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SOCIO ECONOMIC FACTORS AFFECTING EXPLOITATION AND MANAGEMENT OF TOP PREDATORS

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The Challenge of Change: Managing for Sustainability of Oceanic Top Predator Species

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Summary

Tuna fisheries have a long history but the target species and major fishing gears went though much changes in its history. More recently, significant important changes are the shift of catches by pole-and-line/long line fishery to purse seine fishery. Such change is closely related to the expansion of canning industry and market in the world. While tuna stocks are almost fully exploited, fishing capacity seems to be in excess to harvest them at the sustainable level. Besides, technological improvements increase the fishing efficiency every year, even if the sleet structure does not change. The major technological changes for longliners are adoption of super-freezer, use of deep longline and more frequent at sea trans-shipments. For purse seiners, important changes are increasing the size of a vessel holding capacity, adoption of FADs fishing, and establishments of many base ports (where new canning industry has been established).

Change in increasing importance of purse seiners, which catch mostly juvenile tunas influence in stock structure and MSY of tuna stocks, and particularly the availability of large tuna for longline "sashimi" market. This might be most important effect on tuna management scheme.

Increasing importance of coastal states is changing the fishing structure. Establishment of modern and more economic and efficient transshipment system is also important. That is particularly notable for air-transshipments. Dispersing the processing sites (both for canning and fresh or frozen fish) near the landing ports also cut down the cost of labor, transportation and efficiency.

Consumption of canned and fresh tunas by continents are discussed and increase in canned products is very notable particularly for Europe. Analysis of fresh tuna consumption is very difficult as the statistics do not separate those for canning and fresh fish consumptions.

Tuna farming is relatively new industry and many complicated relationship of socio-economics and stock/managements are simplified and condensed in this activities. Therefore as a case study, the effect of farming on bluefin stocks, managements, market and local economy is examined.

Finally recent change in social concept of management is important in relation to the management schemes and fishing procedures. Presently echo-system approach is much required.

INTRODUCTION

Tunas and billfishes are the group, which is most valuable and well exploited one among the top predators in the marine echo-system, possibly followed by Elasmobranches. The management used to be based on the knowledge of the stock conditions of target species alone. However, the current management of any species has to be considered in terms of the impacts that the fishery gives to the entire echo-system. Species interactions, by-catch problems, and gear competitions are all related in a very complicated manner.

The elements which affect on these relationships include; 1) biological elements, 2) oceanographic elements (physiochemical components); 3) fishery management policies; and 4) socio-economic elements. In this paper, only aspects in socio-economic natures are discussed. Among socio-economic elements, many political issues are included. For example, the most important socio economic issues would be directly related to the adoption of the new UN Law of the Sea. However, those political issues are not discussed in this paper. In other words, the paper discusses only the impacts given by recent changes in fishing industry, technological developments, processing industry, trade, markets and consumers preference on fisheries resources and consequently on management of fisheries.

All the species in the top predators' category (including human) are actually biologically competitive in terms of their baits, habitats and territories. The management plan for one species would significantly affects on stock status of other species. For example, if a policy of total protection of marine mammals is taken for a reason not for sustainable use of resources, it would definitely affect, most likely negatively, on the sustainable exploitation level of resources of the competing species, such as tunas and sharks. In this case, the standards for managements of marine mammals and tunas are very different according to the social and political reasons. Those indirect socio-economic influences are not discussed.

Besides, the subject matter is too broad to discuss in a single short paper. Therefore, the issues are simplified and only major changes alone are pointed out in this paper. The details and analysis of magnitude of effects on tuna group as well to other groups of species on the top predators will be discussed in future papers.

Tuna catch (=reported landing) data are based on various tuna RFMOs data base, compiled by the author, as of February, 2007. Product data are based on FAO base for products (to 2004).

1. TUNA FISHING INDUSTRY

a) Short summary of developments of various fisheries and improvements in fishing technology

Tunas have been eaten much before Christ and their bones and pictures are found in many ancient ruins. Their fisheries are the oldest ones recorded in history (Sara, 1983). The substantial fisheries started in 17th to 18th Century in many places in the world, mostly in near coast waters (Bard, F.X., 1981). The major fisheries at that time was gillnet, angling and a type of trap (set) nets. In 19th Century, trolling, and pole-and-line fisheries started and in early 20th Century, already longline fishing was done (Miyake, P.M., 2006).

In Figure 1, the total world catch of major tuna species (albacore, bluefin, Pacific bluefin, southern bluefin, bigeye, skipjack and yellowfin) are given by major fishing gears. The figure is self explanatory. The trends of catch by each gear are much related with market demands and technological developments in fishing. The details of developments are given in various literatures such as Miyake P.M. (2006), Ward, P. and S. Hinmarsh (2006) and Itano, D. (2005). Very short summary is given below.

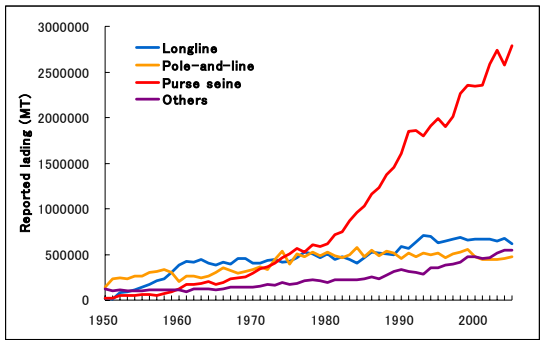

Fig. 1. Reported landing of major tuna species by fishing gears.

