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A SUMMARY OF THE DATA AVAILABLE FOR THE ESTIMATION OF CONVERSION FACTORS (PROCESSED TO WHOLE FISH WEIGHTS) FOR YELLOWFIN AND BIGEYE TUNA.

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Paper prepared by

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1. Introduction

Size frequency data represent an important input into the stock assessments for yellowfin and bigeye tuna in the western and central Pacific Ocean (WCPO) (Hampton et al 2005a, 2005b). For the longline fisheries, size frequency data are available both as fish lengths and fish weights. Fish weights are usually recorded as the weight of individual processed fish in the gilled-and-gutted (GG) state.

A large proportion of the weight samples are collected from the Japanese longline fleet (principally distant-water vessels) and, in more recent years, from the Taiwanese and Chinese vessels particularly from the western equatorial region of the WCPO (Table 1). For bigeye, a significant proportion of the weight samples are also collected from the Hawaiian longline fishery. The source of the various data sets is summarised in Table 2.

For inclusion in the stock assessment models, the processed (GG) weights are converted to estimated whole fish weights using a species specific conversion factor. For the 2005 assessments, a single conversion factor was applied to all recorded weight intervals (yellowfin 1.1561; bigeye 1.1018). These conversion factors were based on an analysis of processed and whole weight data collected from individual fish (Anon. 2001).

The bigeye and yellowfin stock assessments are likely to be sensitive to the conversion factors applied to the weight frequency data as the estimation of growth parameters, particularly maximum length (L_∞) will be determined by the length and weight of the largest fish observed in the samples. This in turn will influence the level of the key biological reference points for the stock.

At the first Scientific Committee meeting of the WCPFC, it was recommended that the conversion factors used to calculate whole weights for yellowfin and bigeye is reviewed. The purpose of this paper is to summarise the available information concerning processing techniques in each of the fisheries provided weight frequency data and review the appropriateness of the conversion factors for the weight data collected from individual fisheries.

2. Data sources

Conversion factors are commonly estimated by calculating the relationship between whole weight and processed weight from a dataset where pairwise observations are available from individual fish. Limited data are available for calculating yellowfin and bigeye conversion factors as the collection of these data requires accurate measurement of weights prior and post processing.

Four separate sources of data were available for computing conversion factors for both species:

I. Australian observer data.

These data were collected by Australian observers on board Japanese distant-water longline vessels operating within the area of the Australian EEZ off the east coast Australia during 1991–97. A total of 9,427 yellowfin and 3,208 bigeye were sampled. Most of the samples were collected between July and September.

II. Japanese training vessel data.

These data were collected by training vessels of Japanese fishery high schools through their longline operations during the training cruise. Their sampling area was mainly north to north-west, and south to south-west off the Hawaiian Islands (Figure 1). The number of fish sampled was 195 and 33 bigeye and yellowfin tuna, respectively. Most of samples were collected by the *Ashu-Maru* (98 bigeye and 23 yellowfin) and *Yuzan-Maru* (84 bigeye and 9 yellowfin) in 2000. Samples collected by 10 other training vessels between 2000 and 2004 are also included (13 bigeye and one yellowfin).

III. **Kaihatsu-Maru (Japanese Marine Fishery Resources Research Center)**

This sample was collected by NRIFSF staff collaborating with the staff of JAMARC during the longline operation research of the JAMARC's *R/V Kaihatsu-Maru* from June to July 1994. The sampling area was in the tropical region of the east Pacific Ocean (Figure 1). The number of fish sampled was 281 and 330 for bigeye and yellowfin, respectively.

IV. Pacific Island observer data.

These data were collected by observers on board domestic and locally-based foreign (principally Taiwanese) longline vessels operating in the Solomon Islands and federal States of Micronesia. Samples were collected by observers collecting the discarded viscera and gills following onboard processing. The offal was then weighed following landing and combined with the corresponding processed fish weight to determine the whole weight. A total of 184 fish (79 bigeye; 105 yellowfin) were sampled in January–February 1997.

Overall, the conversion factor data collected by the Australian observers represented the most comprehensive data set (Table 3). These data cover the main size range of yellowfin and bigeye caught by the longline fisheries (Figure 2 and Figure 3). In contrast, the other data sets were relatively small and covered a more limited length range of fish.

There are principally two methods of processing fish to the gilled-and-gutted states. The GG processing onboard the Japanese distant-water freezer vessels includes the removal of the tail and the operculum (gill covers) (Figure 4). Typically, most locally-based vessels landing fresh, chilled tuna only remove the viscera and gills during processing (Figure 5). Consequently, given the larger amount of processing undertaken by distant-water vessels, it is likely that a higher conversion factor is appropriate. On this basis, the three sources of data from the Japanese fleet (Australian observer, training vessel and research vessel) are appropriate for determining the conversion factors for tuna processed on board ultra-low temperature freezer vessels (distant-water vessels), while the limited amount of data from the Pacific Islands observer programme is appropriate for calculating conversion factors for the domestic and locally-based foreign vessels (i.e. those vessels landing fresh, chilled tuna).

3. Methods

Previous analysis of the Australian and Pacific Island observer data applied a linear model (with an intercept at zero) to predict the whole fish weight from the processed weight and the resultant slope was used as the conversion factor estimate (Anon. 2001). However, an examination of the fit to the model reveals a negative trend in the residuals with increasing fish size, indicating that a size specific conversion factor is more appropriate.
For each species, a non linear model was used to determine the relationship between whole weight and processed weight. The model is of the form

$$\text{whole\_weight} = \boldsymbol{a} * \text{processed\_weight}^{\boldsymbol{b}}$$

where both whole weights and processed weights are measured to the nearest kilogramme (rounded).

Separate models where derived for the Pacific Island observer data and to the cumulative data set derived from the three sources of data from the Japanese distant-water fleet. For the Japanese data, the residuals were examined to determine whether all three data sets yielded comparable fits to the data. The models were also assessed to determine whether the non linear model represented a statistically significant improvement from the simple linear model (with a zero intercept).

The conversion factor was computed for individual weight intervals; i.e., predicted whole weight divided by the processed weight.

4. Results

4.1. Yellowfin

The non linear model represented a good fit to the three sets of data from the Japanese freezer vessels (Table 4). The predicted relationship between processed weight and whole weight approximates a linear relationship with a slope equivalent to the conversion factor used in the 2005 assessment (1.1561). However, the non linear model represents significant improvement to the data.

