Consideration on the difference of average weight by estimation method for tunas caught by Japanese longline in the Indian Ocean

by
Takayuki Matsumoto

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

Summary

The reason for the difference of average weight of tunas caught by Japanese longline in the Indian Ocean between by catch and effort data and by size data was considered. Overview of size sampling and estimation of average weight of fish in creating catch and effort data by Japanese longline is also described. The difference of average weight of the fish based on estimation method seems to be caused by the combination of (1) estimation process of average weight for catch and effort data which include substitution of size data, (2) difference of weight of the fish induced by slight difference of fish length, (3) potential difference of length-weight relationship used and (4) insufficient size sampling. Considering these issues, it seems to be not unnatural that such a difference of average weight occurs.

1. Introduction

Longline is main fishing method by Japanese vessels to catch tunas and tuna-like species in the Indian Ocean, and has been being operated since 1950s. Size data by Japanese longline are used not only for input data or age slicing for stock assessment models but also for estimating average weight of the fish for estimating total amount of catch in weight. One concern for Japanese longline catch and effort (CE) and size data is that there is some difference of average fish weight between by size sample data and by CE data. Therefore, 2015 IOTC WPDCS11 report says, "*the WPDCS REQUESTED that this work is undertaken in collaboration with the IOTC Secretariat, to understand the lack of coherence in the historical time series between the size frequency data, catch-and-effort and nominal catch reported by Japanese longline vessels*". Although collaborative work has not yet been conducted mainly due to resource issues, some possible causes for the difference of average weight are considered and described.

2. Overview of the situation of concern and size data for Japanese longline fishery

In this document, although detailed analysis was not conducted (some of the results were referred from past documents), some possible causes for the difference of average weight between by size sample data and CE data were listed and considered.

2.1 Difference of average weight

Fig. 1 shows historical trend of average weight of three tuna species caught by Japanese longline in the Indian Ocean by estimation method with the difference of the two. Up to more or less 10kg of difference is observed for yellowfin and bigeye tuna, and up to more or less 5kg of difference for albacore. As for average weight based on catch and effort data, total catch in weight divided by total catch in number was calculated for each year. Catch and effort data and size data submitted to IOTC from Japan was used. Catch and effort data were originally from Japanese logbook database that has been compiled at National Research Institute of Far Seas Fisheries (NRIFSF) based on the logbooks mandatory submitted by the fishermen of the longline vessels larger than 20 gross ton (GRT). As for average weight based on size data, the weight for individual fish converted from length to round weight and converted from product weight (gilled and gutted, except for albacore) to round weight was averaged. The equations shown below were used for conversion.

Convert from length to weight:
Bigeye tuna: $W=1.799*10^{-5}*L^{3.0415}$
Yellowfin tuna: $W=1.062*10^{-5}*L^{3.1268}$
Albacore: $W=1.3718*10^{-5}*L^{3.0793}$

Convert from product weight (gilled and gutted) to round weight:
Bigeye tuna: W=GGT*1.13
Yellowfin tuna: W= GGT*1.13

where L is fork length in cm, W is body weight in kg, and GGT is product weight (gilled and gutted) in kg.

2.2 Size data for Japanese longline

Size sampling of the fish caught by Japanese longline fishery in the Indian Ocean is mainly made by onboard measurement by crew members of commercial vessels, onboard measurement by training vessels and onboard measurement by scientific observers on the commercial vessels. Size data for bigeye, yellowfin and albacore tuna caught by Japanese longline fishery are collected and compiled at NRIFSF and are available from 1965 onward. The data include period (date or month), location (the resolution differs depending on the record, but usually equal to or higher than 5° latitude ×10° longitude for on board measurement of longline fishery), sampling method (onboard measurement by crew members of commercial vessels, onboard measurement by training vessels, onboard measurement by scientific observers on the commercial vessels, and so on), measurement unit, and so on.

Observer program for Japanese longline vessels in the Indian Ocean started in 1992, which has been being conducted in response to the recommendation by CCSBT. The operations mainly in the fishing grounds for southern bluefin tuna (SBT) are monitored, but other areas such as tropical and subtropical areas in the Indian Ocean are also covered when the vessels have reached individual quota of SBT. Not only SBT but also other species including other tunas are measured by scientific observers.

Fig. 2 indicate annual change in number of size data by species and sampling category. Fig. 3 - Fig. 5 show geographical distribution of size sampling by sampling methods for bigeye, yellowfin and albacore, respectively. As for yellowfin and bigeye tuna, most of the size data were collected by training vessels during 1970s and mid-1980s, by both commercial and training vessels comparatively equally between late 1980s and early 1990s, mainly by commercial vessels between mid-1990s and early 2000s, and mainly by scientific observers especially as for bigeye tuna from mid-2000s onward. As for albacore, the fish were mainly measured by training vessels until around 1990, by each method comparatively equally during 1990s, and mainly by scientific observers after that. Sampling rate is usually around or less than 10% except for a part of period, and is very low in recent years.

3. Possible cause of the difference of average weight

3.1. Difference of fish size based on sampling protocol

Although the main component of size data source changes over the period as mentioned above, Matsumoto (2013a; 2013b) reported that fish size was similar among sampling methods (Fig. 7-Fig. 12). Therefore, change in sampling protocol may not be main reason for the difference of average weight, although slight difference of fish size and/or difference of sampling area may cause slight difference of average weight.

3.2. Estimation for average weight

In Japanese longline catch and effort database, method of estimation of average weight of the fish differs depending on period. Before 1993, when catch in weight was not available from logbook data, average weight for estimating catch in weight was calculated based on size data and aggregated for each by 2 month interval, 5x10 latitude-longitude (“Level 1”), average weight by annual and 10x20 latitude-longitude (“Level 2”), and annual ocean-wide (“Level 3”). If average weight in the corresponding strata was not available, average weight was substituted based on the following priority:

1. Neighboring area with the same latitude (eastern side) in the same two months interval (Level 1 average weight table).
2. Neighboring area with the same latitude (western side) in the same two months interval (Level 1 average weight table).
3. Average between neighboring areas which are north and south to the original stratum in the same two months interval (Level 1 average weight table).
4. Annual average weight by 10x20 latitude and longitude (Level 2 average weight table).

5.-7. The same procedures as above 1-3 but for Level 2 average weight table.

8. Annual ocean wide average weight (Level 3 average weight table).

However, no detailed procedure for estimation method conducted before 1993 is recorded.

As for the period from 1994 onward, when both catch in number and weight are available from logbook data, average weight was calculated based on the number and weight of the catch from logbook data.

Considering the procedure for estimating average weight, the difference of the weight between estimation methods may have caused by insufficient size data, non-equal distribution of size sampling and/or substitution process of average weight. As shown in Fig. 7-Fig. 12, fish size is usually similar among areas but there is slight difference. That may cause of some bias in estimating average weight which includes substitution process.

