



**SCIENTIFIC COMMITTEE
SIXTH REGULAR SESSION**

10-19 August 2010
Nuku'alofa, Tonga

**Accuracy of species identification of yellowfin and bigeye in three canneries of Kingdom of
Thailand**

WCPFC-SC6-2010/ST-WP-04

**Keisuke Satoh^{1 2}, Hiroaki Okamoto¹, Takumi Fukuda³, Nohara Kenji¹, Yasuyuki Sasaki⁴,
Tatsuki Oshima⁴**

¹ National Research Institute of Far Seas Fisheries, Fisheries Research Agency, 5-7-1 Orido, Shimizu-ku, Shizuoka-city, Shizuoka 424-8633, Japan

² Email: kstu21@fra.affrc.go.jp

³ Fisheries Agency, 1-2-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-8907, Japan

⁴ Marine Fisheries Research and Development Center(JAMARC), Fisheries Research Agency, Queen's tower B15, 2-3-3 Minatomirai, Nishi-ku, Yokohama-city, Kanagawa 220-6115, Japan

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Abstract:

In WCPFC area and Indian Ocean the catch of four tuna species (skipjack, yellowfin, bigeye and albacore) was over 3400 thousand metric ton in 2008. Around 750 thousand tons (22 %) of these were landed at Kingdom of Thailand. Accuracy of species identification of yellowfin and bigeye in three canneries of Kingdom of Thailand was investigated in April 2010. In these factories yellowfin and bigeye are sorted to five market categories according to their sizes (1.4 kg down, 1.4 - 1.8 kg, 1.8 - 3.4 kg, 3.4 - 9.0 kg and 9.0 kg up) for each species. We conducted species identification for 2,572 individuals of total 25 market categories except for the largest category (9.0 kg up), and measured body lengths and weighed up to 20 individuals for each category, and then calculated the mixture rates of species ($\% \text{ of BET (or YFT) / (YFT+BET)}$) by market category and cannery (and in some cases by each fishing boat). For the smallest categories the mixture rates were relatively high, 12.6% on average which ranged from 0.0% to 21.7% (% weight) varying among factories. The mixture rates for the larger three categories represented relatively-accurate values, 2.8% on average (0.0 to 6.8 %). The estimated accuracy of amount of catch in market report (corrected catch / market report) were from 98.7 % to 113.3 % for bigeye, and from 98.0% to 105.1 % for yellowfin. The accuracy of amount of catch by species in market report of the three Thai canneries investigated seems to be reliable, although the accuracy is depend on the amount of catch in smallest market categories, where the species mixture rates are relatively high.

INTRODUCTION

The catch by species of Japanese purse seine fishery operated in WCPFC tropical area have been collected by log book, and which is cross-checked by the market reports collected from the Yaizu, Makurazaki and Yamagawa markets in Japan. The vessels had been unloaded their catch at the domestic three markets in most cases, therefore majority (98.6%; 3543 / 3593 cruises since 1995) of the catch from the log book were verified by the market reports. However, in the future the vessels are more likely to unload at the foreign ports, especially in Kingdom of Thailand.

The tuna canning industry in of Kingdom of Thailand had been rapidly developed since early 1980s. The amount of export have increased continuously and reached to 480 thousand metric ton in 2009 except for stagnant period in 1990s. As domestic catches of the four tuna species (skipjack, yellowfin, bigeye and albacore) in Thailand was 10 to 20 thousand ton in recent years, and even if it includes small tuna species as candidate of materials for tuna canning (frigate tuna, longtail tuna and kawakawa) it was from 120 to 150 thousand, the materials for tuna canning have mainly depended on imported fish. The time-series of amount of frozen four tuna species imported, which moved parallel to that of amount of export of canning, came up to 810 thousand ton in 2009 (**Fig. 1**, FishStat Plus version 2.32⁵, The customs of Department of the Kingdom of Thai⁶). And about 22 % (750 thousand tons) of total catch of these species in WCPFC area and Indian Ocean was landed at Thailand as materials of tuna canning. Thai's import trading partners distributed among 79 countries and regions during last nine years, the top five countries and regions (Chinese Taipei (14%), Vanuatu (8%), Japan (6%), Republic of Korea (5%) and Federates of Micronesia (4%)) occupied about 60 % as average of last nine years (**Fig. 2**). The products of the Thai canneries were marketed to almost the entire world (180 countries and regions), the top five countries (USA (22%), Australia (8%), Egypt (7%), Canada (7%) and Libya (6%)) accounted for about 50 % (**Fig. 3**). If we can know the amount of purse seine catch transported to each

⁵ <http://www.fao.org/fishery/statistics/software/fishstat/en>

⁶ <http://www.customs.go.th/Customs-Eng/Statistic/Statistic.jsp?menuNme=Statistic>

of the main countries of canning industry by using cannery report, it would be possible to grasp total catch of small sized bigeye tuna caught by purse seine fishery. Japanese Fisheries Agency identified the importance to know more about data collecting system from the tuna cannery of Thailand and to confirm the accuracy of the data (**Anonymous 2009**).