The residuals of the model indicate a considerable variation in the processed and whole weight observations (Figure 6). This may be at least partly attributable to the level of observation error introduced by using rounded weight measurements (all weights were rounded to the nearest whole kilogramme). There are also likely to be issues regarding the accuracy of the weighing procedure on board these vessels.

Overall, there was no systematic trend in the residuals with respect to fish size (Figure 6). The model is dominated by data from the Australian observer programme. Residuals from the data collected on board the Japanese research vessel tended to have a greater proportion of positive residuals (is this a measurement/rounding issue?), while the few observations from the Japanese training vessels showed a high degree of variation than the other data (Figure 6).

The non linear model predicts a slight decline in conversion factor over the main weight range of fish sampled — the conversion factor declines from about 1.20 for a 15 kg processed weight to 1.15 for a 50 kg fish (Figure 8).

Limited data are currently available for deriving a conversion factor for fresh, chilled yellowfin (105 records only). The non linear model (Table 5) approximates a linear model with a zero intercept (Table 6), although there is a significant trend in the residuals from the non linear model. However, while the non linear model represents an improvement in the fit to the data the improvement is not statistically significant (F = 22.1, p > 10%). The resulting weight-specific conversion factor is considerably lower than for the Japanese processing data — the conversion factor declines from about 1.10 for a 15 kg processed weight to 1.07 for a 50 kg fish (Figure 8). This is considerably lower than the conversion factor used in the 2005 assessment.

4.2. Bigeye

As for yellowfin, the relationship between processed weight and whole weight for Japanese freezer vessels is approximately linear (*b* parameter close to 1.0). However, there is a significant improvement in fit to the data using a non liner model (Table 7). Nevertheless, the model residuals indicate a considerable degree of variation in the observations (Figure 7) and, again, this is likely to be largely due to the precision of the observations (nearest whole kilogramme).

A similar pattern in the residuals among datasets is evident in the bigeye model as for the yellowfin model. The model is dominated by data from the Australian observer programme. By comparison to these data, the data from the Japanese research vessel exhibited more positive residuals, while the training vessel data were much more variable (Figure 7).

The non linear model predicts a declining conversion factor with increasing processed weight and a conversion factor that is considerably higher than the value used in the 2005 assessment over the entire weight range (Figure 9). For the main weight range, the decline in conversion factor is relatively small — the conversion factor declines from about 1.22 for a 15 kg processed weight to 1.17 for a 50 kg fish.

For fresh, chilled bigeye, limited data were available to predict the relationship between processed and whole weight (n = 79). The non linear model (Table 8) approximated the linear model (with zero intercept) fitted to the data (Table 9). While the former represented an improvement in the fit to the data the improvement is not statistically significant (F = 27.4, p > 10%).

The resulting conversion factor for fresh, chilled bigeye is considerably lower than for the Japanese freezer vessels (Figure 9). The predicted conversion factor decreases with increasing processed weight from 1.15 at 15 kg (processed weight) to 1.09 at 50 kg.

5. Summary and recommendations

For the 2006 stock assessment, it is proposed to use the species specific non linear conversion factors derived for each of the two different processing types (Japanese freezer vessels and fresh, chilled vessel). These conversion factors will be applied to the weight frequency data from the respective fisheries defined in the MFCL model. The one exception is the weight data available from the longline and handline fisheries operating in Hawai'i. These fleets land small bigeye and yellowfin in the unprocessed state (whole weight) or are processed and conversion factors are applied given processing criteria.

Nevertheless, there are a number of outstanding issues to be addressed, particularly with the historical Japanese longline data. Correspondence with retired Japanese scientists revealed that prior to the introduction of the first ultra-low temperature freezer (ULT) vessels in 1966, tuna were processed to the gilled-and-gutted form with the operculum and tail retained, as per the processing style of the fresh, chilled tuna vessels. From 1980 onwards, the Japanese distant-water longline fleet was exclusively comprised of ULT vessels. For this period, the conversion factors derived from the Japanese freezer vessel data (GG, operculum and tail removed) are appropriate.

However, during the transitional period, when the ULT vessels were being introduced (1966–79), there are likely to be weight sampling data collected from vessels processing the catch in either GG state (operculum and tail removed/retained). Currently, there are no associated data available that identify the principal processing method used by the sampled vessels and it is necessary to assume a conversion factor for the weight data for the transitional period. An examination of the weight frequency data from this period reveals a decline in fish weight and the decline is probably at least partly due to a gradual shift in processing method over the fleet through the period. Further analysis of historical sampling records, if available, is required to ascertain the appropriate conversion factor for each vessel during the transitional period. In the absence of these data, as an interim measure it was decided to apply the two sets of conversion factors pre- and post-1973 — representing the mid point in the transitional period. This will undoubtedly introduce a degree of bias in the weight frequency data through the transitional period, although this is considered preferable to excluding these data from the assessments. Hopefully, this issue can be resolved in the coming year through the recovery of Japanese sampling records.

The conversion factors for fresh, chilled yellowfin and bigeye were derived from a small number of samples. Further, sampling is required to improve the estimates of the relationship between processed weight and whole weight. The presence of scientific observers on board longliners based in Pacific Island countries and territories provide the best opportunity to collect the requisite data.

A more comprehensive conversion factor data set from both the freezer vessels and fresh, chilled vessels would enable spatial and seasonal trends in conversion factor to be investigated. The current conversion factors for freezer longline vessels are dominated by data from the Japanese fleet operating in Australian waters. There are indications that these data may differ from data collected by Japanese research vessels operating in other areas. These differences may be attributable to differences in data recording or suggest differences in condition factors of both yellowfin and bigeye in different areas and/or at different times.

A further complication with the weight sampling data is the protocol used in recording the weight measurement. Most of the data sets include weights measured to the whole kilogramme, although a number of different recording schemes have been used, including rounding and truncation of the actual weight measurement. These recording protocols have been reviewed for each of the main data sets and an appropriate correction factor has been applied to these data prior to the application of the conversion factor to determine the whole fish weight (see Langley 2006).

The correction factor introduces an additional random weight in each individual fish weight; random weight to one decimal place over a 1 kg range, with the weight range dependent on the recording protocol (e.g. 0–1 kg for truncated weights, -0.5–0.5 kg for rounded weights). The introduction of this correction factor removes the potential bias introduced in the conversion of truncated processed weights to whole weights (Langley 2006) and also avoids the "saw tooth" distributions — a size frequency distribution with strong peaks and troughs at regular size intervals — generated by applying a conversion factor to weight data with low resolution.