Pole and line fishery

Until the end of 1950s, this was the most important tuna fishing method, providing fresh fish and canning materials. Even at present, their catch is almost equivalent to industrialized longline catch. A part of the catch is used for “katsuobushi (smoked molded and dried skipjack product)” and some for "sashimi" but a major part is used for canning. Also it should be noted that some of reported catches by pole-and-line are actually caught by purse seiners, since a baitboat can get a share of the catches when it assisted the seiner’s operation.

Longline

Large scale industrial tuna longline fishery with freezing facilities started in 1950s for canning industry. However, the invention of super-freezer (lower than 40 degrees below zero) in the beginning of 1960s, made it possible to use frozen tuna for "sashimi". That explains the significant increase in longline catch in early 1960s. The increase in 1990 is mostly that in the catch of coastal small longliners (see Fig. 2), which are brought in by development of coastal fisheries as well as increased operations of small tuna longliners of fishery-advanced countries, to avoid international

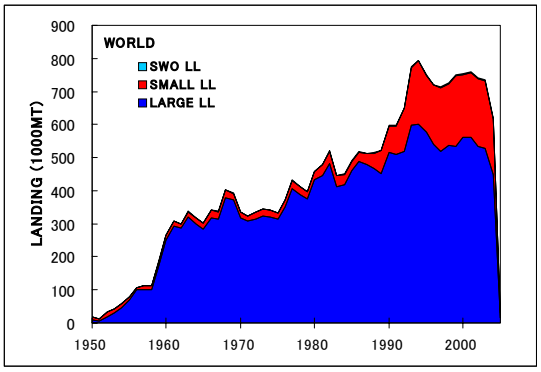

Fig. 1. Reported landing of major tuna species by types of longliners.

restrictions on large longline fishing (i.e. generally applied to the vessels above 24 meters in overall length).

Purse seine

Modern purse seine fishing started only in early 1960s with invention of hydraulic power block. Together with the expansion of canning industry and market, the purse seine catch constantly increased in past 50 years. Except of bluefin, most of the purse seine catches are used for canning. As the results of various management measures (Olympic system quota, prohibition of at sea trans-shipments, etc.) and for the economical efficiency, fish holding capacity per vessel also increased very rapidly, which contributed the increasing fishing capacity and the catch.

Since early 1990s, use of FADs (fish aggregating device) became very popular and added efficiency to the purse seine fishery. FADs fishing contributed greatly to the recent increase in catch of juvenile fish of target species (e.g. yellowfin) and non-target tuna species (e.g. bigeye tuna), and other species of top-predators (e.g. dolphin fish). (Anonymous, 2006a).

b) Change in fishing capacity

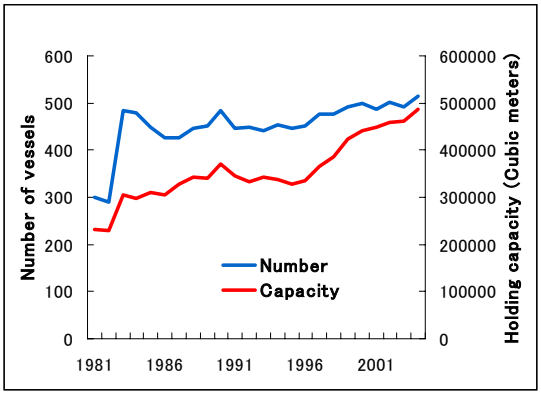

Fig. 3. Number and holding capacity of large purse seiners (>400 MT).

Fishing capacity does not mean number of vessels or fish holding capacity. It is related with many biological and socio-economical factors. However, fleet size is to some extent indicative of fishing capacity. Figure 3 shows the number and fish holding capacity of the world large purse seiners (over 400 cubic meters capacity). The IUU vessels are missing from the statistics. For longline, it is almost impossible to create such a figure, since the size and specifications of the vessels vary significantly from a vessel to the other, and also because many boats operate in more than one ocean and duplicated in the list by Ocean. Another major reason is that many licenced longliners are not active. It is estimated that there are about 1500 large longliners, which have been declining, and over few thousands small longliners which are increasing (Miyake, P.M., 2005b).

Recently much concern has been expressed on world fishing capacity, in terms of available tuna resources. FAO established a Technical Advisory Committee and this problem has been studied for four years. Its reports are available and very comprehensive studies are included (FAO, 2004 and FAO, 2007-in press). The conclusions of the studies were that the fishing capacity of large longliners as well as purse seiners are in excess by 20 to 30% for harvesting currently available tuna stocks at a sustainable level.

Possibly, controlling fishing capacity alone would not solve the problem of fishery managements. However, an international agreement on a TAC and/or quota, or any other conservation measures have become increasingly difficult, due to the fact that there is an excessive fishing capacity in the world. The elements contributing to the fishing capacity include almost all the issues considered in this paper. Therefore, only major changes which directly affect on fishing capacity is listed below.

Most major changes in technology

The technological changes in fishing gears and methods can be found in many literatures and are well summarized in the Section 2a) of this report. Even with the same fishing fleet, due to the improvement in fishing efficiency, the fishing capacity has been increasing every year, particularly for purse seines. ICCAT, SCRS assumed the annual increase in efficiency to be about 12 % (Anonymous, 2004)

The most important changes for pole-and-line fishing would have been forced temperature controlled circulation of water in the bait well.

For longliners, the most revolutional technological improvement was the invention of super-freezer. Recent changes include improvements in navigation equipments, developments of deep longline and adoption of monofilament lines. However, various restrictions set on longline gears to mitigate undesirable by-catches may have reduced fishing efficiencies. Those include, adoption of various equipments or fishing procedure to mitigate sea birds, turtle and possibly sharks.