The aims of the present study were to: (1) describe species mixture rates of market categories of the canneries; (2) estimate of accuracy of species identification in these canneries.

METHODS

Sampling in canneries

The number of major cannery is over 30 (as of 2010, Thai Food Processors' Association⁷) in Thai. Of these, three largest canneries (A, B and C) were selected for the investigation. In recent years, the market share of these three packers in Thailand was about 60 % (Kawamoto⁸, personal communication). Accuracy of species identification and sizing of market categories as to yellowfin and bigeye in these three canneries was investigated in Bangkok from 20 April to 23 April 2010 (**Table 1**). In these factories yellowfin and bigeye are sorted to five market categories according to their sizes (1.4 kg down, 1.4 - 1.8 kg, 1.8 - 3.4 kg, 3.4 - 9.0 kg and 9.0 kg up) for each species. We conducted species identification for up to 100 individuals for each market category except for the largest category (9.0 kg up), and measured body length and weighed up to 20 individuals. Then species mixture rates (% of BET (or YFT) / (YFT+BET) in number and in weight) was calculated by market category and by factory (and in some cases by fishing boat) and the corrected catch by species was estimated by market category.

Species identification was conducted using the combination of three criteria as

⁷ http://www.thaifood.org/member_directory/member_directory_2009.htm

⁸ <http://www.geocities.jp/wcpfc/>. Globalized suppliers of materials of tuna canning (The relationship between Japanese purse seine fishery and Thai packing industry as to tuna canning) (In Japanese). The market share was calculated by the proportion of amount of receiving fish per day as of 2006.

reviewed in Itano and Fukofuka (2007); 1) horizontal lines pattern on trunk and tail (YFT; slightly curved and evenly spaced and separated by rows of spots, BET; irregular pale lines) 2) pectoral fin characteristics (YFT; shorter and just reaching base of second dorsal fin, BET; longer and reaching second dorsal fin) and 3) body morphology (YFT; elongate and long tail, BET; deep and rounded). In some cases these criteria were difficult to apply because the fish were damaged too much in fishing process or transportation process, and/or fish shows intermediate characteristics of two species. In such cases, small portion of tissue was sampled from specimen and then PCR-RFLP (Polymerase chain reaction – restriction fragment length polymorphism) on flanking region (ATCO) between ATPase and cytochrome oxidase III genes of mtDNA was applied to identify bigeye and yellowfin tuna. In first, detecting bigeye using multiplex PCR amplification (Nohara et al, 2008), and then PCR products of remaining specimen (not identified as BET in the previous step) was digested by restriction endonuclease EcoNI (Chow et al. 2003) to confirm as it is yellowfin.

Comparison of the accuracy between Thai canneries and Japanese markets

For making perspective on the feasibility for using the cannery data to verify the catch by species from log book, the comparison of species mixture rates between the accuracy between Thai canneries and Japanese markets. The two smallest market categories of YFT in Yaizu market, and the smallest category of YFT in Makurazaki were composed of bigeye and yellowfin because of their commercial customs, the sorting of species as to the market category at landing was not carried out. Therefore port samplings, with objectives of estimation of species mixture rate and corrected catch by species in these categories, have been carried out since 1995 in the two major Japanese markets (**Anonymous 2009**).

RESULTS

Sampling in canneries

The number of specimen, amount of fish weight for measurement and results of species identification by cannery and market category were showed in **Table 1**. As to the “cannery A”, the fish were from two different vessels therefore the results were treated separately. We assumed a total of 32 market categories subject to the investigation, however there were no corresponding catch to seven market categories. Therefore, a total of 25 market categories were investigated. The number of specimen ranged from 5 to 300 individuals of each market category, which reflected the receiving status at the timing of the measurement (**Table 1**). A total of 2572 individuals were identified its species, of these, 38 specimen were applied for the PCR-RFLP method to identify the species. They were identified as yellowfin for seven individuals and as bigeye for remaining (31 individuals).

The body weight frequencies by market category and cannery observed in this investigation were shown in **Fig. 4**. The range of body weight observed in each category basically coincided with the size range defined for each market category with some exceptions.

For the smallest categories the mixture rates were relatively high, 12.6% on average which ranged from 0.0% to 21.7% (% weight) varying among factories (Table 1). The mixture rates for the larger three categories represented relatively-accurate values, 2.8% on average (0.0 to 6.8 %). The amount of catch by market category was described in market report for each fishing vessel or for each transport track (**Table 2**). For the cannery A, the catch were based on the transport track, and for other canneries, the catches in market reports were cruise-based. The estimated accuracy of market reports (corrected catch / market report) in weight base were from 98.7 % to 113.3 % for bigeye, and from 98.0% to 105.1 % for yellowfin (**Table 2**).