The proposed amendments to the treatment of weight frequency sampling data outlined in this paper are likely to resolve some of the outstanding issues in the stock assessments for both yellowfin and bigeye, principally the inconsistencies in the fit to the length and weight data sets included in the respective models (Hampton et al 2005a, 2005b).

6. References

Anon. 2001. Report of the Fourteenth Meeting of the Standing Committee on Tuna and Billfish (SCTB14), 9–16 August 2001, Noumea, New Caledonia. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia

Hampton, J., P. Kleiber, A. Langley, Y. Takeuchi, and M. Ichinokawa. 2005a. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. SC1 SA WP-1.

Hampton, J., P. Kleiber, A. Langley, Y. Takeuchi, M. Ichinokawa, and M. Maunder. 2005b. Stock assessment of bigeye tuna in the western and central Pacific Ocean, with comparisons to a Pacific-wide assessment. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. SC1 SA WP-2.

Langley, A. 2006. Summary report from yellowfin and bigeye stock assessment workshop. ME WP-1, WCPFC-SC2, Manila, Philippines, 7−18 August 2006.

Table 1. Definition of fisheries for the 2005 MULTIFAN-CL analysis of WCPO bigeye and yellowfin tuna and the number of fish weight measurements.

Fishery Number	Reference Code	Nationality	Gear	Region	Number of fish sampled for weight	
					YFT	**BET**
1	LL ALL 1	Japan, Korea, Chinese Taipei	Longline	1	845,265	928,425
2	LL ALL 2	Japan, Korea, Chinese Taipei	Longline	2	40,309	191,677
3	LL HW 2	United States (Hawaii)	Longline	2	0	0
4	LL ALL 3	All excl. Chinese Taipei & China	Longline	3	2,479,224	1,756,231
5	LL TW-CH 3	Chinese Taipei and China	Longline	3	1,117,578	496,537
6	LL PG 3	Papua New Guinea	Longline	4	129,155	31,245
7	LL ALL 4	Japan, Korea	Longline	4	353,212	412,308
8	LL TW-CH 4	Chinese Taipei and China	Longline	4	0	0
9	LL HW 4	United States (Hawaii)	Longline	4	161,376	526,367
10	LL ALL 5	All excl. Australia	Longline	5	213,285	60,610
11	LL AU 5	Australia	Longline	5	311,995	145,892
12	LL ALL6	Japan, Korea, Chinese Taipei	Longline	6	2,102	2,598
13	LL PI 6	Pacific Island Countries/Territories	Longline	6	28	59
14	PS ASS 3	All	Purse seine, log/FAD sets	3	0	0
15	PS UNS 3	All	Purse seine, school sets	3	0	0
16	PS ASS 4	All	Purse seine, log/FAD sets	4	0	0
17	PS UNS 4	All	Purse seine, school sets	4	0	0
18	PHID MISC 3	Philippines, Indonesia	Miscellaneous (small fish)	3	0	0
19	PH HL 3	Philippines, Indonesia	Handline (large fish)	3	0	0
20	HL HW 4	United States (Hawaii)	Handline	4	NA	67,898

Table 2. Source of weight frequency samples included in the 2005 bigeye and yellowfin WCPO stock assessments by fishery.

Fishery Number	Reference Code	Nationality	Reference to source and comments (refer to Table 2b)
1	LL ALL 1	Japan distant-water	Note 1
		China, Chinese-Taipei, FSM, Japan, Korea, USA	Note 3, Note 4
2	LL ALL 2	Japan distant-water	Note 1
		China, Chinese-Taipei, FSM, Japan, Korea	Note 3, Note 4
3	LL HW 2	United States (Hawaii)	-
4	LL ALL 3	Japan distant-water	Note 1
		(other fleets principally Chinese Taipei, China and Japan offshore)	Note 3, Note 4
5	LL TW-CH 3	Chinese Taipei and China	Note 4
6	LL PG 3	Papua New Guinea	Note 5
7	LL ALL 4	Japan distant-water	Note 1
		(other fleets except Chinese Taipei, China and USA-Hawaii)	Note 4
8	LL TW-CH 4	Chinese Taipei and China	Note 4
9	LL HW 4	United States (Hawaii)	Note 2
10	LL ALL 5	Japan distant-water	Note 1
		Other fleets except Australia	Note 4
11	LL AU 5	Australia	Note 6
12	LL ALL 6	Japan distant-water	Note 1
13	LL PI 6	Pacific Island Countries/Territories – e.g. Fiji	Note 4
20	HL HW 4	United States (Hawaii)	Note 2

Table 2b. Details of source of weight frequency samples.

Note No.	Source and Comments of weight frequency samples
1	Individual fish weights collected from distant-water Japanese longline vessels operating throughout the Pacific Ocean. Prior to about 1966, individual fish were processed by removing the gills and guts only, and from about 1980 onwards, processing involved the removal of the gills, gill cover, guts and tail. The years from 1966 to 1980 was a transition period where former processing procedures gradually changed to the latter processing procedures within this fleet. Prior to inclusion in the stock assessments, the weight data have been adjusted in the following manner: ❑ For data with years prior to 1973, it has been assumed that fish have been processed with the removal with of gills and guts, and the weights are adjusted to whole weights. Prior to 1973 - BET : 1.2750 * [Gilled-gutted weight+random factor] ^ 0.960 Prior to 1973 - YFT : 1.1893 * [Gilled-gutted weight+random factor] ^ 0.972