3.3. Difference of weight induced by slight difference of length

Table 1 shows body weight at length for three tuna species calculated by length-weight relationship shown above. This indicates that even 5cm difference of fish length leads to 5kg or larger difference of fish weight for middle size or large fish.

3.4. Difference of length-weight relationship

This may be a cause of comparatively consistent (systematic) difference of the weight based on estimation method. However, now we cannot find the information on the equation used for calculating average weight to create catch and effort data.

3.5. Insufficient sample size for size data

As shown in Fig. 2, the coverage of size sampling for Japanese longline is not high and usually less than 10%. In this situation, it may be difficult to precisely estimate average weight of the fish. In conjunction of the issues mentioned in the subsections 3.3 and 3.4, difference of average weight of fish based on estimation method may inevitably occur.

4. Discussion

The difference of average weight of the fish may have occurred based on the combination of the components mentioned in this document. The procedure for estimating average weight from size data made by IOTC secretariat may differ from that for estimating average weight for catch and effort data conducted by Japan. This may also be one of the reasons for disagreement of fish weight.

5. References

Matsumoto, T. (2013a) Comparison of size data and average weight for bigeye and yellowfin tuna caught by Japanese longline in the Indian Ocean based on different sampling or estimation methods. IOTC–2013–WPTT15–22, p.18.

Matsumoto, T. (2013b) Comparison of fish size and average weight for tunas caught by Japanese longline in the Indian Ocean based on different sampling or estimation methods. IOTC–2013–WPDCS09–09, p.25.

Table 1. Body weight of three tuna species calculated from length-weight relationship (for equations, see text).

Fork length in cm	Body weight in kg		
	BET	YFT	ALB
80	11	11	10
85	13	13	12
90	16	15	14
95	19	18	17
100	22	21	20
105	25	24	23
110	29	28	27
115	33	31	30
120	38	36	35
125	43	40	
130	48	46	
135	54	51	
140	61	57	
145	67	63	
150	75	70	
155	83	77	
160	91	85	
165	100	94	
170	109	102	
175	119	112	
180	130	122	

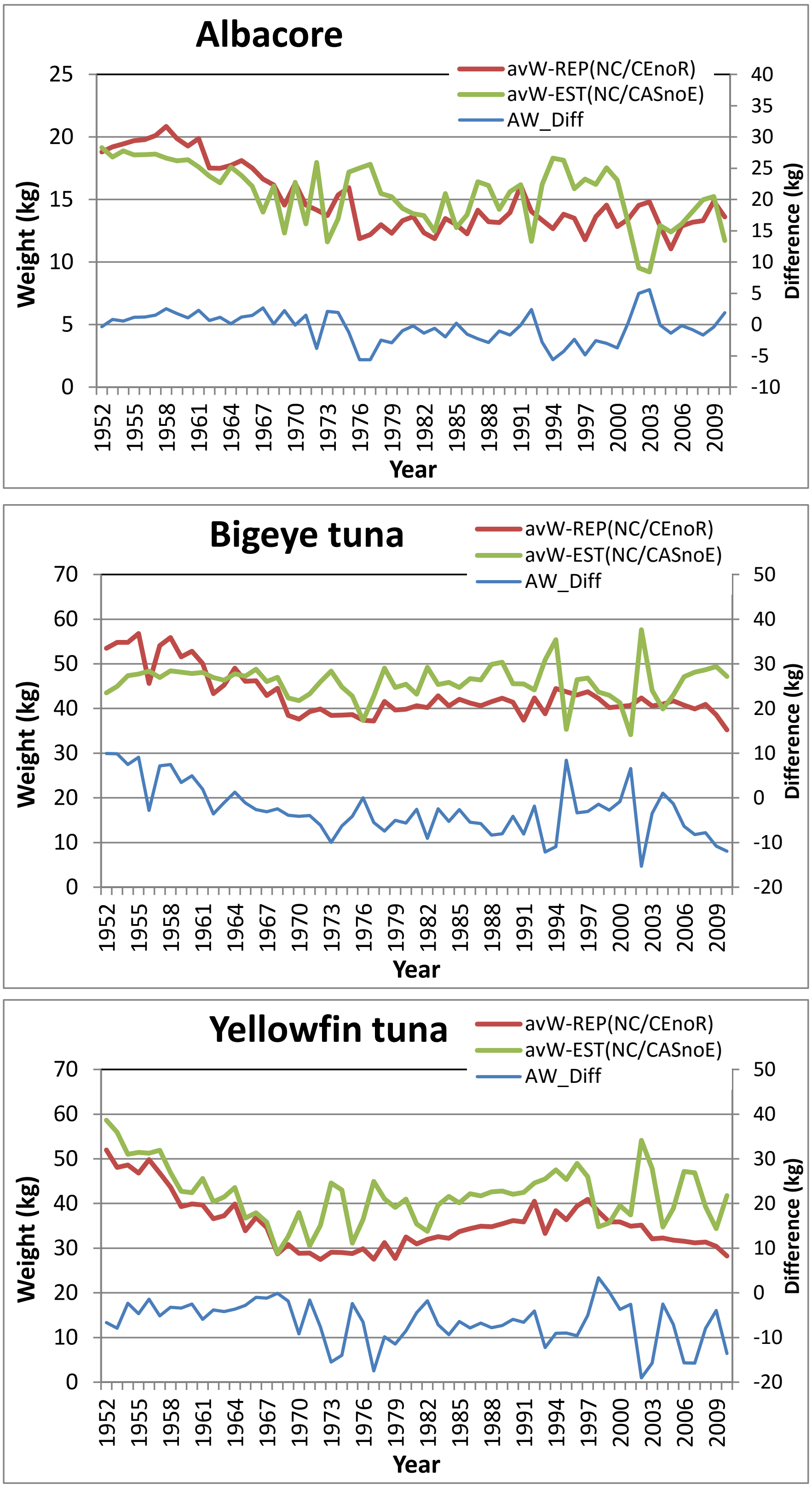

Fig. 1. Comparison of annual average weight of albacore, bigeye and yellowfin tuna caught by Japanese longline fishery based on catch and effort and size data. “avW-REP(NC/CEnoR)”: average weight of the fish estimated using the total weight recorded as nominal catch divided by the number of fish recorded in CE. “avW-EST(NC/CASnoE)”: average weight estimated by the IOTC Secretariat using the available NC, CE, and SF data for each fleet and year (from Matsumoto, 2013b).