Probably the most important technological changes in purse seine fishery was use of FADs. This fishing technique not only increased fishing efficiency and contributed economy of operations, but influenced to to other fisheries such as longline fishing. Besides, thousands of man made FADs now in each ocean may have or be affecting on fish ecology and/or behavior. Other important technological changes include introduction of bird radars and increased capacity of sonar.

Economical changes

Many economical changes are related directly to the subjects dealt under other chapters. Major changes directly related to the fishing capacity are:

- Vessel construction cost (mostly negatively correlated)
- Fish price and demand in the world market (positive correlated).
- Reduction of difference between landing value and consumers market (very positively correlated, see Chapters 4 and 5).
- Operating cost such as fuel (see Fig. 4), labor and fishing gears (mostly

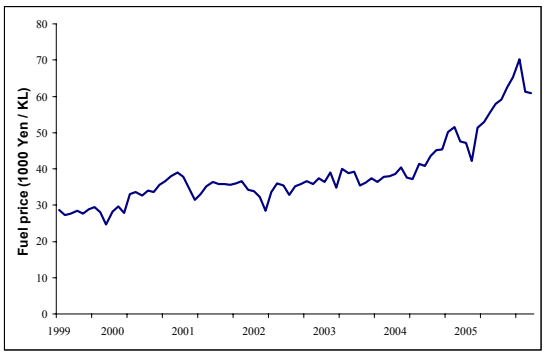

Fig. 4 Recent fuel price paid by Japanese longliners.

negatively correlated).

- License fees. (negatively correlated)
- Cost for managements such as cost of observers. (negatively correlated).

Increasing importance of coastal states

Following the new Law of the Sea, the right for access to top predators by the coastal states has been much strengthened. Accordingly recent fish management measures give special considerations for coastal states to allow their development of fisheries. If this is done by the corresponding sacrifice by the fishery-advanced nations (not necessarily developed nations), the fishing capacity would not change. However, in many cases, developments of coastal states merely added new fishing capacity. Some capitals of advanced fishing nations took advantage of this situation and made a great investment in coastal states. It would give some economical gain for the coastal states but more so for the investors. Besides, these would give the hide out for IUU fishing vessels and companies, and contribute greatly an increase in the world fishing capacity.

c) Fishing gear and species interactions

It is obvious from Figure 1 that the purse seine catch has increased very significantly, while the longline catch has been stabilized (except for small coastal longliners). One of the major reasons for such a contrast is that the gear and cost efficiencies are much higher for purse seiners. Longline catch per day is around 0.5 metric ton, while that for purse seine is in order of 20-30 metric tons. Besides, purse seiners generally operate near the base ports but longliners look for the fishing ground very far from the base. It is ironical that the reason of declining longline catch rate is significantly related to declining target large fish, due to the increase in purse seine catches of juvenile tunas.

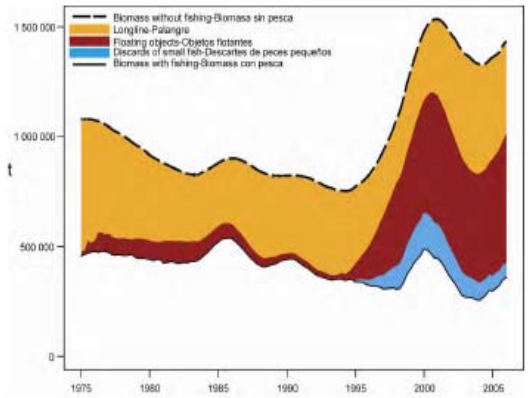

Fig. 5. Impacts by various gears on eastern Pacific bigeye stocks. (IATTC, 2006; unpublished)

Of course the bottom line of such shift in gear is the strong demand for canned tuna, which is further discussed in later Chapters. It is important that the gear shift naturally effected on the stock. The yield per recruit analyses exhibit that most of the fish taken by purse seiners are much smaller than the optimal size for maximum yield (e.g. Anonymous, 2006b) Therefore the increase in purse seine catch resulted in the reduction of AMSY (average maximum sustainable yield). Whatever the reasons are, the reality of such shift in fishing gear would directly affect the management measures, in respect to the share between the gears and methods of measures. For several stocks, RFMOs adopted catch quota system for longliners and effort control for seiners (e.g. bigeye in the Central and Western Pacific, Atlantic and eastern Pacific oceans).

(MRAG Ltd., 2006).

Recent increase of coastal fisheries (particularly of small longliners) has to affect on management measures. For example, most of the RFMOs adopted positive list of fishing vessels only for those over 24 meters overall length. As the small longliners are not included in this category, the RFMOs are considering to expand the lower limit of the size for the positive list or to apply a different type of management plan for small boats.

This gear interaction is more severe in case of purse seine fishing around FADs (see Figure 5). Fishing around FADs is very cost effective for purse seiners to catch the target species (mostly skipjack and partially yellowfin tuna). However, it catches very small fish of target species as well as those of non-target species, including bigeye tuna (adult fish of which are important for longline fishery) and other important species for coastal artisanal fisheries. Therefore, it would directly affect on management measures and resource problems. As of now, RFMOs have been unsuccessful in solving the problem of reducing such small fish by-catches while not reducing target species catches.

2. FROM CAPTURE TO PROCESSING (OR LANDING)

Most of the purse seiners used to be and still are unloading the catch at a base port. Unloaded fish are either processed near the landing spot or further transshipped to the area, where processing takes place. In many countries and organizations, purse seine transshipments at sea are prohibited. This contributed to the increase of carrying capacity of seiners; particularly their catch per day is far more than that of longliners.