Note No.	Source and Comments of weight frequency samples
	❑ For data with years after 1972, it has been assumed that fish have been processed with the removal with of <u>gills, gill covers, tails and guts</u>, and the weights are adjusted to whole weights. After 1972 - BET : 1.3264 * [Gilled-gutted-tailed weight+random factor] ^ 0.969 After 1972 - YFT : 1.2988 * [Gilled-gutted-tailed weight+random factor] ^ 0.968
2	Individual fish weight data are collected at the port of unloading in Hawaii. The fish are in processed or whole form when data are collected. Weight is recorded in pounds (lbs) rounded down to the nearest 0.5 lbs, for example, 65.0 or 65.5. Then depending on condition factor, the weight is converted at the Pacific Islands Fisheries Science Center (PIFSC to whole weight in pounds by the following six (6) conversion factors (Keith Bigelow, pers. comm.. 2 June 2006) BET whole weight: Gilled-gutted*1.16; YFT whole weight: Gilled-gutted*1.12; BET whole weight: Headed-gutted*1.25; YFT whole weight: Headed-gutted*1.22; BET whole weight: Headed-gutted-tailed*1.25; YFT whole weight: Headed-gutted-tailed*1.23; BET whole weight: Gutted*1.06; YFT whole weight: Gutted*1.06; BET whole weight: Headed*1.15; YFT whole weight: Headed*1.14; BET whole weight: Shark bitten*1.11; YFT whole weight: Shark bitten*1.11; Prior to 2004 most of the bigeye and yellowfin were landed “whole”. Since December 2004, there is a requirement (Hazard Analysis and Critical Control Point (HACCP) regulation) to process the fish as gilled and gutted if the bigeye and yellowfin are greater than 25 lbs. Other species have different weight criteria. The individual fish weight data are converted to kgs (by multiplying by 0.4536) and have a random factor added to account for the rounding to the nearest kilogram prior to use in stock assessments at SPC.
3	Packing list data provided to SPC by the Guam Department of Commerce. Weights represent gill-and-gutted processed weights. The original data contain recorded weights based on one of three methods (i) weights “truncated” down to the nearest whole kg, (ii) weights with decimal place from 0.5 and up are rounded up (weights less than 0.5 are rounded down), and (iii) weights with decimal place from 0.7 and up are rounded up (weights less than 0.7 are rounded down) (James Cushing, pers. comm. 16 May 2006). Unfortunately, it is impossible to determine which recording method has been used in the historical data. Due to the complicated nature in the recording procedures of these weight data, it was decided that all weights are assumed to be rounded to the nearest kilogram for use in stock assessments. The individual fish weight data have a random factor added to account for the rounding to the nearest kilogram, prior to use in stock assessments at SPC.
4	Individual fish weight data collected by port samplers from Pacific Island national monitoring programmes (Palau, FSM, Marshall Islands, Solomon Islands, New Caledonia, Fiji, Tonga, Cook Islands, French Polynesia). Weights represent gill-and-gutted processed weights. The original data contain a mixture of weights recorded to the nearest decimal place and weights rounded to the nearest kilogram; all weight data have been rounded to the nearest kilogram prior to use in stock assessments. The individual fish weight data have a random factor added to account for the rounding to the nearest kilogram, prior to use in stock assessments at SPC.

Note No.	Source and Comments of weight frequency samples
5	Packing list data collected by agents in PNG ports and then provided to the PNG National Fisheries Authority and then forwarded to SPC. Weights represent gill-and-gutted processed weights. The original data represent weights recorded to the nearest decimal place (Donna Asi, pers. comm. 17 May 2006). All weight data have been rounded to the nearest kilogram prior to use in stock assessments. The individual fish weight data have a random factor added to account for the rounding to the nearest kilogram, prior to use in stock assessments at SPC.
6	Individual fish weight data collected from domestic longline vessels active in the East Australia Tuna and Billfish fishery by port samplers contracted by the Australian Fisheries Management Authority (AFMA). Only weights for fish that were gill-and-gutted are recorded and entered into the AFMA weight database (Kevin Williams, pers. comm. to John Hampton, 18 April 2006). The original data have weights recorded to the nearest decimal place, however, all weight data are rounded to the nearest kilogram before provision to the SPC. The individual fish weight data have a random factor added to account for the rounding to the nearest kilogram, prior to use in stock assessments at SPC.

Table 3 Summary of the four conversion factor data sets.

Source	Number of samples		Processing state	Weight measurement
	YFT	BET		
Australian observer	9,427	3,208	GG, tail removed, gill covers removed.	Nearest kg, rounded. P.Ward, BRS, *pers. comm.*
Japanese training vessel	33	195	GG, tail removed, gill covers removed.	Nearest kg, rounded.
Kaihatsu-Maru	330	281	GG, tail removed, gill covers removed.	Nearest kg, rounded.
Pacific Island observer	105	79	GG, tail and gill covers retained.	Nearest kg, rounded.

Table 4. Summary of the non linear fit to the yellowfin conversion factor data for the Japanese freezer vessels.

Parameter	Estimate	Std.error	t-value	Pr(>|t|)
a	1.298823	0.003949	328.9	<2e-16
b	0.967869	0.000843	1148	<2e-16

Residual standard error: 1.121 on 9787 degrees of freedom.
Residual sum-of-squares: 12291.60

Table 5. Summary of the non linear fit to the yellowfin conversion factor data for the Pacific Island observer data (fresh, chilled vessels).

Parameter	Estimate	Std.error	t-value	Pr(>|t|)
a	1.189346	0.023757	50.06	<2e-16
b	0.972009	0.006089	159.63	<2e-16

Residual standard error: 0.3941 on 103 degrees of freedom.
Residual sum-of-squares: 15.9974

Table 6. Summary of the linear fit to the yellowfin conversion factor data for the Pacific Island observer data (fresh, chilled vessels).

Parameter	Estimate	Std.error	t-value	Pr(>|t|)
a	1.085182	0.001665	651.9	<2e-16

Residual standard error: 0.4307 on 104 degrees of freedom.
Residual sum-of-squares: 19.292

Table 7. Summary of the non linear fit to the bigeye conversion factor data for the Japanese freezer vessels.

Parameter	Estimate	Std.error	t-value	Pr(>|t|)
a	1.32641	0.005772	229.8	<2e-16
b	0.968651	0.001171	827	<2e-16

Residual standard error: 1.22 on 3672 degrees of freedom.
Residual sum-of-squares: 5462.643

Table 8. Summary of the non linear fit to the bigeye conversion factor data for the Pacific Island observer data (fresh, chilled vessels).

Parameter	Estimate	Std.error	t-value	Pr(>|t|)
a	1.274959	0.03523	36.19	<2e-16
b	0.960613	0.007511	127.9	<2e-16

Residual standard error: 0.9103 on 76 degrees of freedom.
Residual sum-of-squares: 62.98

Table 9. Summary of the linear fit to the bigeye conversion factor data for the Pacific Island observer data (fresh, chilled vessels).