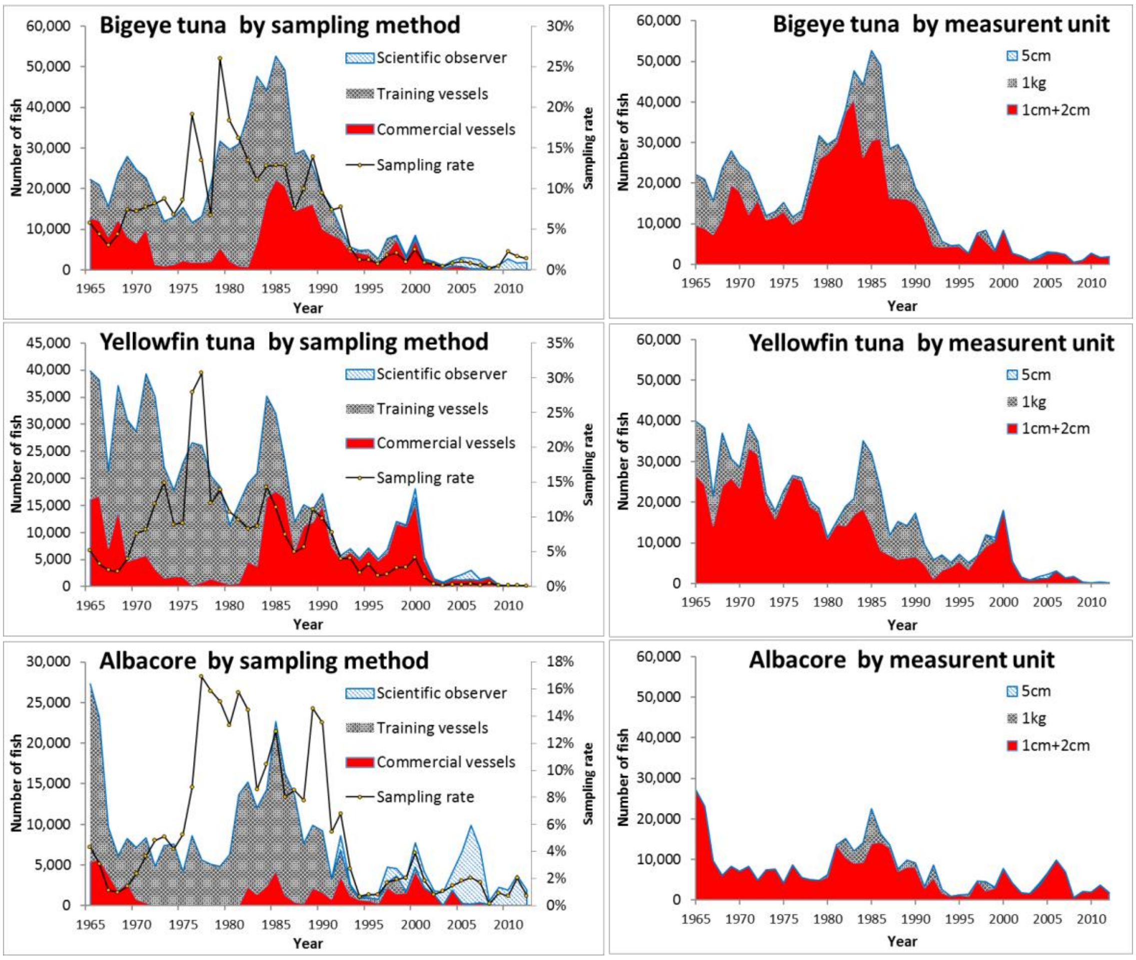

Fig. 2. Annual change in the number of size data by Japanese longline fishery. Left: by sampling category, right: by measurement unit. Note: calculation for sampling rate does not include catch by training vessels, and so actual sampling rate is lower.

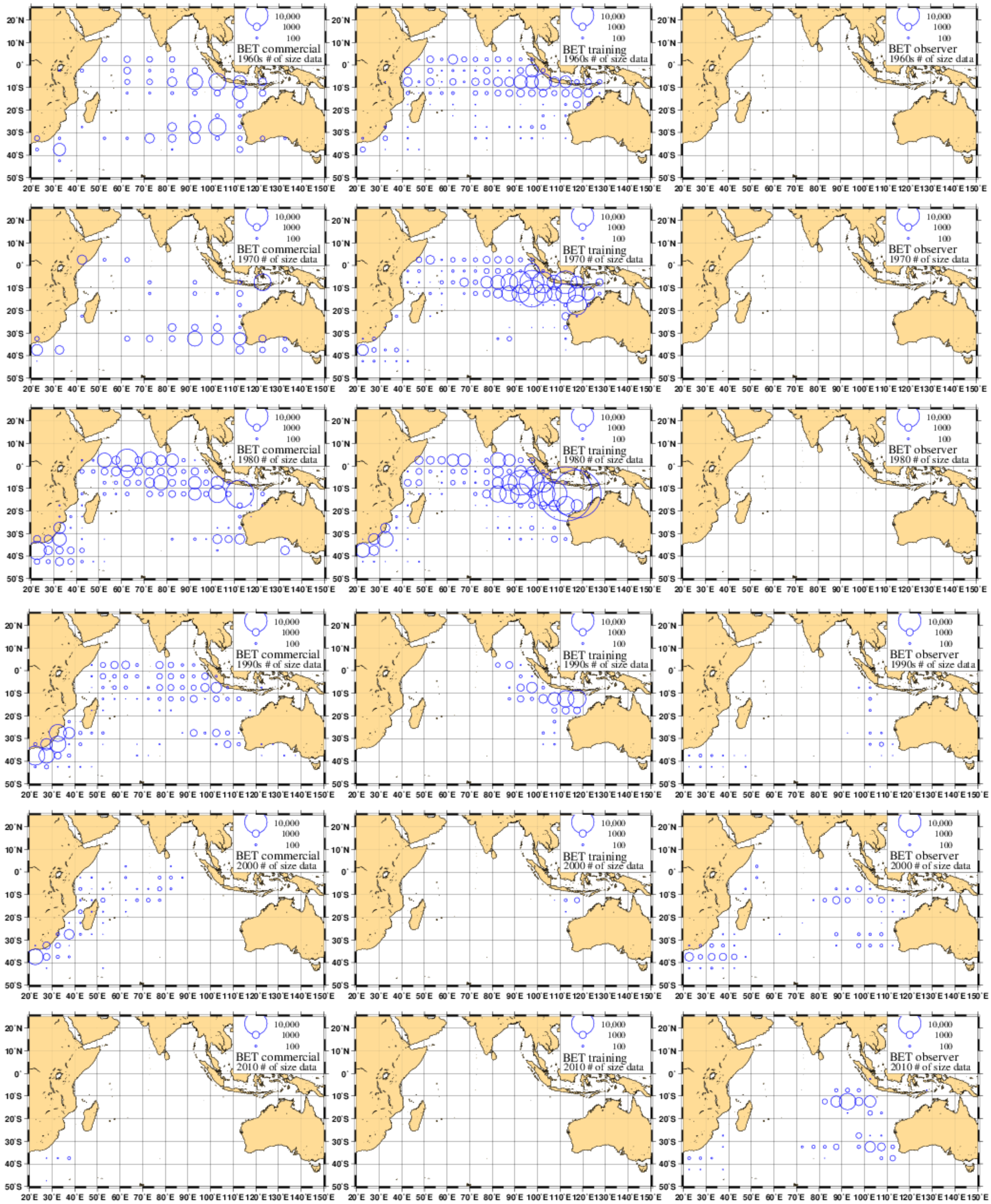

Fig. 3. Geographical distribution of size sampling (annual average for number of fish) for bigeye tuna by sampling method and decade.