Longliners used to unload the fresh fish catch at their home ports, particularly those for "sashimi" market. However, in 1950s to early 1960s, (and some are even now), the fishing grounds expanded to the entire world and the captured fish were frozen for canning. At the same time, unloading or transshipments of the catches at foreign ports started. When super-freezers became major part of the fleet, they had to come back to the home ports or at some very limited ports where super-cold storage were available. Since 1980s, trans-shippers started equipped with super-cold storage facilities and in consequence, at sea transshipments became quite popular. Recently, at sea transshipment activity is increasing as the catch per day of longliners dropped significantly and fuel cost increased to a great extent.

3. CHANGE IN PRODUCTS, TRANSSHIPMENTS AND PROCESSING

a) Change in products

Historical change in type of products has been roughly mentioned in the previous chapter, in relation to the fishing methods. Figure 6 shows weight of materials (estimation by the author) used for "sashimi" and other fresh consumption

and canning. It is very similar to the figure 1 for purse seine and longline catches. It is reflection of that almost all the purse seine catches are used for canning and major part of the longline catches are consumed as fresh (including "sashimi"). Such trends represent the resource availability as well as market demands.

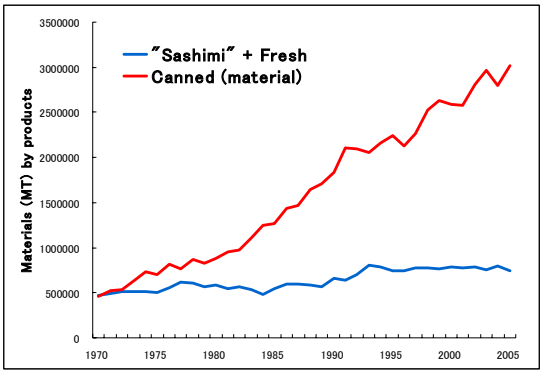

Fig. 6. Tuna materials (in MT) used for canning and "sashimi" + fresh products

Figure 7 gives average price of imported products for canned and fresh or frozen products (FAO statistics). Figures 6 and 7 are not comparative in nature. Weights used in Figure 6 are in round fish at capture, while Figure 7 gives product weights. If canned net weight is assumed to be about 60% of the round weight of fish, the price per round fish would be about 60% of these shown in this figure.

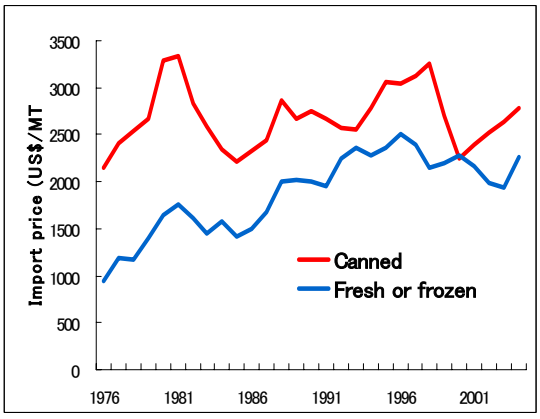

Fig. 7. Import price of canned and fresh/frozen products (US $ per metric tons). Source: FAO

Sashimi products were of fresh fish until 1950s, but since 1960s, super-frozen tuna were also used. However, they were all naturally caught tunas. In 1990s, large scale bluefin tuna farming (fattening) started and spread very widely. This new industry influenced a lot to all the aspects of the tuna "sashimi" market, not only to the bluefin tuna but other species. In the whole picture of the tuna industry, the change can be minor but it shows all the aspects the influence of a socio-economical or technical change may impacted. (XXXXXXXXX) So it is taken up in Chapter 7 as a case study.

b) Change in the world processing sites

The change in share of products (canned vs. fresh) influenced much on the processing industry; i.e. significant expansion of caning industry. Many new canning factories have been built near tuna landing ports. Figure 8 shows the production (in net weight in metric tons) of canned tuna by countries. The data are taken from FAO data base of “fish products” but it should be pointed out that some figures significantly differ from

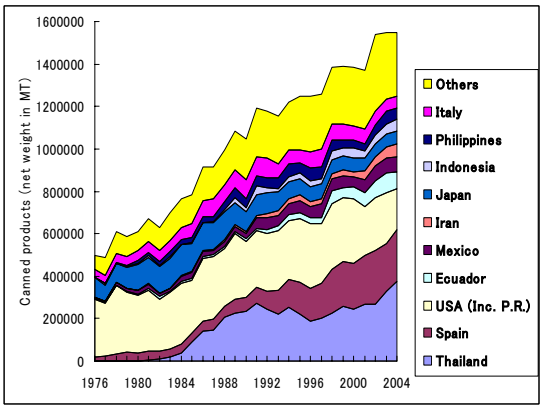

Fig. 8. Production (net weight in MT) of canned tuna by major producers.

national statistics.

Increases of canned tuna production in Thailand, Spain, Indonesia, and Iran are most significant. Other coastal countries developing canning industry in recent years include; Seychelles, Papua New Guinea, Turkey, and Cote d'Ivoire. There is no more tuna canning in U.S. mainland. Those new canneries have been mostly built with a big capital of advanced tuna industry countries

It is very obvious that most of the canned tuna are now produced at the coastal states which are easily accessible by the fishing vessels, with some exceptions where canning is depending on transshipped tunas (e.g. Puerto Rico).

Similar data are available for fresh tuna products but the data can not be well interpretable. For example, in FAO data, frozen tuna include both the ones used for "sashimi" kept under 40 degrees below zero and those used for canning kept at 20 degrees below zero in centigrade. This should be kept in mind in understanding the Figure 7.