Parameter	Estimate	Std.error	t-value	Pr(>|t|)
a	1.103402	0.003434	321.4	<2e-16

Residual standard error: 1.055 on 77 degrees of freedom.
Residual sum-of-squares: 85.69

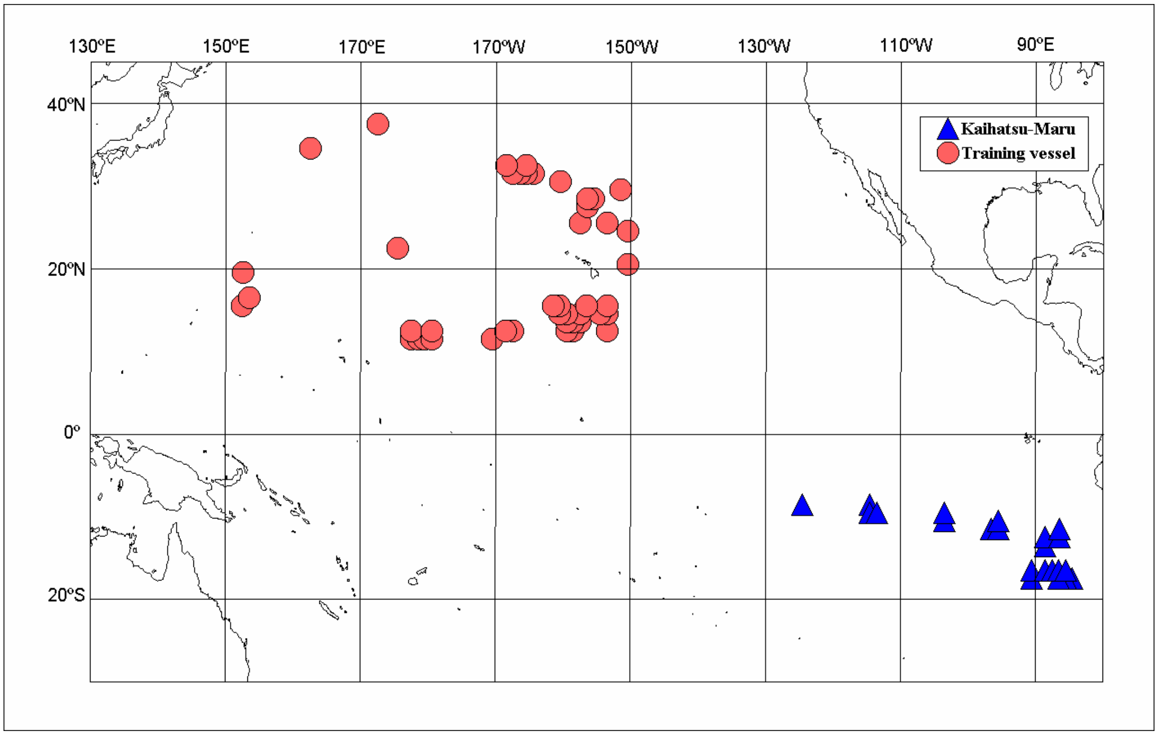

Figure 1. Location of the bigeye and yellowfin conversion factor samples collected on board Japanese training vessels and by NRIFSF staff.

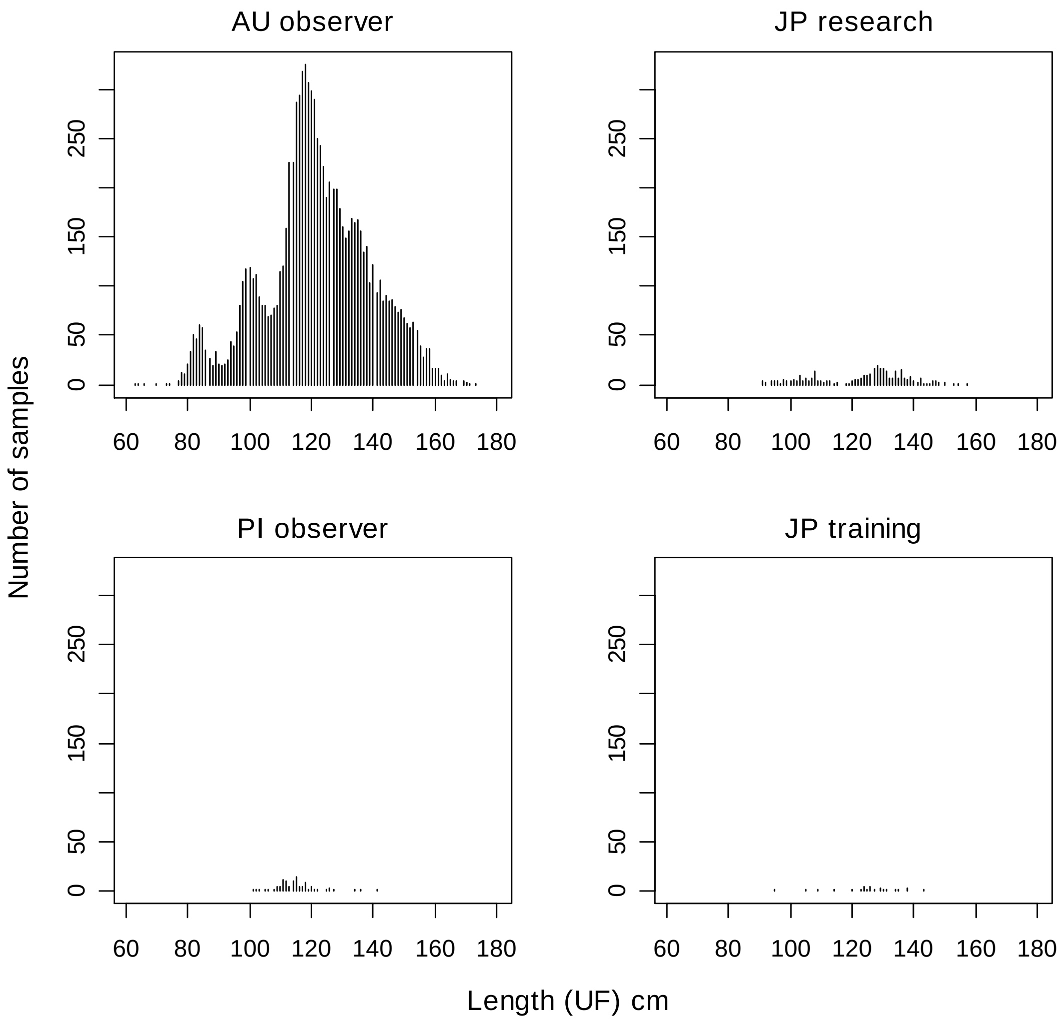

Figure 2. Length composition of the yellowfin conversion factor samples included in each data set.