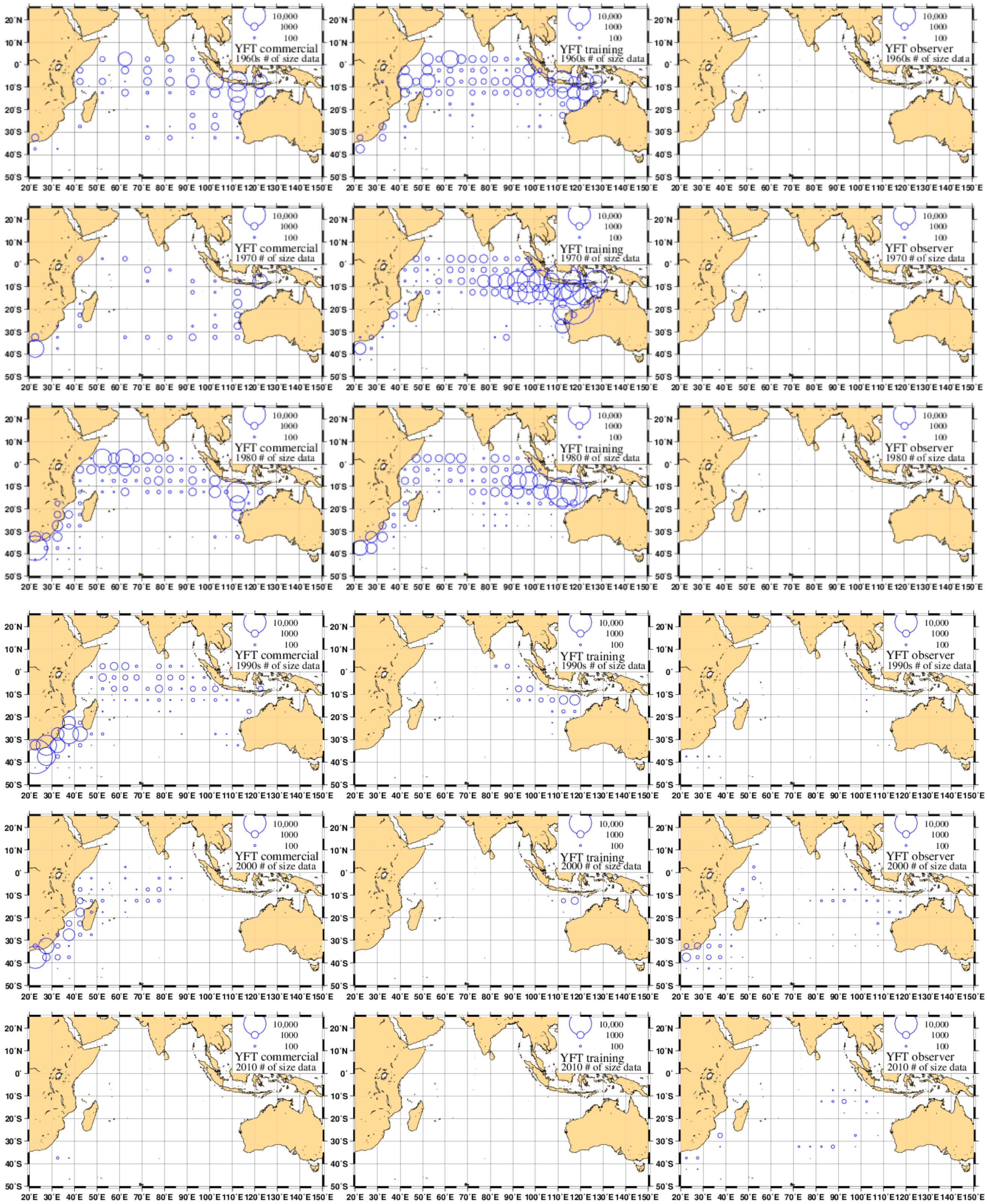

Fig. 4. Geographical distribution of size sampling (annual average for number of fish) for yellowfin tuna by sampling method and decade.