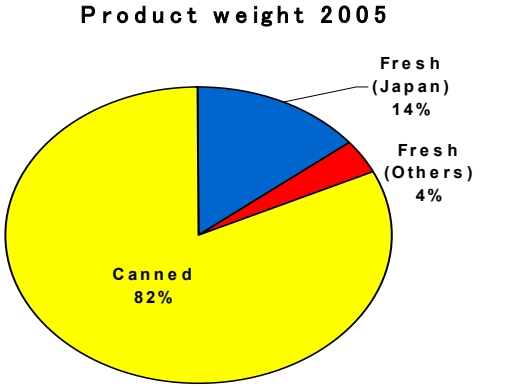

Fig. 9. Proportions of fresh and canned products in the world.

c) Change in transshipments

The changes in fishing and processing procedures explained in the previous Section affected on transportation of tuna products, while change in transportation system affected on fisheries in reverse. The relationship is like eggs and hens. The major historical steps and changes are listed below:

1. Until mid-1950s; All the fish were landed at home ports
2. From mid-1950 to 1960s; Some frozen fish were unloaded at foreign ports and mostly transshipped to canning farms.
3. Since 1980s – Canning material; More fish were landed directly to canning sites rather than transshipped, as canning industry spread along the coastal states.
4. Since 1980s - "Sashimi" quality fish: Transshipped to the super-freezer trans-shippers, at sea.
5. Since early 1980s: Air transshipments of fresh products started.
6. In early 1990s: Special permanent routes of air-transshipments were established.

The history of developments of air shipment is very interesting. It started first to transship fresh bluefin tuna from east coast of North America to Japan in 1970s. The shipments were on irregular basis. However, it became more frequent and regular basis as shipments increased in 1980s. The know-how developed during this period is now applied to transshipments of natural bluefin from Turkey and later

from Spain, Italy and other Mediterranean countries in 1980s to 1990s. When tuna farming started in late 1990s, air shipments became very common practice and regular air shipping routes have been established. Also since early 1990s, many fresh tuna caught by coastal longliners in Indonesian and Philippines waters, later from Australia and many other south Pacific Island states have been air transshipped either to Japan or U.S. fresh fish markets. Such regular routes of fish transshipments now cover many parts of the world and major driving forces to increase coastal tuna catches by small longliners.

d) Change in processing procedures

"Sashimi" market structure

Approximately 85-90% of the world fresh tuna consumption occurs in Japan in the form of "sashimi". Historically all tuna have to be brought in to the landing market (such as Tsukiji) in gilled and gutted form or round (albacore), regardless fresh or frozen. Those fish are sold by public auction where only authorized whole sale companies can participate. This traditional system has been changed when big capitals came into tuna business, mostly in late 1970s to 1980s. These companies buy the whole load of fish taken by a fishing vessel (even before the ship arrives in port). Often, this was pre-arranged condition for financing a trip of certain vessels. Fish are directly unloaded into the super-cold storage by buyers. The stored fish can be sold through the traditional market but also can be sold directly to big retailers such as super-market or restaurant chains, cutting the margin of market and wholesale costs.

Such change in national market also changed the form of products and processing systems. As some fish do not have to go through the traditional fish market auctions, they can be in any forms. Still many fish imported to the Japanese markets are gilled-and-gutted (particularly in case of super-frozen fish), but much of fresh and chilled fish are in the form of dressed, fillet, loins and even of belly meat. This cuts down the cost of transshipments and handling, while gives more job opportunities at the coastal landing states.

In recent years, further processing has been developed in coastal states, involved cutting the fish further to small sections of about 100 grams and pre-vacuum packing. Such products are then trans-shipped to Japan and can be sold directly at the super-market. Pre-packed products can be transshipped as fresh but at present, deep frozen are more common. This would further cut down the transshipping cost; handling cost in high-labored Japan; and whole sale margins. They also guarantee stable supply of products. For this reason, once sanitary problems are all cleared, it would increase rapidly in near future. However, it may promote IUU fishing as the products would be difficult to identified to the species at the time of imports, unless carefully examined.

Canned products

Probably the most important change is cannery site. As explained in Section 4b),

the canned products instead of frozen tuna can be transshipped from coastal states to the big canned tuna market in Europe and North America, representing important cost cut and convenience. Another significant change occurred since late 1990s is the development of a product so-called “loins”. The fish are cleaned, trimmed into the form of loins, ready to pack near the landing ports, before they are further re-exported to the country of cannning. This system uses cheaper labor at the coastal states, cut down the transshipment cost and save cost and labor at the canneries located far from the landing ports. This system is coming an important part of the canning materials.

4. CHANGE IN NATIONAL AND INTERNATIONAL MARKETS, TRADE AND CONSUMPTIONS

a) Trade

General pictures are already well given in the previous Chapters. Therefore, this section summarizes the whole situation using various graphics. All the graphics given in this Chapter is from FAO Production data base. There are several serious uncertainties, besides many data are suspected missing. Those limitations include:

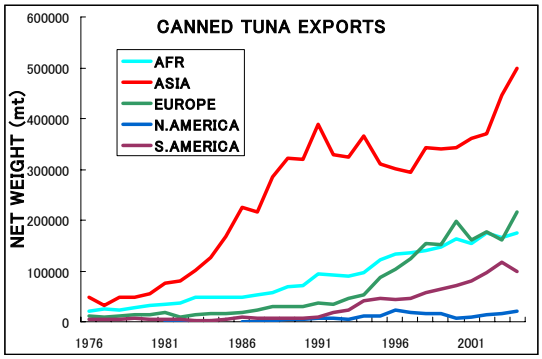

Fig. 10. Export quantities of canned tuna products by continent.