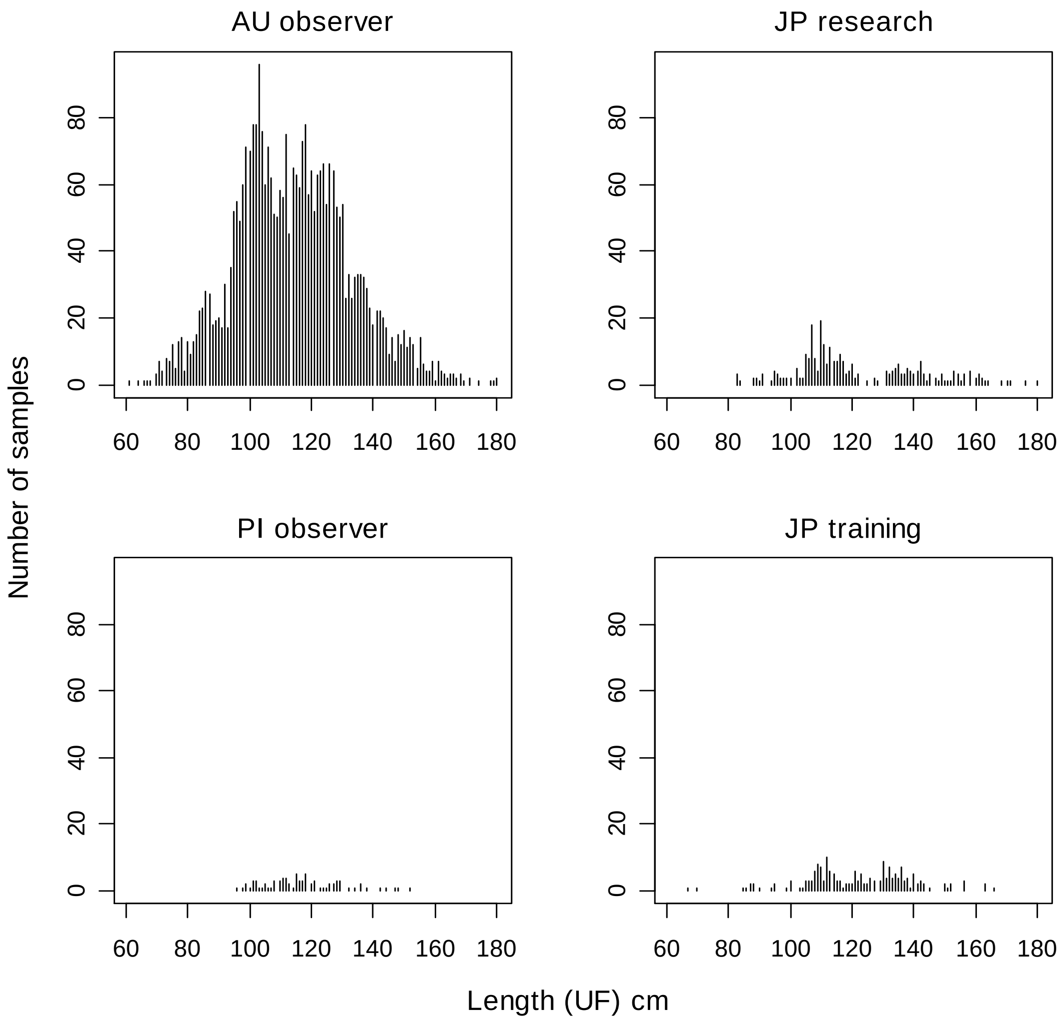

Figure 3. Length composition of the bigeye conversion factor samples included in each data set.

Figure 4. Photograph illustrating gilled-and-gutted processing conducted by Japanese distant-water freezer vessels. Note the removal of the gill covers and tail. (Photo courtesy of Fabrice Bouyé, OFP).

Figure 5. Photograph illustrating gilled-and-gutted processing conducted by locally-based longline vessels. Note gill covers and tail are retained. (Photo courtesy of Peter Sharples, OFP).