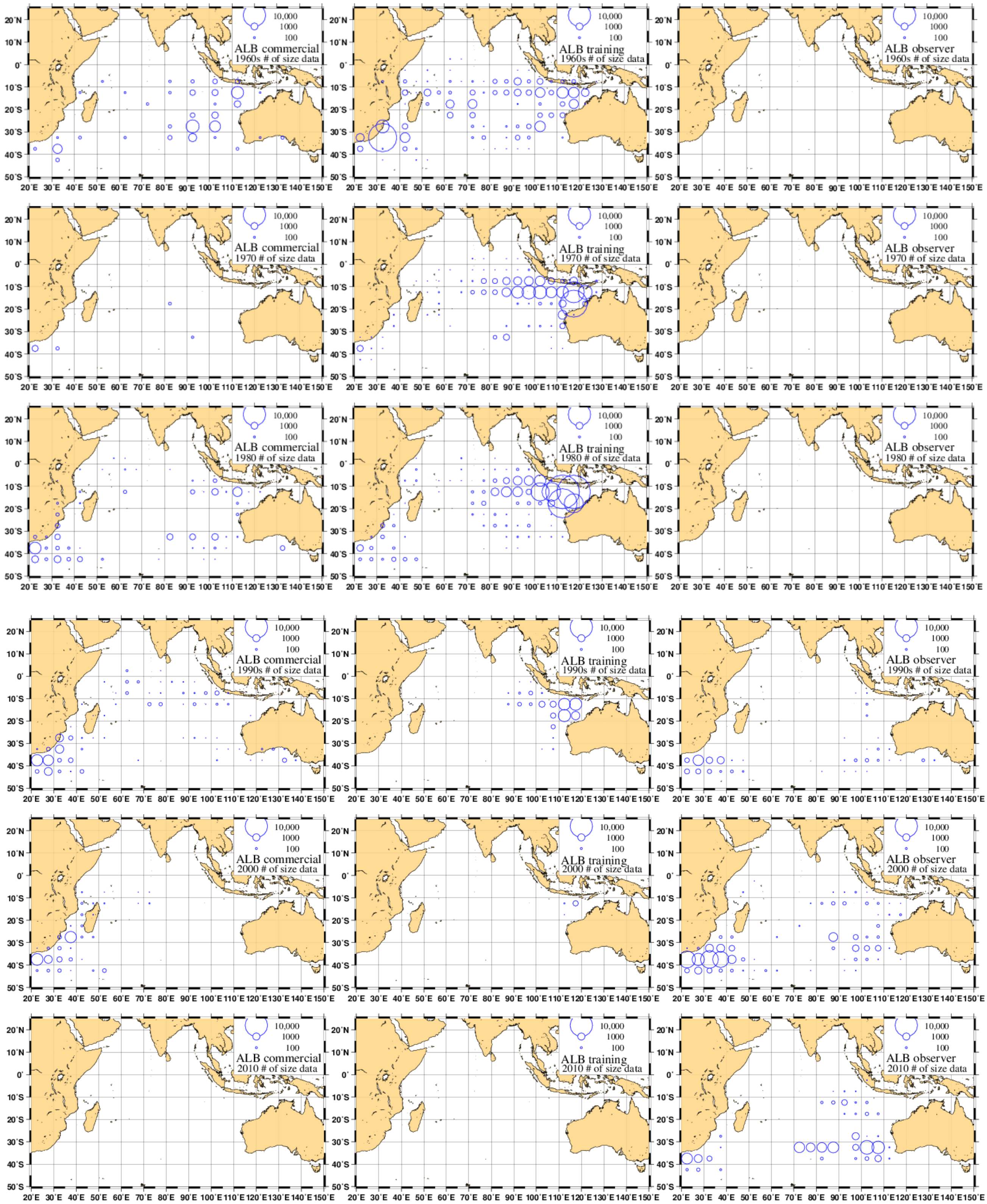

Fig. 5. Geographical distribution of size sampling (annual average for number of fish) albacore by sampling method and decade.

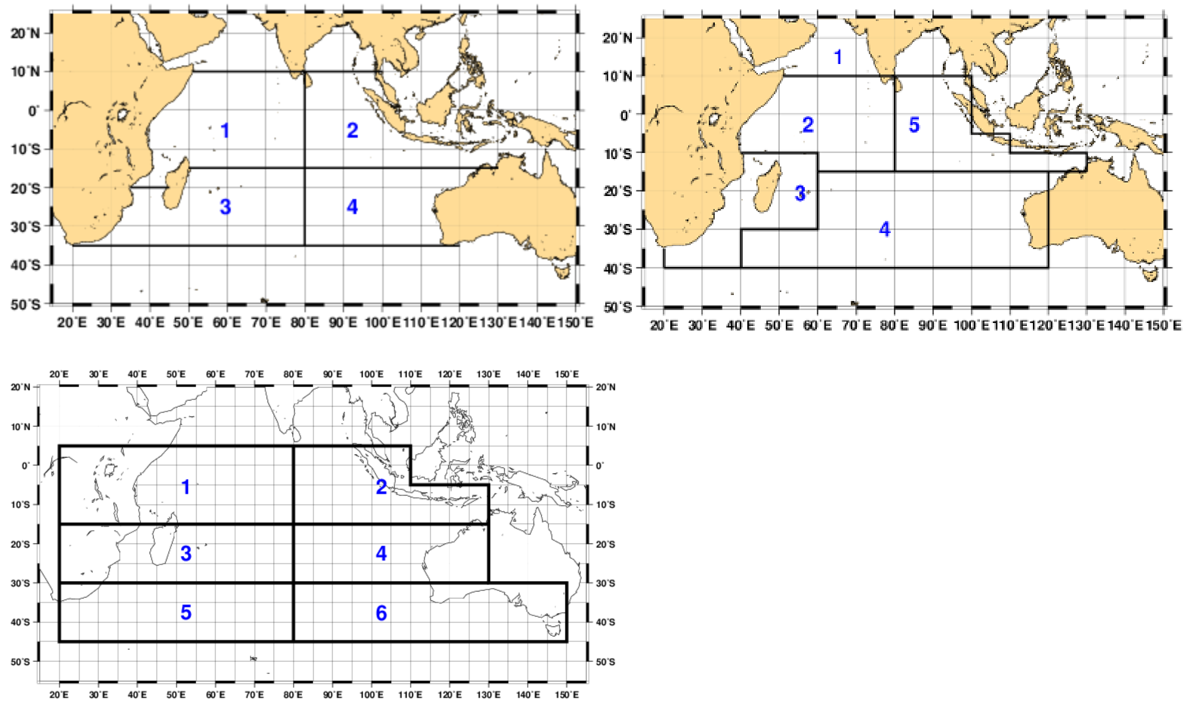

Fig. 6. Area definition to compile the length data for bigeye (upper left), yellowfin tuna (upper right) and albacore (bottom) made by Matsumoto (2013a; 2013b) (from Matsumoto, 2013b).