- Weight is supposed to be net weight in case of canned products. However, some seems to be given in other units.
- Fresh, chilled or frozen tunas are given in processed weight and the conditions of processing are generally not given and thus not comparable.
- As fresh, chilled or frozen tuna weight is in wet weight, they are not comparable to the canned product net weight.
- Quantities of exports, imports, productions and re-exports are not necessarily consistent as data sources are different even for the same country
- Fresh, chilled or frozen tunas can be used for canning or fresh fish market. Those are not distinguished in the statistics.
- Canned tuna may include other species than major tunas (e.g. bonitos).

For the reason given above, those figures should be used only as indicators of trends and for rough comparisons. Figure 10 is almost the reflection of Fig. 8. Asian exports increased very rapidly from mid1970 to 1990. This increase represents mostly increase in the production of the new canneries in Thailand. More recent increase represents establishments of even more canneries other than Thailand. African canning industries are mostly conducted within the custom (free-tax) zone and hence the fish are immediately processed and re-exported as canned products. The quantities are increasing very rapidly as well, representing new canning

industries in Cote d'Ivoire, Seychelles, and Kenya etc. European products also increased, mostly by Spain while increase in South America reflects developments of new canning industry in Mexico and Ecuador.

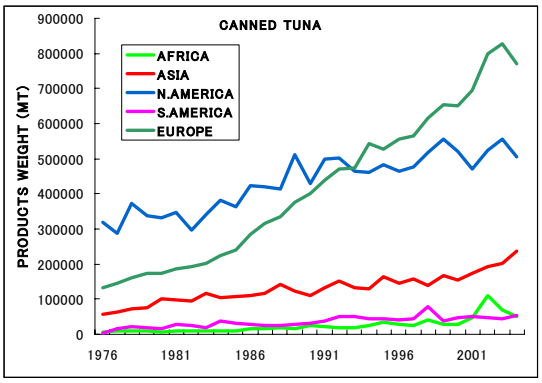

Fig. 11. Estimated consumption of canned tuna products.

Similar graphic was not made for fresh, chilled or frozen fish, as they can be for canning or for "Sashimi". Since the markets are completely different, it is meaningless to compare the trade of the mixture of these two different types of products.

b) **Consumption**

There are no world-wide data for real consumption of tuna products. Figure 11 gives estimated consumption of canned tuna in the world by continent. The consumption is actually the product balance calculated as follows:

<Consumption>=<Products>+<Imports> - <Exports> - <Re-exports> - <Reduction>

The limitations discussed in Section 5a) are all applicable to this case. Particularly inconsistency in statistical base for production and trade might add many uncertainties in their balance. But the figure is still indicative. The consumption increased in almost all the continents. Particularly large increase has been noted for European market. It exceeded, in early 1990s, that of North America and now almost 40% more than the latter. This is definitely related with increased fishing capacity of EU seiners or those capitalized by EU money. The relationship may be that of eggs and hens.

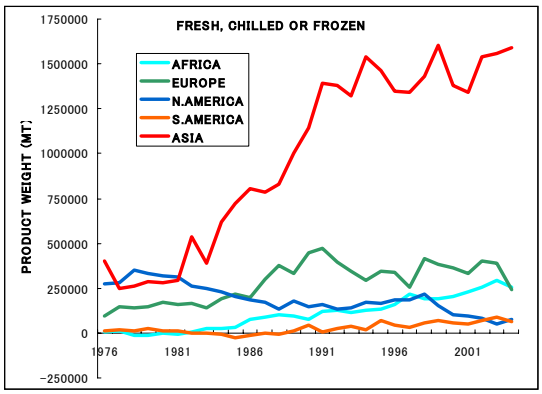

Fig. 12. Estimated consumption of fresh, chilled or frozen tuna products.

Similar consumption (balance sheet) estimates for fresh, chilled or frozen tunas are illustrated in Figure 12. Firstly, it should be noted that the scale on the Y axis are different from Fig. 11. For the reasons already explained, the figure is not as meaningful as for the case of canned products. Non-the-less, Asia dominates all other continents and also has increased rapidly during 1990s. Two factors are contributing to these. Firstly, Asia has a big market of fresh fish consumption. Japanese "sashimi" market alone consumes above a half million tons. Second reason is that this consumption represents only a balance sheet. Fish imported as fresh, chilled or frozen can be used for canning. Those are imported or produced as fresh fish but exported as canned products and

hence the balance sheet of these does not correspond to the consumption.

Catch increase met those increasing demands so far, while it is also true that the demands have met the increasing catch. The increasing demand may reflect the change in preference of world population for healthier and reasonably priced sea food, such as tuna. Also promotion of big capitals (producer and retailers) publicity created more demands. These relationships are really combination of eggs and hens.

6. OTHER SOCIO-ECONOMICAL ELEMENTS

Another very important change in socio-economics observed in recent years is the change in the approaches for fisheries management. The management used to give consideration only to the stock status of target fish. Recent management requires echo-system approaches. This issue alone could be a title of a whole symposium and the author of the present paper does not wish to discuss the matter,

It is also true that the influence of environment and other competitors in the echo-system on the target species has to be understood well. Therefore the capture of incidental species while fishing tunas became one of the major issues in the management as a whole. Since most of the by-catch species are top predators (e.g. sharks, billfishes), the triangle relationship is very complicated and difficult to evaluate the magnitude of influence between interactions of each components.

7. TUNA FARMING – A CASE STUDY

a) Development of tuna farming

"Tuna farming" is used referring to tuna fattening operations and should be distinguished from tuna aquaculture. Small sized tuna or after spawning adult tuna are lean and have values not enough to import to the Japanese market. However, once the fish are kept in cages, fed well for a few months, they gain much fat contents in meat and can be sold in the Japanese "sashimi" market for relatively high, sometimes very high price.