Comparison of the accuracy between Thai canneries and Japanese markets

A total of 466 times of port sampling in the two Japanese major tuna markets (Yaizu and Makurazaki) was carried out from 1995 to Feb. 2010 (**Table 3**). For the comparison it is appropriate to compare the mixture rates of Japanese sorted market category with those of category of corresponding body size (1.4 - 1.8 kg, 1.8 - 3.4kg) in the Thai canneries. For the sorted categories the mixture occurred sometime (% frequency; 9.8 % to 39.6 %) and the mixture rates (% weight) showed low value from 0.3 to 3.7%. The species mixture occurred more frequently and was relatively large in smaller category. The mixture rates resemble those of the Thai canneries (0 – 7.5 %) except for 20.3% of the 1.4-1.8 kg of YFT in cannery C. The similarity of species mixture rates between the Thai canneries and Japanese markets suggest that the ability of sorting species is similar level.

The species mixture rate represented higher value from 14.9 to 24.2 % for unsorted market categories of YFT 1.5kg down and YFT 1.5kg up in Yaizu and YFT 1.5kg down in Makurazaki, which were also similar to those of smallest categories in Thai cannery (0 – 21.7%).

DISCUSSION

The accuracy of amount of catch by species in market report in the three Thai canneries seems to be reliable, however the accuracy is depend on the amount of catch in smallest market categories, where the species mixture rates are relatively high. Their motivation for avoiding deterioration in quality of their products caused by the contamination of bigeye, which represents red spot when it is cooked, results in their high performance to identify species. Thus, the market reports of the Thai canneries seem to be credible data source for verification of catch by species reported in logbook. Nevertheless, in smaller bigeye and yellowfin, it is difficult to identify the species in one glance in sorting line, and it leads to relative high mixture rate, and then it results in uncertainty of the catch by species in market reports. The

high mixture rates are similar to those of unsorted categories in Japanese markets. In order to estimate accurate amount of catch by species from market report, it is needed further investigation of the extent to which the sorting for the smallest categories is in practice at other canneries. And also there is room to investigate differences among factories and seasonal and annual changes for the mixture rate, which have been suggested from investigation of Japanese markets.

Acknowledgement: We would like to thank stuffs of three canneries in Kingdom of Thailand for collecting data. We are also grateful to stuffs of Training department (TD) of Southeast Asian Fisheries Development Center (SEAFDEC) and ITOCHU Corporation. Without their considerations, supports and arrangements, we could not conduct this study.

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Table 1 Results of accuracy of species identification as to number and weight.

| sampling date | sampling place (cannery) | fishing vessel | market category species | market category size (kg) | species mixture rate (% number) | number of bigeye | number of yellowfin | species mixture rate (% weight) | weight (kg) of BET | weight (kg) of YFT |
|---------------|--------------------------|------------------------|-------------------------|---------------------------|---------------------------------|------------------|---------------------|---------------------------------|--------------------|--------------------|
| 2010/4/20 | A | A | BET | 1.4 down | - | - | - | - | - | - |
| | | | | 1.4-1.8 | - | - | - | - | - | - |
| | | | | 1.8-3.4 | 0.0% | 5 | 0 | 0.0% | 15.4 | 0.0 |
| | | | | 3.4-9.0 | 0.0% | 79 | 0 | 0.0% | 424.3 | 0.0 |
| | | | YFT | 1.4 down | - | - | - | - | - | - |
| | | | | 1.4-1.8 | - | - | - | - | - | - |
| | | | | 1.8-3.4 | 0.0% | 0 | 28 | 0.0% | 0.0 | 76.2 |
| | | | | 3.4-9.0 | 0.0% | 0 | 100 | 0.0% | 0.0 | 498.4 |
| | | B | BET | 1.4 down | - | - | - | - | - | - |
| | | | | 1.4-1.8 | - | - | - | - | - | - |
| | | | | 1.8-3.4 | 0.0% | 17 | 0 | 0.0% | 46.7 | 0.0 |
| | | | | 3.4-9.0 | - | - | - | - | - | - |
| | | | YFT | 1.4 down | 16.7% | 4 | 20 | 15.1% | 2.9 | 16.4 |
| | | | | 1.4-1.8 | 2.7% | 3 | 110 | 2.6% | 5.0 | 185.6 |
| | | | | 1.8-3.4 | 0.0% | 0 | 200 | 0.0% | 0.0 | 585.5 |
| | | | | 3.4-9.0 | 0.0% | 0 | 100 | 0.0% | 0.0 | 574.1 |
| 2010/4/21 | B | C | BET | 1.4 down | 0.0% | 55 | 0 | 0.0% | 49.8 | 0.0 |
| | | | | 1.4-1.8 | 8.3% | 11 | 1 | 7.5% | 16.1 | 1.3 |
| | | | | 1.8-3.4 | 5.9% | 96 | 6 | 4.6% | 312.6 | 15.2 |
| | | | | 3.4-9.0 | 0.0% | 90 | 0 | 0.0% | 458.9 | 0.0 |
| | | | YFT | 1.4 down | 25.6% | 11 | 32 | 21.7% | 8.5 | 30.6 |
| | | | | 1.4-1.8 | 2.9% | 3 | 101 | 2.8% | 5.0 | 174.9 |
| | | | | 1.8-3.4 | 4.0% | 4 | 96 | 4.0% | 11.0 | 261.8 |
| | | | | 3.4-9.0 | 0.0% | 0 | 132 | 0.0% | 0.0 | 643.3 |
| 2010/4/23 | C | D (Japanese vessel) | BET | 1.4 down | 11.0% | 178 | 22 | 11.6% | 187.7 | 24.7 |
| | | | | 1.4-1.8 | 0.9% | 112 | 1 | 0.8% | 176.0 | 1.4 |
| | | | | 1.8-3.4 | 3.0% | 194 | 6 | 2.7% | 541.0 | 15.0 |
| | | | | 3.4-9.0 | 0.7% | 298 | 2 | 0.5% | 1325.5 | 6.6 |
| | | | YFT | 1.4 down | 14.5% | 20 | 118 | 14.7% | 21.0 | 121.8 |
| | | | | 1.4-1.8 | 20.8% | 5 | 19 | 20.3% | 7.0 | 27.7 |
| | | | | 1.8-3.4 | 3.5% | 7 | 193 | 3.4% | 17.2 | 488.5 |
| | | | | 3.4-9.0 | 7.5% | 7 | 86 | 6.8% | 21.7 | 298.0 |