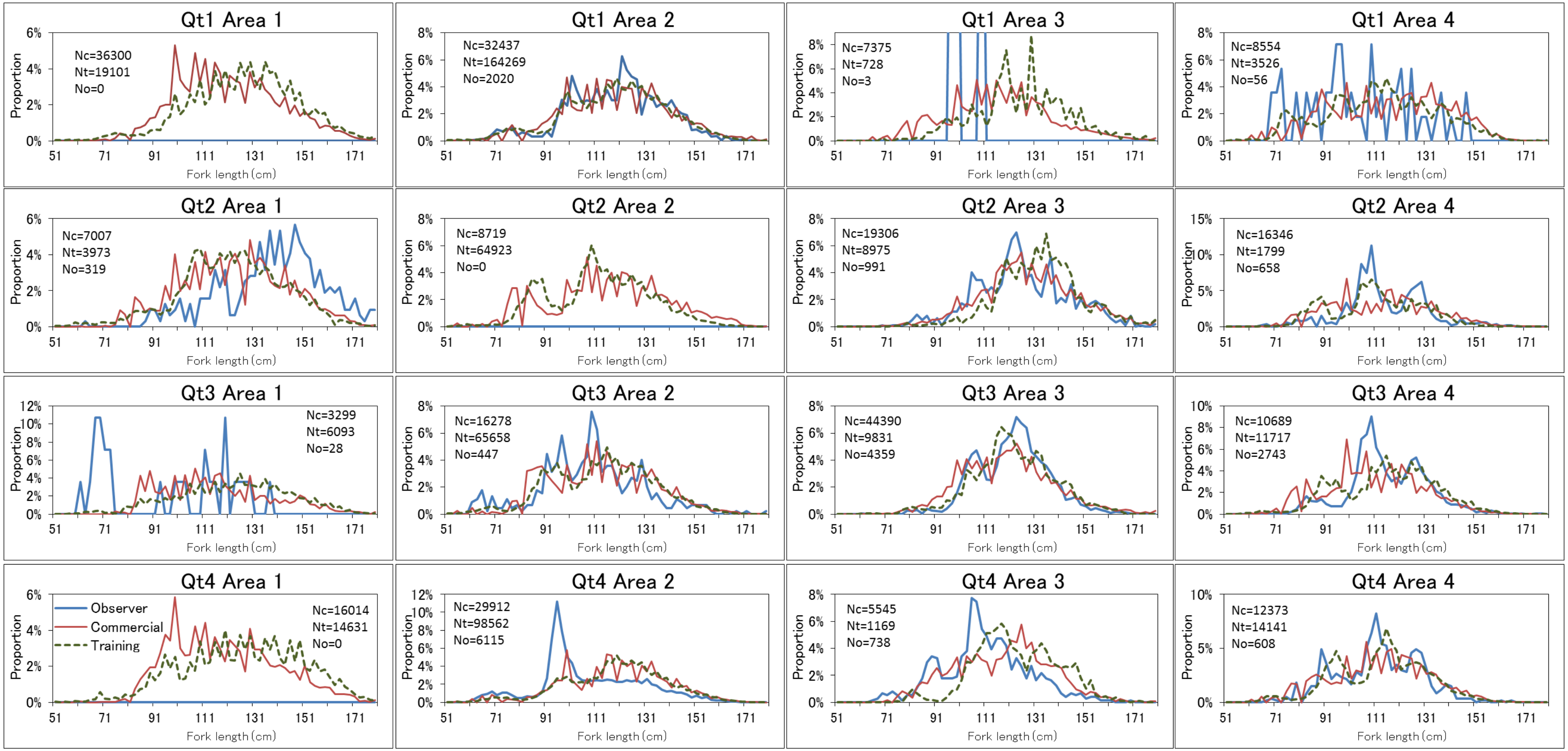

Fig. 7. Length frequency of bigeye tuna in the Indian Ocean caught by Japanese longline by quarter and area. Nc, Nt and No indicate number of fish for commercial vessels, training vessels and scientific observer, respectively (from Matsumoto, 2013b).

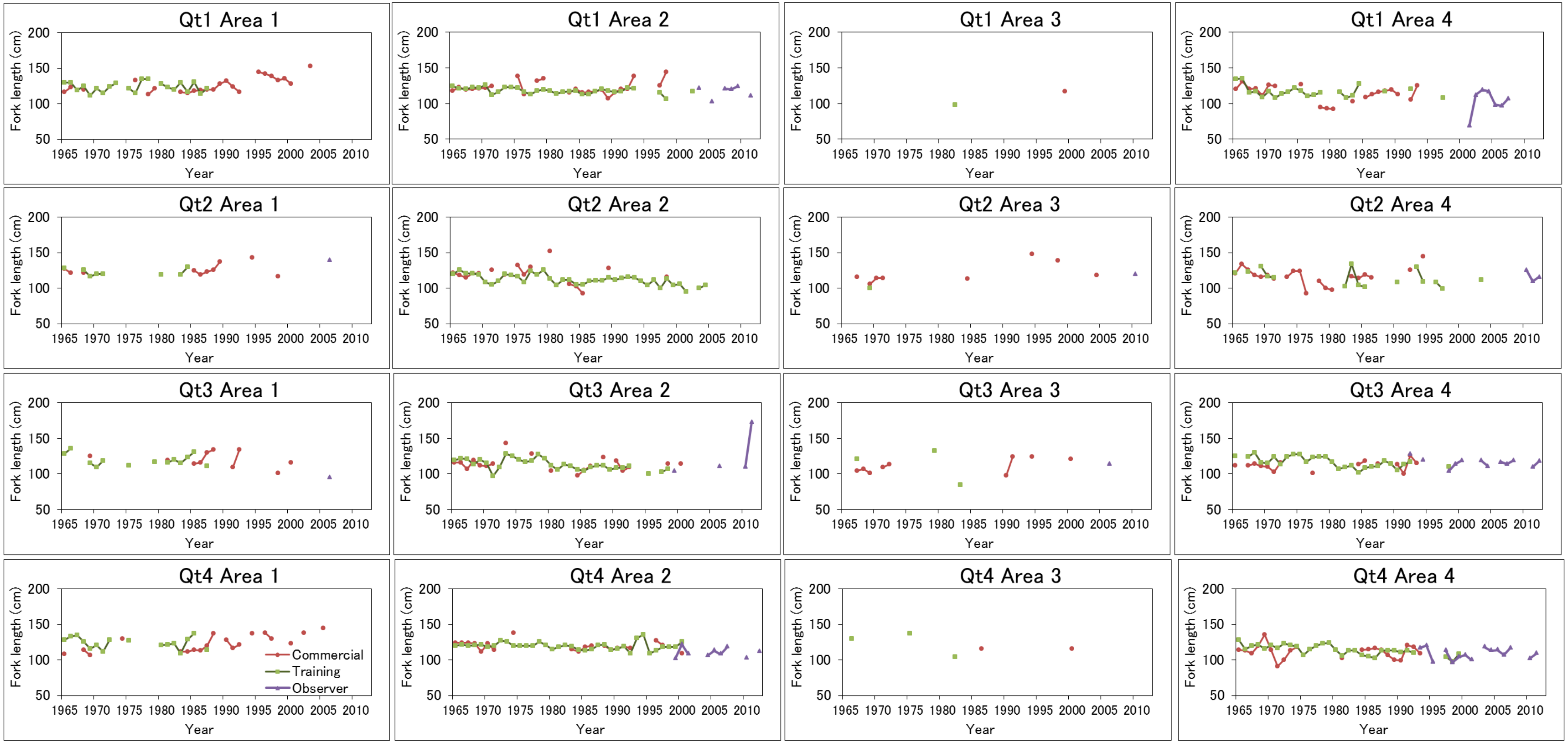

Fig. 8. Annual change in average length of bigeye tuna in the Indian Ocean caught by Japanese longline by quarter and area (from Matsumoto, 2013b).