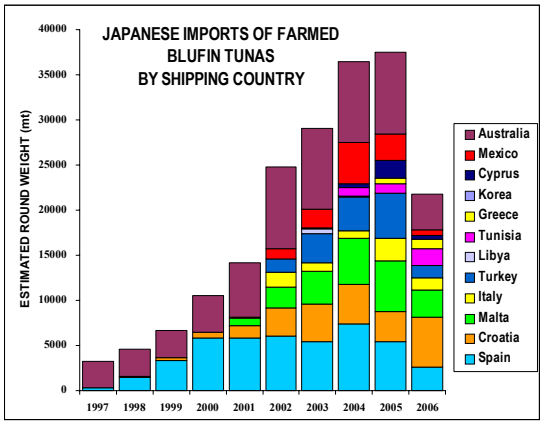

Fig. 13. Japanese imports of bluefins by shipping countries (in converted round weight in MT). Data for 2006 is only for the first half of the year.

The first tuna farming started in 1960s by a Japanese firm in Canadian east coast. Similar farming was resumed in late 1970s in Ceuta, Spain, near Gibraltar. In both cases, the after-spawned lean bluefin adult fish caught by traps were kept in an anchored pool, fattened, frozen and shipped to Japanese "sashimi" market.

Modern farming started in early 1990s by the same Japanese firm in Australia for southern bluefin tuna. In this case, medium size fish caught by purse seiners are kept on floating cages for several months, fattened and shipped to Japan. The smaller to medium size southern bluefin tuna, as captured by seiners, had very low value in Japanese "sashimi" market. But those farmed tuna are sold as fatty tuna (“toro”) for a very high price.

This system has been introduced to the Mediterranean Sea in 1997 and rapidly spread all over the Mediterranean Sea. Figure 13 shows estimated quantities of bluefins (Atlantic, Pacific and southern) imported to Japan based on the statistical documents. Processed weights are converted into round weight. (Miyake, P.M., 2005a). In 2002, Mexico started similar farming operation in the Pacific with Pacific bluefin tuna.

At present, no commercial farming operation is done other than for bluefins.

b) Merits and problems as the effects on tuna stocks

"Sashimi" markets are small portion in the world market in quantity but important for values. Also bluefins are small in quantity even in that "sashimi" market but most expensive species, always having leaded the price of tuna in Japan. Therefore, the new farming industry had a great impact in many aspects of the world tuna industry. Issues are of much complexity and wide in scope (Anonymous, 2005). Therefore, only very short summary of positive and negative impacts that this industry gave are listed below.

Positive impacts:

- Add values to the captured fish.
- Price-rise for many bait fish and hence economical gains for other local fisheries.
- Increase job opportunities in farming areas.
- Provide fat meat of tuna to the market in a large quantity and relatively low price.
- Provide high valued tuna on constant basis.
- Stabilized tuna as an important trade commodity.

Negative impacts:

- Uncertainties in quantity, area, time and size of fish of catches increased.
- Possible tuna laundering.
- Excessive exploitation of bluefin stocks.
- Tuna price in the Japanese market collapsed and lead many fishers to economic difficulties.
- Collapsed people’s taste bud (author’s opinion).
- Possible sanitary problem?
- Any negative effects on environment?
- Introduction of new parasites or disease by baitfish?

One of the most serious problems is increased uncertainties in catch and size data, which are essential for scientific evaluation of stocks. Since fishing countries and farming countries are very frequently different in the case of the Mediterranean, and since in one pen, fish from many origins are all mixed, it is very difficult to trace fish back to the catches. Therefore, compliance of catch quota can not be monitored (Anon, 2005).

Second important issue is that the farming increased significantly the value of small to medium sized bluefin tuna in the Mediterranean. They were generally sold to canning industry or used in local fresh fish market. The price was about 2-3 Euros per kilo. Once farming started, they are sold near 10 Euros to the farmers. The final farmed products are sold at about 25 Euros per kilo in the Japanese market as well as in European retailers. Naturally the pressure for stock increased significantly since farming started (causing over-quota).

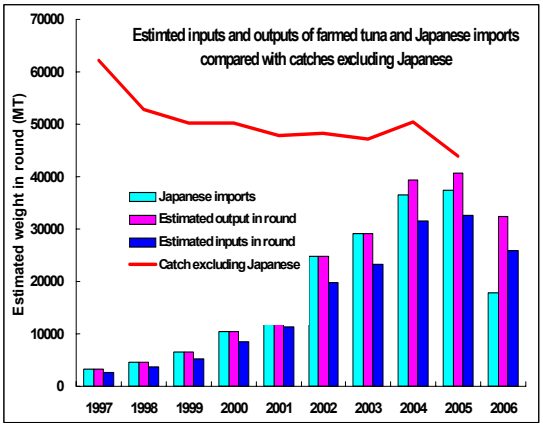

Fig. 14. Estimated input and output for bluefin tunas farming and imports of bluefins by Japan, compared with bluefin catches excluding Japan.

c) Socio economic influence of developments of farmed tuna.

Figure 14 compares quantities of farmed bluefin tunas (Atlantic, Pacific and southern) with their reported catches. The line in the Figure represents the reported catches. Japanese catch is excluded, as the Japanese catch can not be imported to Japan. The farmed tuna are given in histograms and represent Japanese imports, total estimated outputs from farming pens and estimated inputs. They are all converted into round weight basis. As input quantities are very uncertain, they are estimated as 80% of outputs (i.e. 25% average increase in weight was assumed). (Updated from P.M., 2005a).