In some cases, the smallest category is referred as 1.0 - 1.4 kg in market report. However the "1.4 down" was used for easy to understand in such cases.

| Table 2 Estimation of total catch by species. | | | | | | | | | | |
|---|------------------|------------------------|-------------------------|---------------------------|--|-------------------------------|--------------------|--------------------|--|---------------------------------------|
| sampling date | sampling cannery | fishing vessel | market category species | market category size (kg) | species mixture rate (% weight) (from Table 2) | catch (kg) from market report | amount of BET (kg) | amount of YFT (kg) | BET (corrected catch / market report) | YFT (corrected catch / market report) |
| 2010/4/20 | A | A | BET | 1.4 down | - | 0 | 0.0 | 0.0 | 100.0 % (1,269 kg / 1,268 kg) | 100.0 % (4,525 kg / 4,525 kg) |
| | | | | 1.4-1.8 | - | 0 | 0.0 | 0.0 | | |
| | | | | 1.8-3.4 | 0.0% | 48 | 48.0 | 0.0 | | |
| | | | | 3.4-9.0 | 0.0% | 1,220 | 1220.0 | 0.0 | | |
| | | | | 9.0 up | - | 0 | 0.0 | 0.0 | | |
| | | | YFT | 1.4 down | - | 0 | 0.0 | 0.0 | | |
| | | | | 1.4-1.8 | 2.7% a | 17 | 0.5 | 16.5 | | |
| | | | | 1.8-3.4 | 0.0% | 333 | 0.0 | 333.0 | | |
| | | | | 3.4-9.0 | 0.0% | 3,974 | 0.0 | 3974.0 | | |
| | | | | 9.0 up | - | 201 | 0.0 | 201.0 | | |
| | | B | BET | 1.4 down | - | 0 | 0.0 | 0.0 | 100.9 % (1,922 kg / 1,905 kg) | 99.9 % (18,038 kg / 18,055 kg) |
| | | | | 1.4-1.8 | - | 0 | 0.0 | 0.0 | | |
| | | | | 1.8-3.4 | 0.0% | 62 | 62.0 | 0.0 | | |
| | | | | 3.4-9.0 | 0.0% b | 790 | 790.0 | 0.0 | | |
| | | | | 9.0 up | - | 1,053 | 1053.0 | 0.0 | | |
| | | | YFT | 1.4 down | 16.7% | 18 | 3.0 | 15.0 | | |
| | | | | 1.4-1.8 | 2.7% | 540 | 14.3 | 525.7 | | |
| | | | | 1.8-3.4 | 0.0% | 3,385 | 0.0 | 3385.0 | | |
| | | | | 3.4-9.0 | 0.0% | 13,464 | 0.0 | 13464.0 | | |
| | | | | 9.0 up | - | 648 | 0.0 | 648.0 | | |
| 2010/4/21 | B | C | BET | 1.4 down | 0.0% | 55 | 55.0 | 0.0 | 113.3 % (6,539 kg / 5,769 kg) | 98.0 % (36,970 kg / 37,740 kg) |
| | | | | 1.4-1.8 | 7.5% | 11 | 10.2 | 0.8 | | |
| | | | | 1.8-3.4 | 4.6% | 2,574 | 2454.9 | 119.1 | | |
| | | | | 3.4-9.0 | 0.0% | 2,756 | 2756.0 | 0.0 | | |
| | | | | 9.0 up | - | 373 | 373.0 | 0.0 | | |
| | | | YFT | 1.4 down | 21.7% | 711 | 154.4 | 556.6 | | |
| | | | | 1.4-1.8 | 2.8% | 1,136 | 31.3 | 1104.7 | | |
| | | | | 1.8-3.4 | 4.0% | 17,422 | 703.7 | 16718.3 | | |
| | | | | 3.4-9.0 | 0.0% | 5,448 | 0.0 | 5448.0 | | |
| | | | | 9.0 up | - | 13,023 | 0.0 | 13023.0 | | |
| 2010/4/23 | C | D (Japanese vessel) | BET | 1.4 down | 11.6% | 12,610 | 11,142 | 1,468 | 98.7 % (105,445 kg / 106,820 kg) | 105.1 % (28,340 kg / 26,965 kg) |
| | | | | 1.4-1.8 | 0.8% | 2,356 | 2,338 | 18 | | |
| | | | | 1.8-3.4 | 2.7% | 36,868 | 35,871 | 997 | | |
| | | | | 3.4-9.0 | 0.5% | 53,719 | 53,454 | 265 | | |
| | | | | 9.0 up | - | 1,267 | 1,267 | 0 | | |
| | | | YFT | 1.4 down | 14.7% | 3,170 | 467 | 2,703 | | |
| | | | | 1.4-1.8 | 20.3% | 668 | 135 | 533 | | |
| | | | | 1.8-3.4 | 3.4% | 18,119 | 618 | 17,501 | | |
| | | | | 3.4-9.0 | 6.8% | 2,271 | 154 | 2,117 | | |
| | | | | 9.0 up | - | 2,737 | 0 | 2,737 | | |
| a: These figures are substituted for those of different fishing vessel B. | | | | | | | | | | |
| b: These figures are substituted for those of different fishing vessel A. | | | | | | | | | | |