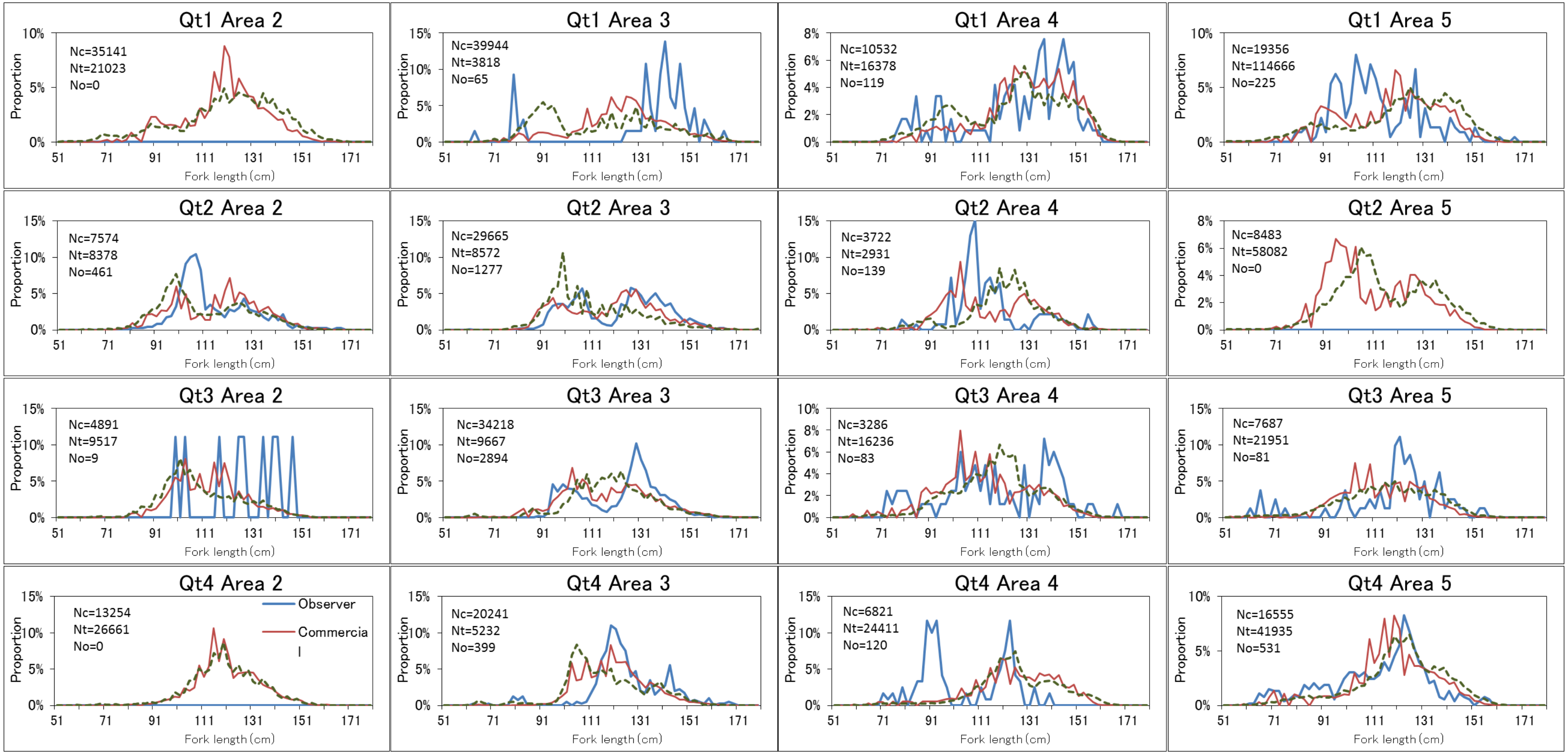

Fig. 9. Length frequency of yellowfin tuna in the Indian Ocean caught by Japanese longline by quarter and area. Nc, Nt and No indicate number of fish for commercial vessels, training vessels and scientific observer, respectively (from Matsumoto, 2013b).

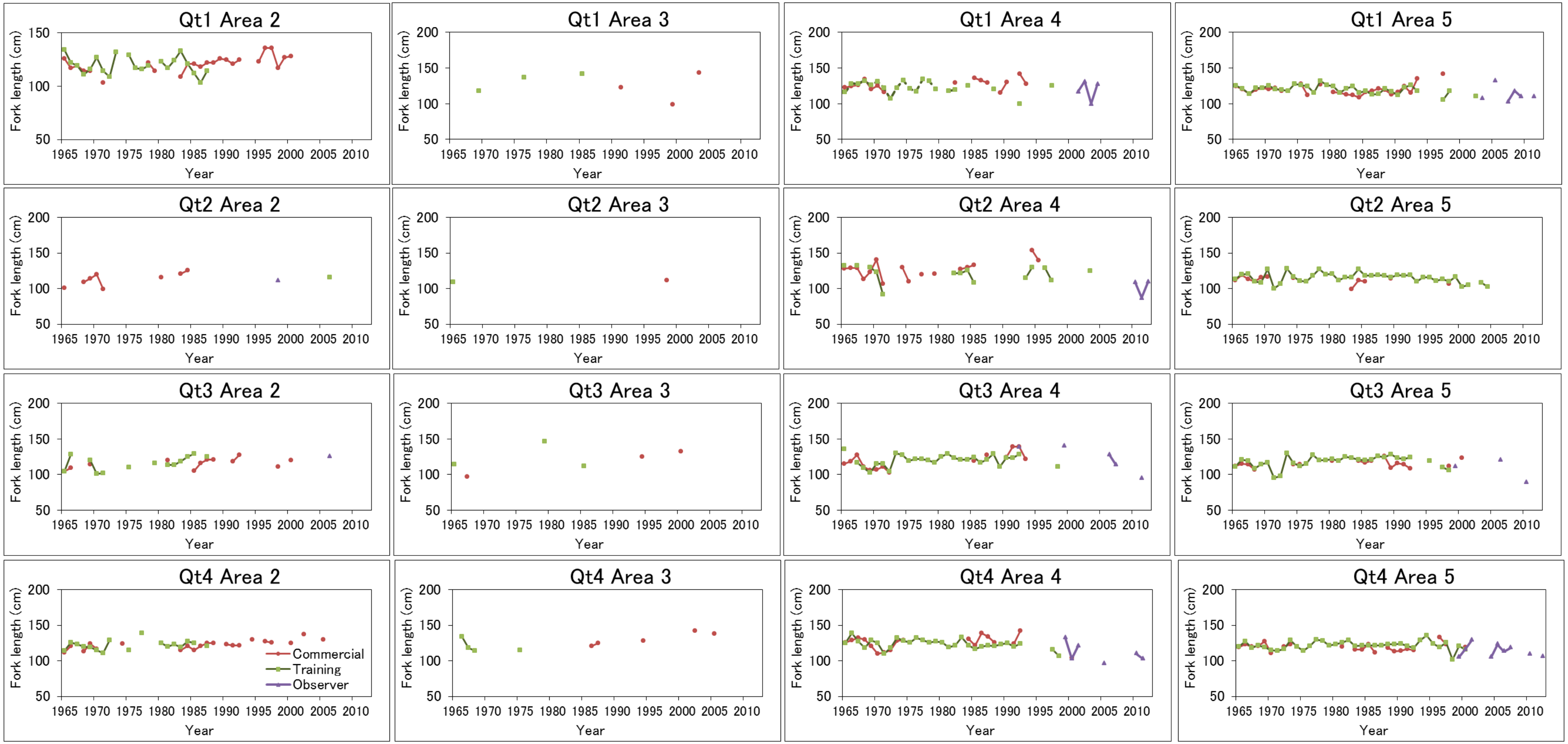

Fig. 10. Annual change in average length of yellowfin tuna in the Indian Ocean caught by Japanese longline by quarter and area (from Matsumoto, 2013b).