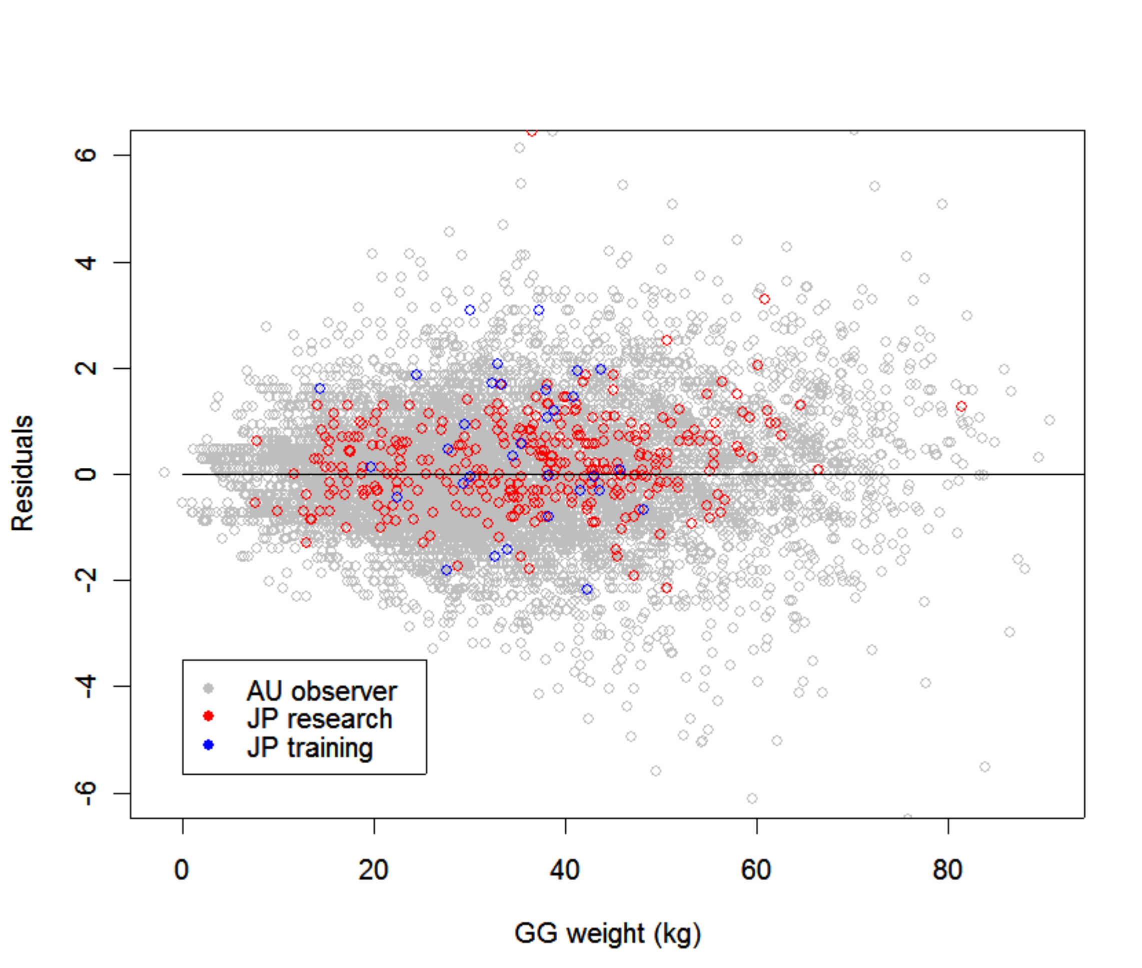

Figure 6. Residuals (observed - expected) of the fit between processed (GG) weight and whole weight for yellowfin from the three Japanese datasets combined.

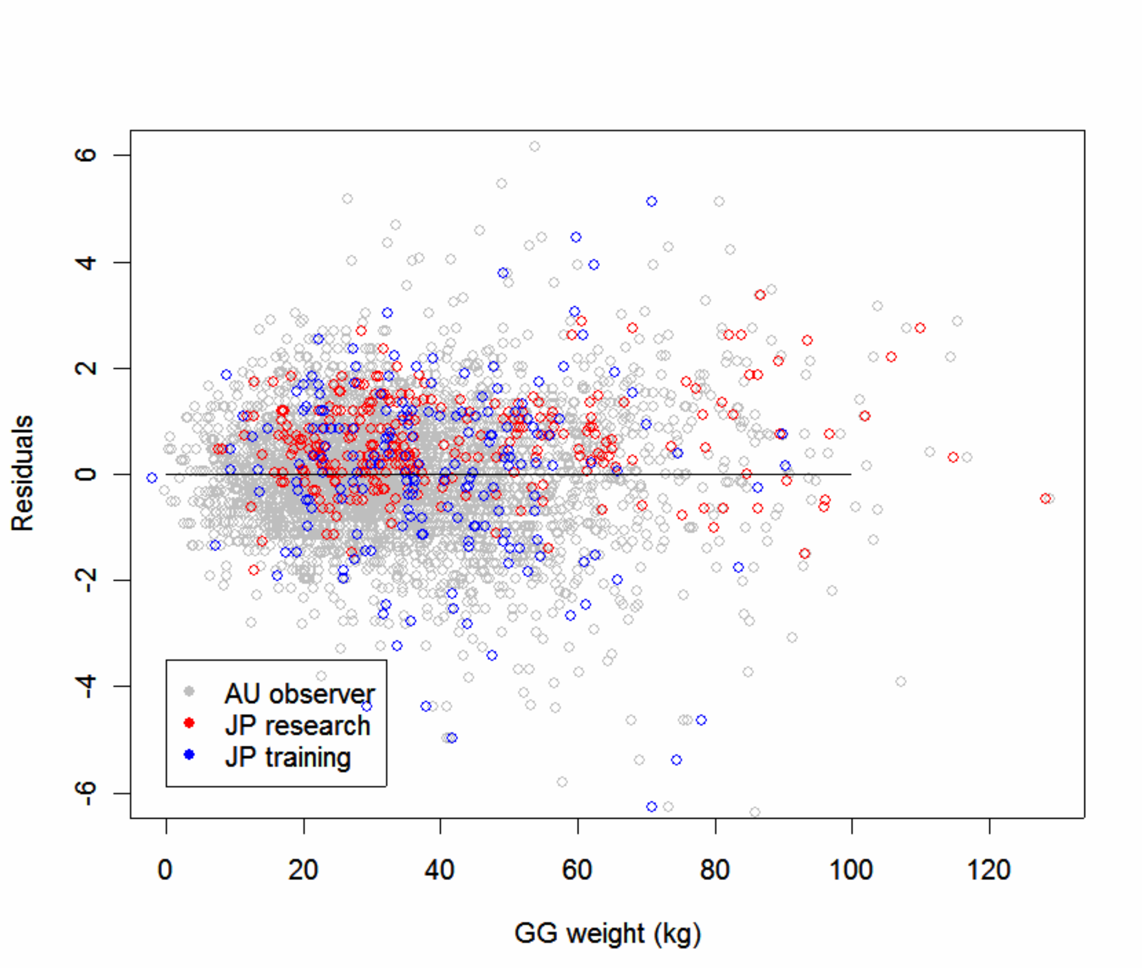

Figure 7. Residuals (observed - expected) of the fit between processed (GG) weight and whole weight for bigeye from the three Japanese datasets combined.