Table 3 Summary of port sampling in two large Japanese domestic tuna markets since 1995

| port | species | market category | number of sampling times* | number of specimen | average number of fish in one sampling | %frequency | species mixture rate | | Remarks |
|--|---|-------------------------|---------------------------|--------------------|--|--|----------------------|---------|----------|
| | | | | | | number of occurrence of mixture / number of sampling times | %number | %weight | |
| Yaizu | YFT | 1.5 down | 300 | 32993 | 110 | 92.0% | 18.4% | 19.0% | Unsorted |
| | | 1.5 up | 299 | 32193 | 108 | 90.6% | 24.0% | 24.2% | Unsorted |
| | | 2.5 up | 304 | 30099 | 99 | 19.1% | 0.7% | 0.4% | sorted |
| | | 10.0 up | 275 | 22590 | 82 | | | | |
| | | KIZU, OOKIZU, OSARE and | 0 | - | - | | | | |
| | BET | 2.5 up | 301 | 28061 | 93 | 9.6% | 1.3% | 0.3% | sorted |
| | | 10.0 up | 2 | 52 | 26 | | | | |
| Makurazaki | YFT | 1.5 down | 143 | 18373 | 128 | 77.6% | 14.3% | 14.9% | Unsorted |
| | | 1.5 up | 146 | 15460 | 106 | 15.4% | 1.3% | 0.8% | sorted |
| | | 3.0 up | 132 | 11915 | 90 | 9.8% | 0.3% | 0.3% | sorted |
| | | 5.0 up | 73 | 5772 | 79 | | | | |
| | | 10.0 up | 141 | 10011 | 71 | | | | |
| | | KIZU, | 1 | 121 | 121 | | | | |
| | BET | 1.5 up | 134 | 13927 | 104 | 39.6% | 5.3% | 3.7% | sorted |
| | | 3.0 up | 133 | 12411 | 93 | 16.5% | 1.5% | 0.7% | sorted |
| | | 10.0 up | 51 | 2381 | 47 | | | | |
| | The market category of "1.5 up" is applied the fish weighting from 1.5 kg to the next category. | | | | | | | | |
| The market categories of "KIZU, OOKIZU, OSARE" and so on" are applied the fish of low quality due to crused or not frozen well. | | | | | | | | | |
| * : From Feb. 1995 to Feb. 2010, the total number of sampling times for Yaizu and Makurazaki markets are 313 and 153 times , respectively. | | | | | | | | | |