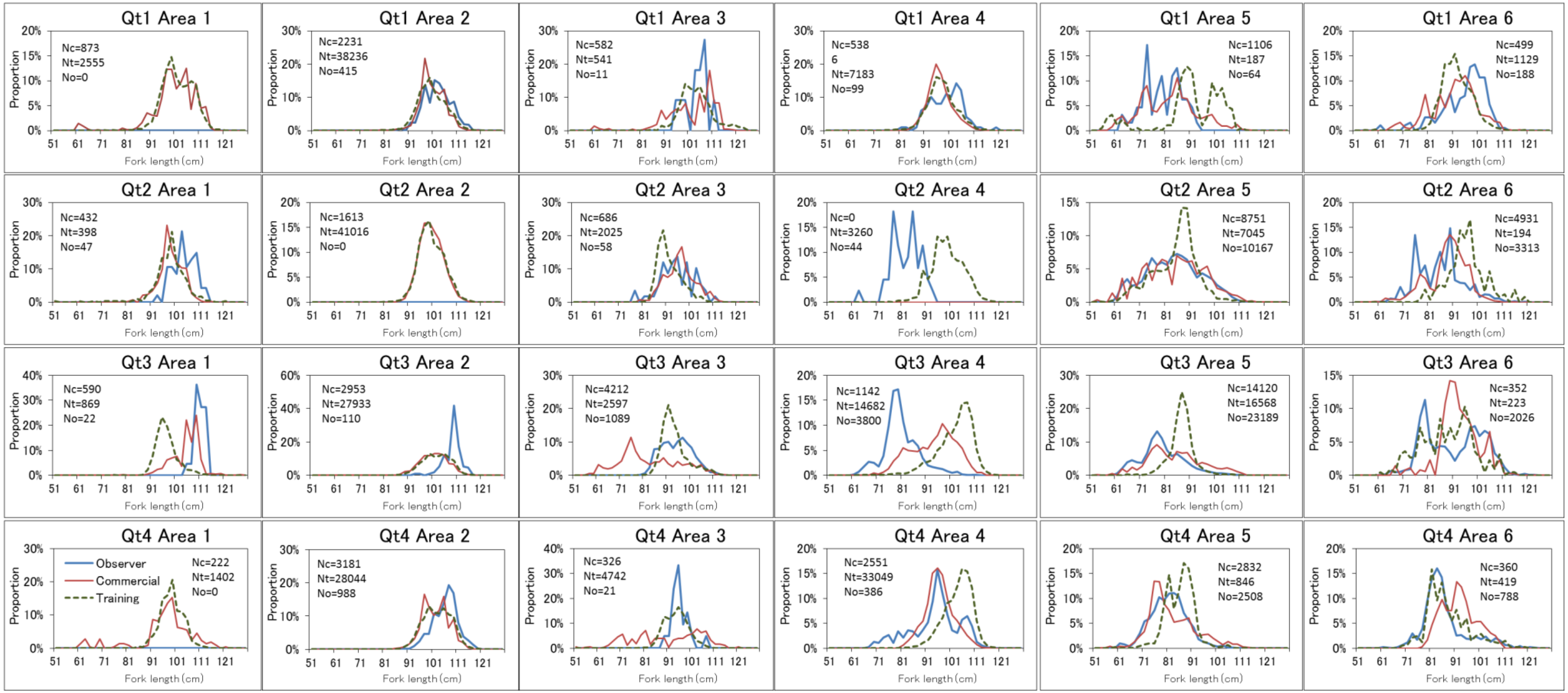

Fig. 11. Length frequency of albacore in the Indian Ocean caught by Japanese longline by quarter and area. Nc, Nt and No indicate number of fish for commercial vessels, training vessels and scientific observer, respectively (from Matsumoto, 2013b).

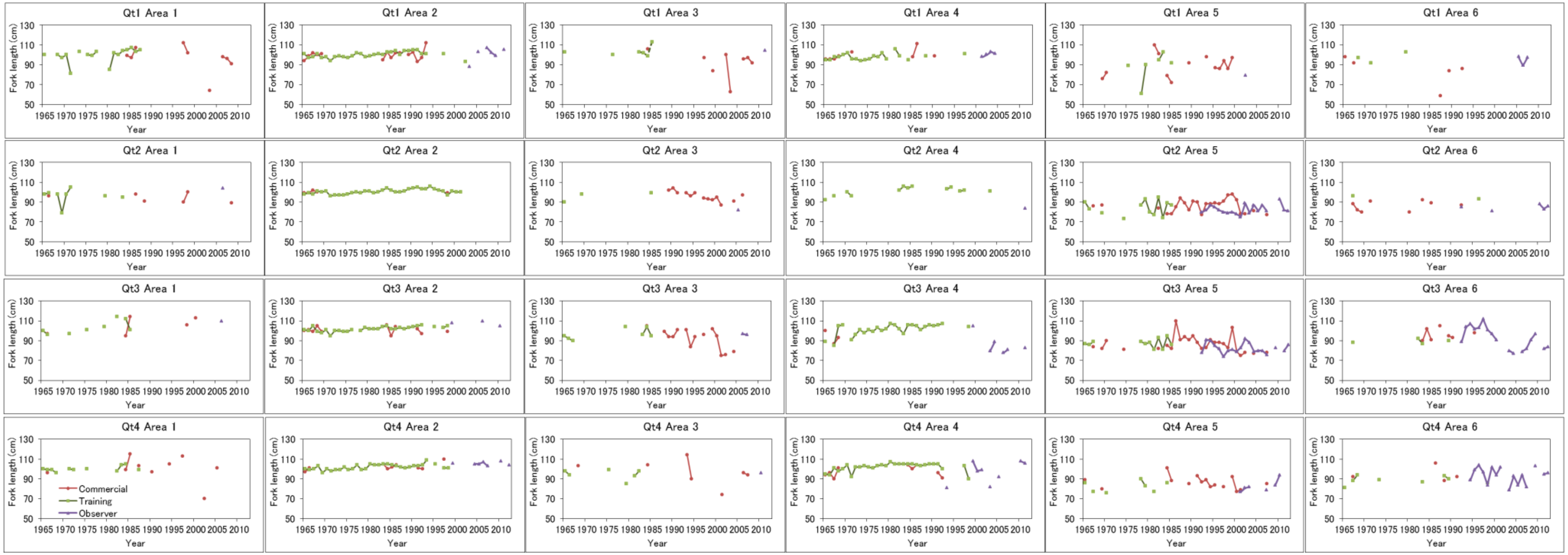

Fig. 12. Annual change in average length of albacore in the Indian Ocean caught by Japanese longline by quarter and area (from Matsumoto, 2013b).