This graphics demonstrates two important facts. The proportion of bluefin tuna catch which went into farming increased very rapidly and now almost all the bluefin tunas are farmed. As some fresh bluefin tuna are also imported, this actually suggests some under-reporting of catches.

The second point is that almost all the bluefin tuna came out of farming was exported to the Japanese market until 2003. Since 2004, some are being sold outside the Japanese market and it may relate to the price in Japan. In 2004, by increased supply, the market price in Japan went down and some inferior quality fish are sold only for less than 20 Euros, below the economical break point. This induced development of new market in Europe and U.S. The author saw, for the first time, farmed tuna being sold in normal Spanish retail shop for 24 Euros in 2005.

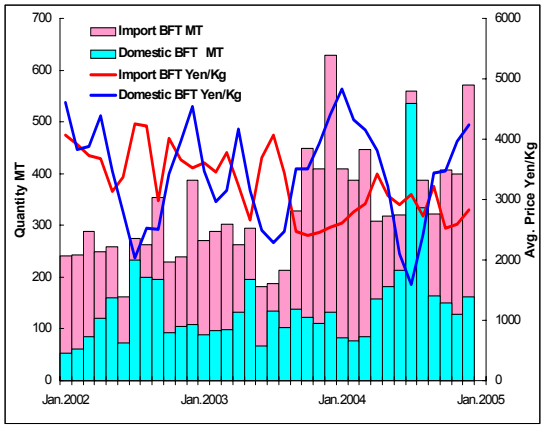

Fig. 15. Comparison of domestic and imported bluefins monthly price (lines) vs. quantities (histograms) sold in Tsukiji market.

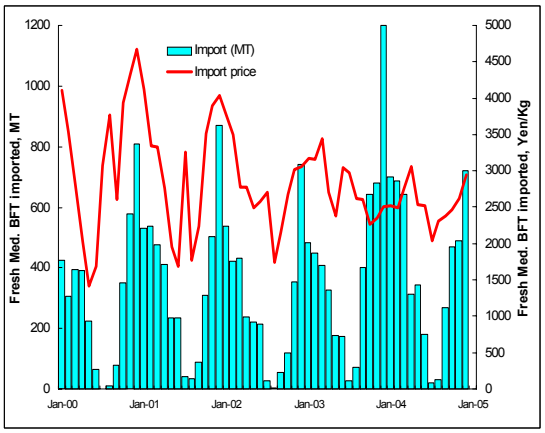

Fig. 16. Monthly quantities (histograms) and average price (lines) of Mediterranean farmed bluefin tuna imported to Japan.

They also started to appear in the U.S. sushi-bars around 2005.

The analysis of price is very difficult as there are so many discrepancies among the data sources. Also each time series are relatively short and can not be compared directly over an extended period. The price range is also very wide. (e.g. from 30,000 yen to 500 yen per kilo for bluefin, on the same day, depending on quality, in Tsukiji market). The best series the author created so far are given in Figs. 15 and 16. Figure 15 shows bluefin quantity sold in Tsukiji market (Tokyo Central market) in histograms, accumulatively for imports and domestic supplies, and price in lines. Figure 16 gives total quantities of bluefin tuna of the Japanese import from the Mediterranean area in histogram and average price for them in lines.

Japanese market demands have two peaks, one in mid summer and another (the highest) in New Years. Mid-year peaks are met by domestic supply but the end of the year supply is mostly of imported farmed tuna. The price also gets highest during the latter period and hence the economic gain by the farmers and exporters would be maximized. It can be observed from this Figure that the peak price has gradually declined from 2000 to 2005.

The average price is not very meaningful and the price range is very wide, as explained above. However, it is interesting to know that the maximum recorded price in Tokyo market, until early 1990s, were about 100,000 yen per kilo while it is now about 20,000 per kilo. Bluefin quantity is probably about 10% of total tuna "sashimi" sold in Japan. However, if only “toro” meat is considered, the picture is different. Before farming started, about 2-3000 tons of bluefin tuna with toro quality were available in the market. Only 15 % of the fish are toro. Therefore the total quantity of toro meat available was 450 tons per year. They were luxury items. At present, about 40,000 tons of tuna are available from farming of which 60 % can be sold as toro. Therefore 24,000 tons of toro are in the market, or 50 times more than before. Most of the people who could not afford quality bluefin but ate bigeye tuna

can now buy toro-bluefin tuna. That naturally brought down the price of all the tunas including other tuna species.

It has been really a social and economical revolutional event in Japanese diet and market. This impact should not be under-evaluated. The importance is that this revolution is all closely related to the bluefin stocks and managements, as well as socio-economics in the farming areas.

8. DISCUSSONS AND CONCLUSIONS

In this paper, the impacts of major socio-economic changes on tuna resources and direct or indirect effects of such changes on the fishery management plans are discussed. The relations are very complicated and on both directions. The changes in fishing methods, fishing gears and efficiencies, processing industry, transshipments, international market, trade, consumptions, and/or social concept of managements were listed (not really discussed) in this paper. All of them would influence on the management directly, or through the change in exploitation patterns of stocks.

On the contrary, any management measures applied and implemented would influence in turn on structure of fishery/processing industry and markets. In order to understand the whole picture, much more research in depths would be required.

If the stock statuses of top predators are on the safe side and if there are much more room to exploit, most of the socio-economic changes can be absorbed by the industry, and a new scheme or system will be established. However, at present, almost all the tuna stocks are near the full exploitation and some are even over-exploited, and capacity to harvest these stocks are already in excess. Under such situations, any small socio-economic changes might lead to a significant re-shuffling of the industry and or market. This is another reason that such studies are urgently required.

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