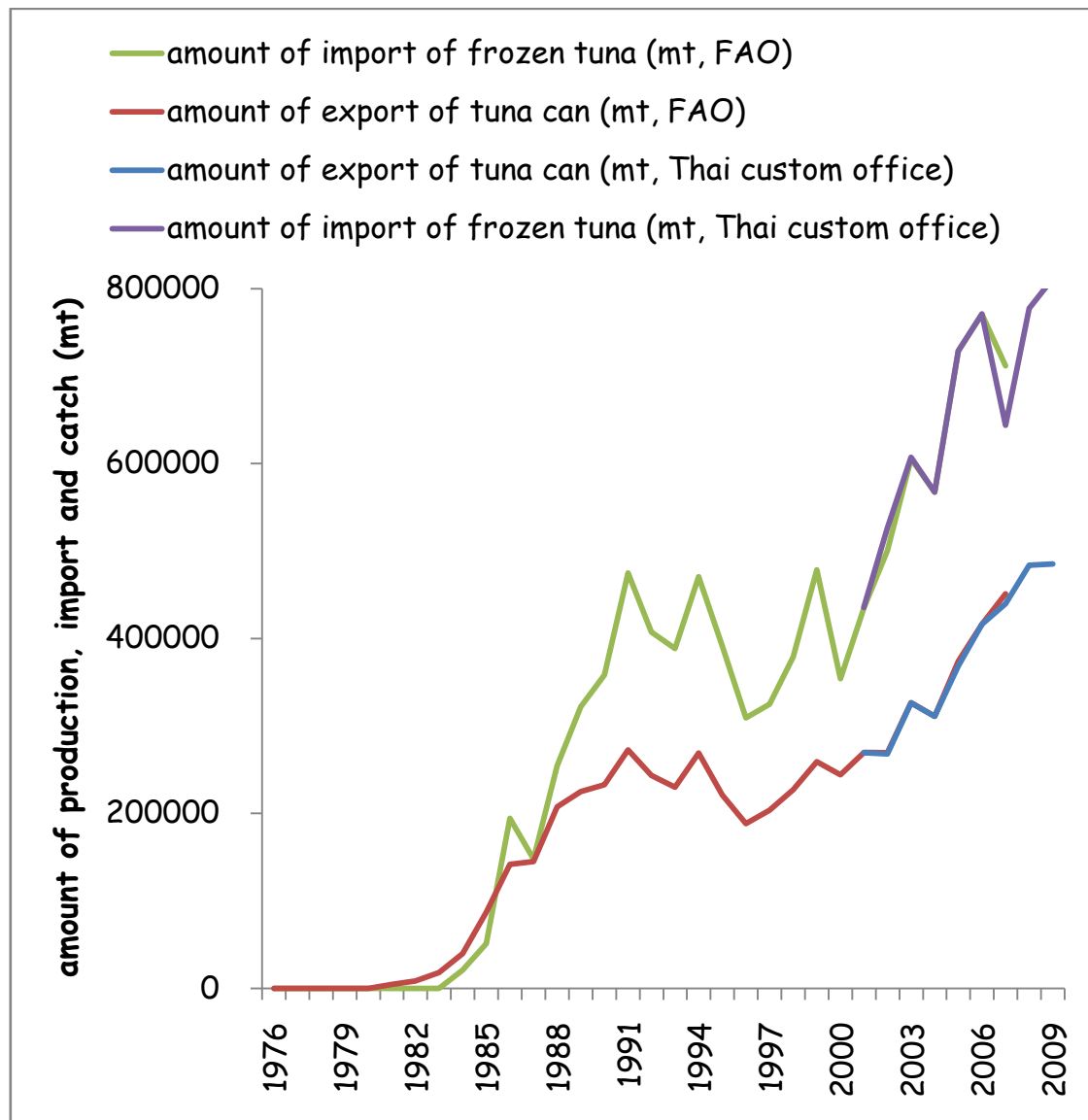


Fig. 1 Annual changes of amount of import of frozen four tuna species (skipjack, yellowfin, bigeye and albacore) and export of tuna canning of Thai. The data from FishStat Plus version 2.32 of FAO and the customs of Department of the Kingdom of Thai.