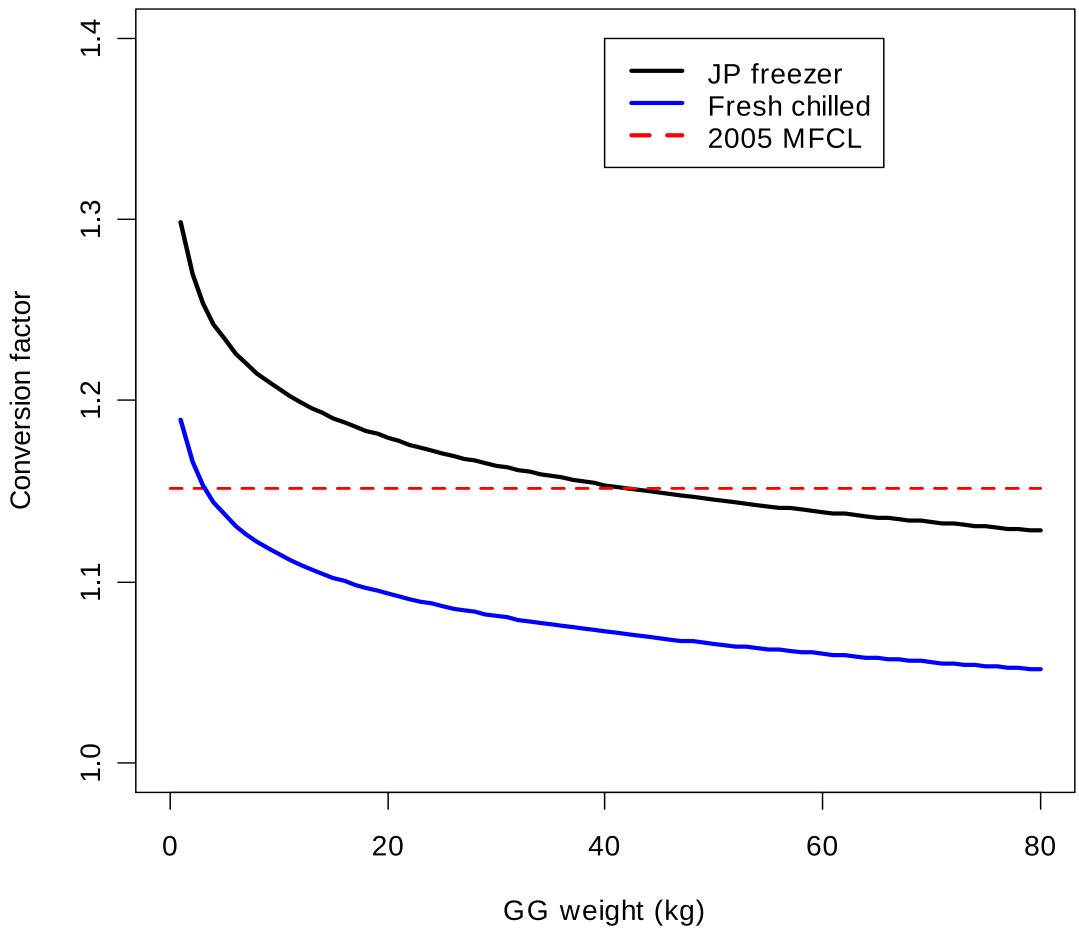

Figure 8. Estimated weight specific conversion factor for yellowfin for Japanese distant-water vessels (freezer) and fresh, chilled tuna. For comparison the conversion factor used in the 2005 stock assessment is also plotted.

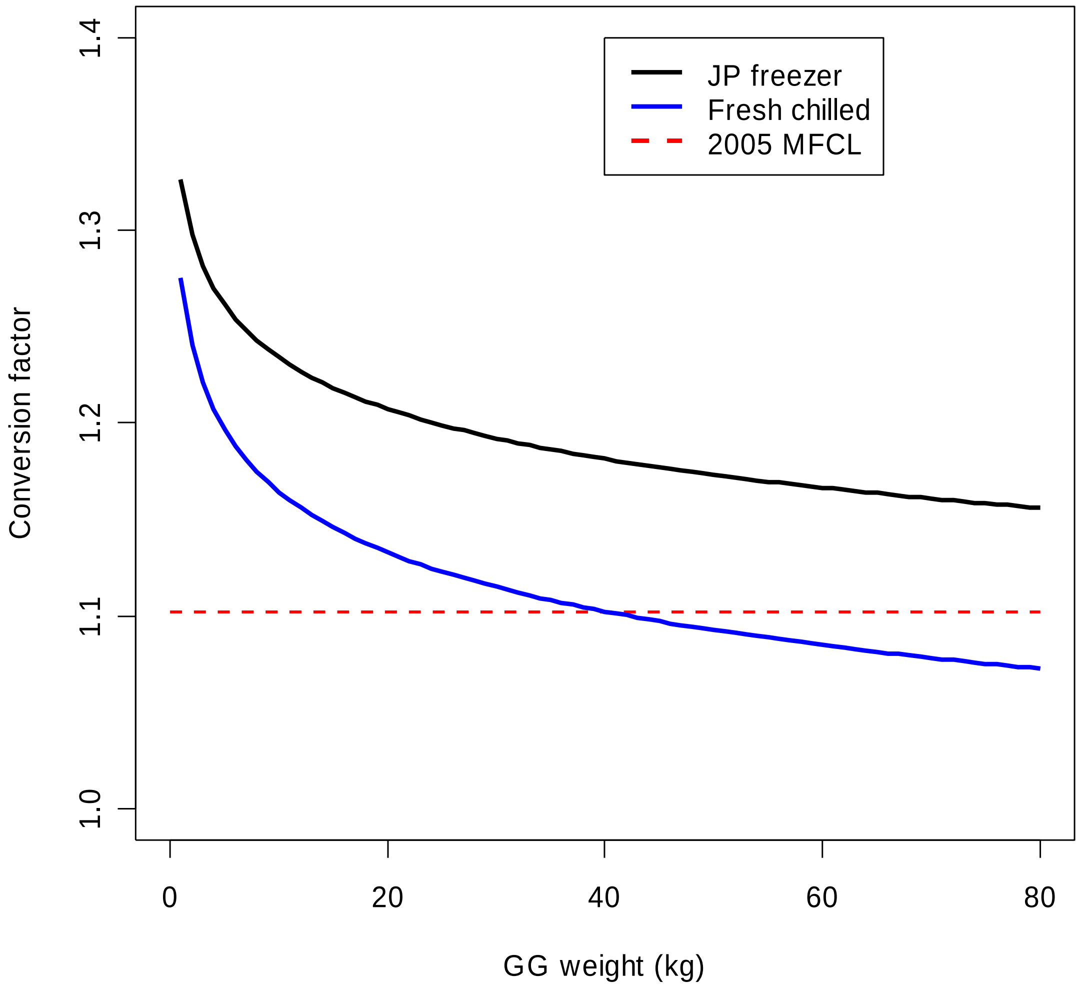

Figure 9. Estimated weight specific conversion factor for bigeye for Japanese distant-water vessels (freezer) and fresh, chilled tuna. For comparison the conversion factor used in the 2005 stock assessment is also plotted.