the price of fresh Yellow tuna, part of the demand for frozen Yellowfin tuna might be substituted by fresh Yellowfin tuna, and the demand for frozen tuna descended. Then, it is necessary to consider the price of tuna, not only frozen but also fresh when the demand for and supply of frozen tuna is analyzed. Therefore the prices of frozen Yellowfin tuna, fresh Yellowfin tuna, frozen Bigeye tuna and fresh Bigeye tuna should be considered as parameters which influence the behavior of the frozen tuna producer.

Figure 2. Changes in price of fresh Yellowfin tuna and landing of frozen Yellowfin tuna



（2）Reasons to employ fish prices in six major cities in Japan

Statistics on the prices of tuna include port prices（Annual Statistics on Fishery Commodities' Distribution, Ministry of Agriculture, Forestry and Fisheries Japan, wholesale prices（Monthly Statistics on Fishery Commodities' Distribution, Ministry of Agriculture, Forestry and Fisheries Japan）and average purchase prices（Family Income and Expenditure Survey, Ministry of Public Management, Home Affairs, Posts and Telecommunications Japan. Port prices have a problem with consistency in data, for the number of fishing ports surveyed was altered twice between 1980 and 1999.

Average purchase prices only have a "tuna" item and do not differentiate species of fish, i.e., bigeye tuna or Yellowfin tuna, etc. and between fresh and frozen. They have other problems: there are no indications of the consumption of tuna outside home and in the "sashimi combination" item that contains tuna.

On the other hand, wholesale prices are appropriate as price indexes which include outside distribution, for these prices fluctuate correlated with import prices and port prices（Figure3 and Figure4）and the market information such as prices and trade quantities is disclosed. The reason employing the prices in the six major cities（Tokyo, Yokohama, Nagoya, Kyoto, Osaka and Kobe）are appropriate is that the wholesale markets in these cities are major markets in all of them and include major markets for Yellowfin tuna and Bigeye tuna（Tokyo and Yokohama, the major consumer markets for Bigeye tuna, and Nagoya and Osaka, the major consumer markets for frozen Yellowfin tuna）（Figure5）.

Figure3. Changes in price of frozen Bigeye tuna

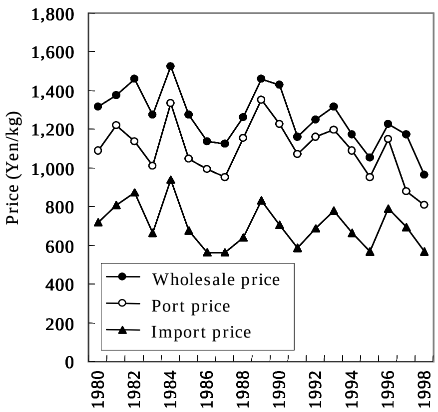


Figure4. Changes in price of frozen Yellowfin tuna

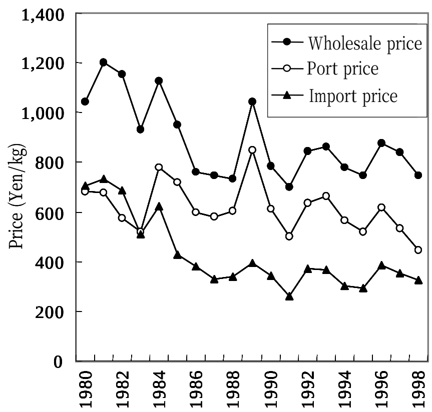
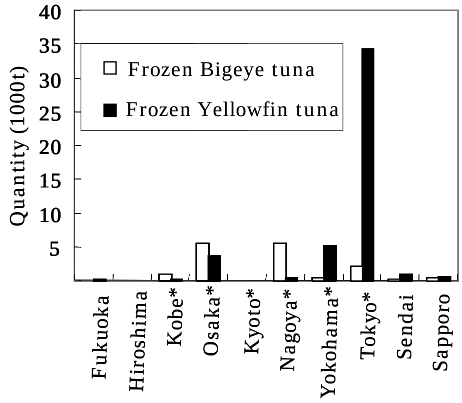


Figure5. Wholesale quantity of frozen tuna by city in 1999



* The six major cities