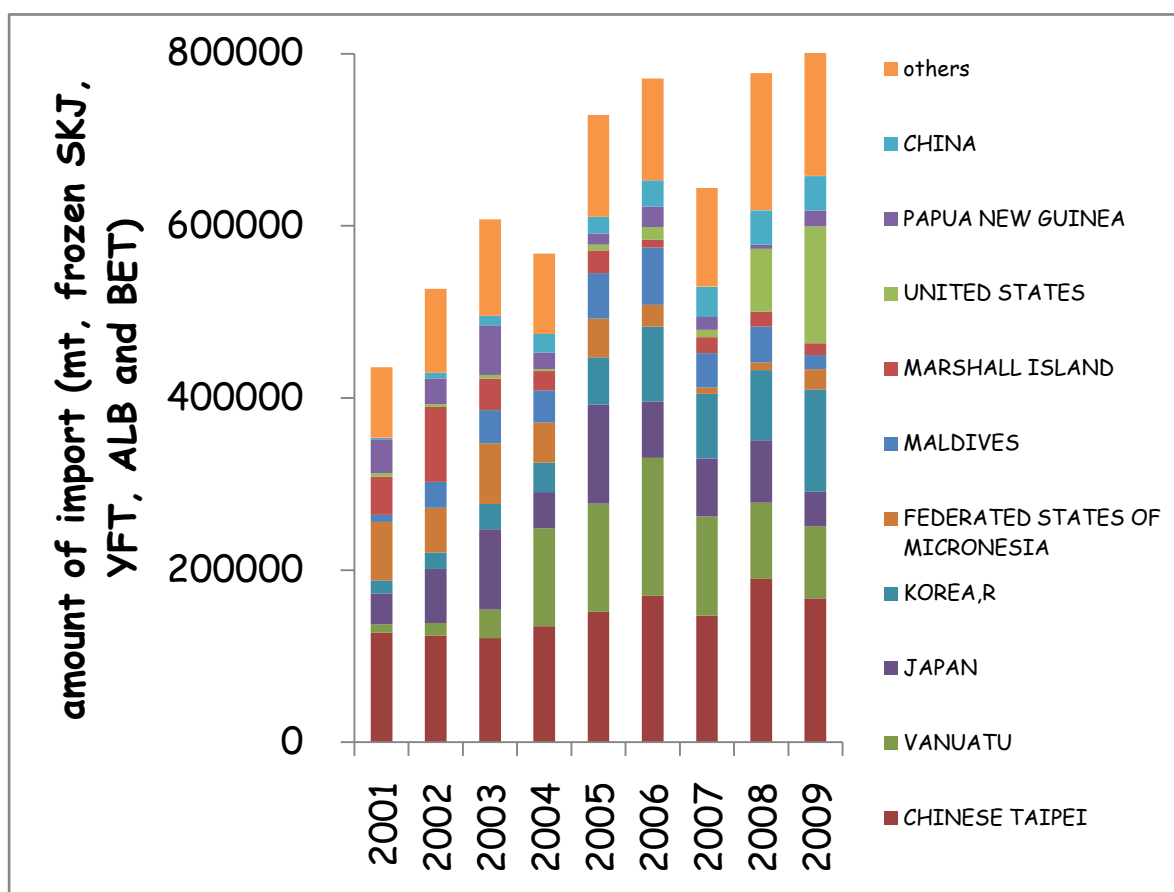


Fig. 2 Annual changes of amount of import of frozen four tuna species (skipjack, yellowfin, bigeye and albacore) by country and region. The data from the customs of Department of the Kingdom of Thai.

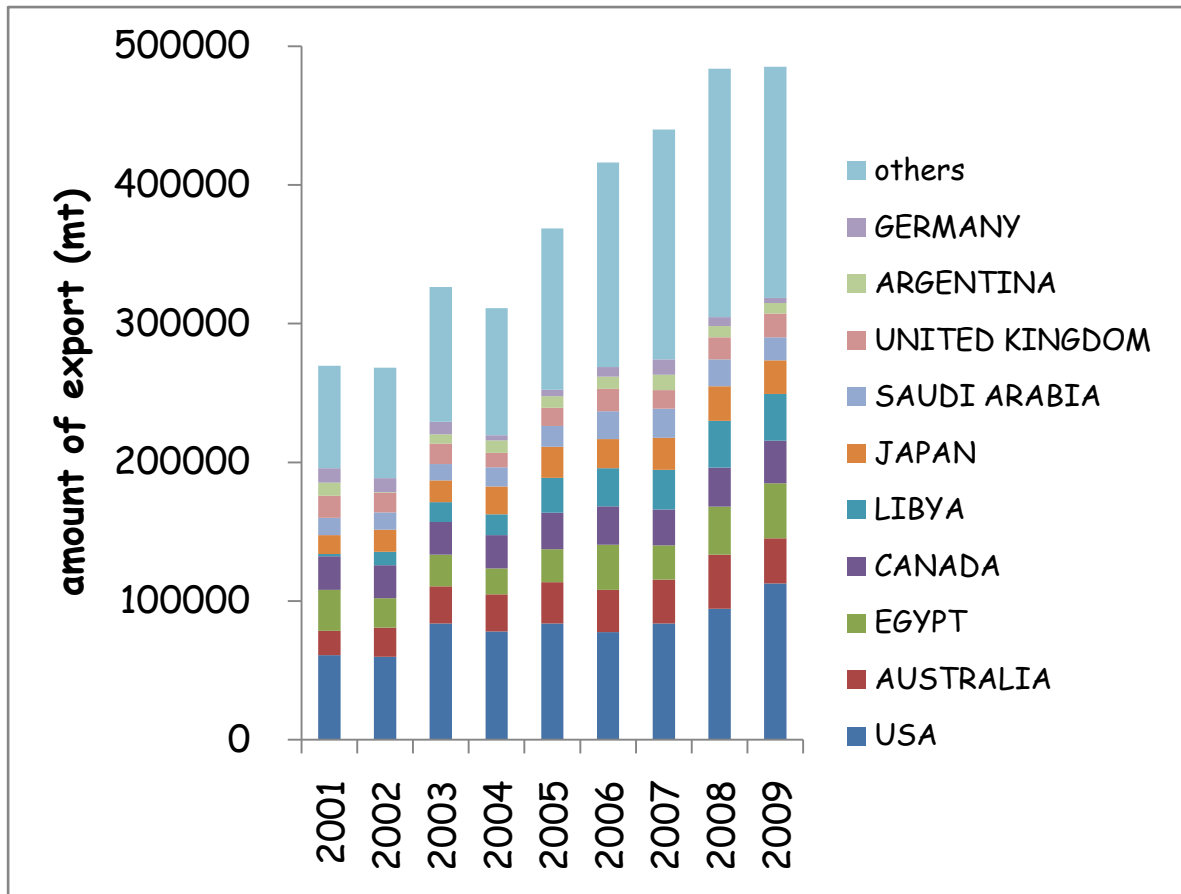


Fig. 3 Annual changes of amount of export of tuna canning by country and region. The data from the customs of Department of the Kingdom of Thai.

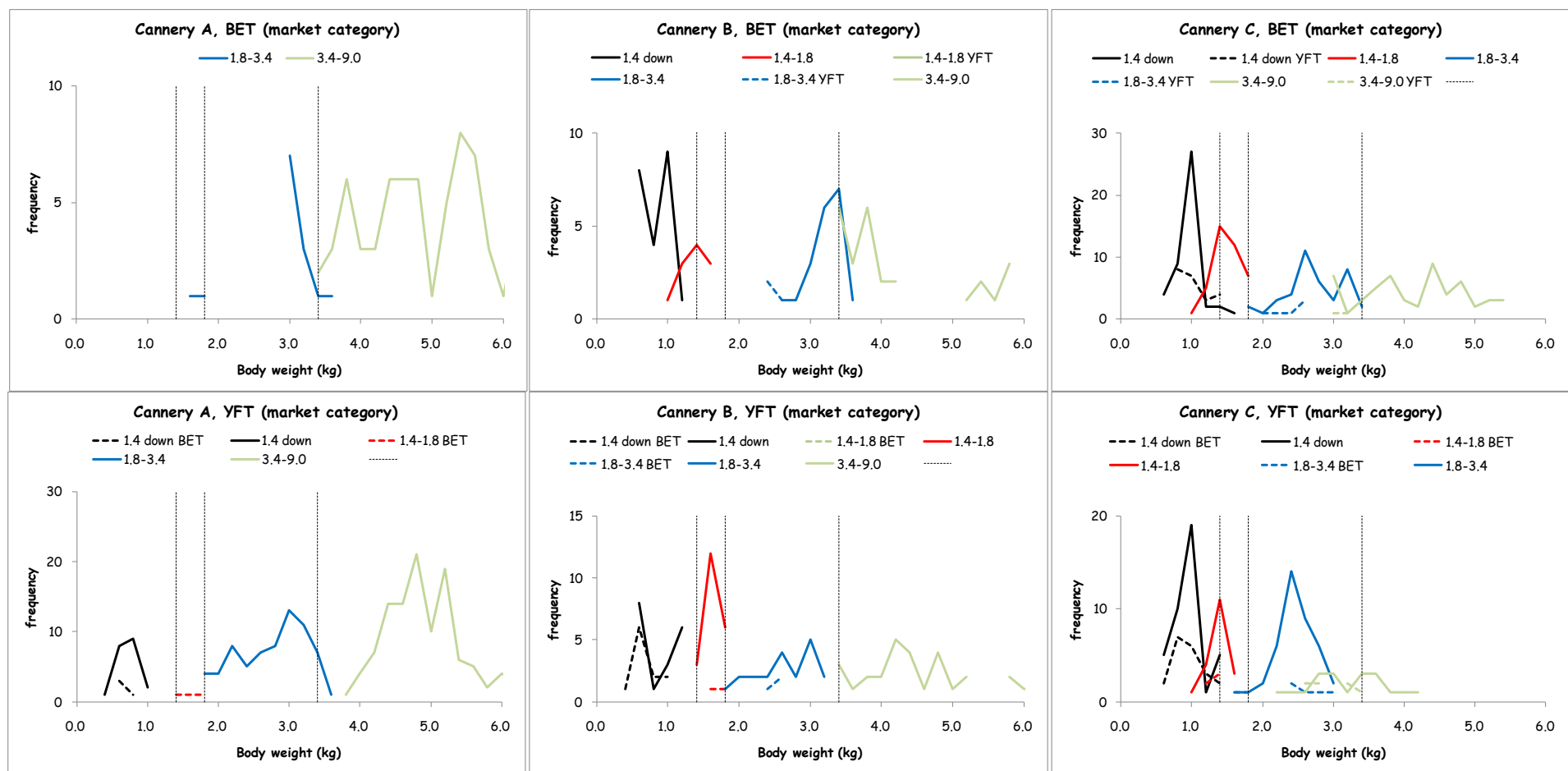


Fig. 4 Body weight distribution by species of each market category and each cannery. The straight lines in each panel show limits among the market categories.