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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

by
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Summary

Comparison of fish size by different sampling methods (commercial and training vessels and scientific observer) for Japanese longline fishery operating in the Indian Ocean was conducted to examine representativeness of size data and to consider how to apply to stock assessment models. Size data by training vessels, which operated mainly between 1960s and 1980s in the tropical area of eastern Indian Ocean, were main component during this period. Size data measured by scientific observers have been main component since mid-2000s especially for bigeye tuna. Length frequencies of the fish in the same area-quarter strata were usually similar among sampling methods if sufficient number of fish were measured, although some differences were observed. In several strata a mode of smaller fish was observed only as for the fish measured by training vessels and/or scientific observers. Difference of average weight of the fish between based on catch and effort data and size data was observed by about 10 kg or more for a part of period. Some considerations and examinations will be necessary to decide how to apply size data to stock assessment models.

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 of the fish caught by Japanese longline fishery in the Indian Ocean are collected in several ways; 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 by scientific observers had not been submitted to IOTC until very recently because these were not included in our size database. Also, size data for commercial and training vessels are not separated in the data submitted to IOTC. In that case, there is a concern if each category of size data especially as for those by training vessels, which account for small proportion of the catch, is representative for entire fish size of longline catch.

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.

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 catch for estimating total amount of catch in weight.

In this document, comparison of size of bigeye and yellowfin tuna for Japanese longline fishery by different sampling methods was conducted for considering how to deal with size data in the stock assessment models. Also, comparison of fish (average) weight of both species based on size data and landing statistics (catch and effort data) was conducted.

2. Materials and methods

2.1 Data source

Size data for the bigeye and yellowfin tuna caught by Japanese longline fishery are collected and compiled at NRIFSF and are available for 1965-2012. Data for 2012 are very preliminary. In the database, it is possible to distinguish 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. Data for the fish whose length was measured at 1or 2cm and 1kg interval were used for analyses. Area stratification to compute the area-specific size of the fish is shown in Fig. 1, which is similar to or the same as that for stock assessment based on integrated models (SS3 and/or Multifan-CL).

Comparison of fish (average) weight for bigeye and yellowfin tuna between based on size data and based on catch and effort data was conducted. 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 have 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) to round weight was averaged. The equations shown below were used for conversion.

Convert from length to weight:
Bigeye tuna: $W=2.7*10^{-5}*L^{2.951}$
Yellowfin tuna: $W=1.886*10^{-5}*L^{3.0195}$

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.

3. Results

3.1. Summary of availability size data

Table 1 and Fig. 2 indicate annual change in number of size data by species and sampling category, and Table 2 indicate number of size data by quarter and/or area. Fig. 3 and Fig. 4 show geographical distribution of size sampling by sampling methods for bigeye and yellowfin tunas, respectively. 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. The number of size data per year was usually less than 10,000 fish except for a part of period, and in recent years about 1,000-2,000 and more or less 1,000 for bigeye and yellowfin tuna, respectively.

3.2. Comparison of size data

Fig. 5 shows length frequency of bigeye tuna stratified by decade, area and quarter. There were several changes by decade especially from 2000s, when sample size was smaller except for that by scientific observer. The fish in the eastern part (Areas 2 and 4) were a bit smaller than those in the western part (Areas 1 and 3). Fig. 6 shows length distribution of bigeye tuna stratified by quarter and area. Length frequency in the same strata was usually similar among sampling methods except for the strata whose sample size was small. In several strata, clear mode of smaller fish appeared only as for the fish measured by training vessels and/or scientific observers. Fig. 7 and Fig. 8 show annual and decadal changes in average length of bigeye tuna in each area and quarter. Although the period of sampling for each method does not always overlap, fish lengths are usually similar among categories.

Fig. 9 shows length frequency of yellowfin tuna stratified by decade, area and quarter. As with bigeye tuna, decadal changes were observed from 1990s. Several differences of length frequency were observed among areas and quarters; a mode of smaller fish (smaller than 110cm FL) was seen in several strata, some of which were seen only for the fish measured by training vessels and/or scientific observers. Fig. 10 shows length distribution of yellowfin tuna stratified by quarter and area. Length frequency in the same strata was usually similar among sampling methods except for the strata whose sample size was small. As with bigeye tuna, in several strata, a mode of smaller fish appeared only as for the fish measured by training vessels and/or scientific observers. Fig. 11and Fig. 12 show annual and decadal changes in average length of bigeye tuna in each area and quarter. As with bigeye tuna, fish lengths are usually similar among categories.

3.3. Comparison of average weight of fish

Fig. 13 shows comparison of average weight of bigeye and yellowfin tuna caught by Japanese longline. Annual trend are similar for both species, but sometimes the difference between average weight by size data and that by catch and effort data was over 10kg.

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)

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 and/or substitution process of average weight.

3.4. Application of size data to the stock assessment models

This paper indicated that fishing effort by training vessels are temporally and spatially limited, and availability of size data differs depending on periods. It was also indicated that the size of the fish is usually similar among sampling methods if sufficient number of fish were measured, although some differences were observed. It is not certain if these differences affect the results of stock assessment. Therefore, it may be necessary to conduct sensitivity analyses to see the difference. It may also be necessary to drop size data if sufficient sample size was not obtained in one stratum.

Table 1. Number of size data for bigeye and yellowfin tuna caught by Japanese longline fishery for each category.

Year	Bigeye tuna				Yellowfin tuna			
	Commercial vessels	Training vessels	Scientific observer	Total	Commercial vessels	Training vessels	Scientific observer	Total
1965	12,838	9,359	0	22,197	16,202	23,665	0	39,867
1966	12,077	8,877	0	20,954	16,737	21,410	0	38,147
1967	8,243	7,342	0	15,585	7,168	14,173	0	21,341
1968	12,469	11,191	0	23,660	14,207	22,865	0	37,072
1969	8,247	19,760	0	28,007	4,703	26,059	0	30,762
1970	6,739	17,861	0	24,600	5,165	23,448	0	28,613
1971	10,234	12,341	0	22,575	5,903	33,358	0	39,261
1972	1,361	15,972	0	17,333	3,275	31,752	0	35,027
1973	1,068	10,990	0	12,058	1,664	20,463	0	22,127
1974	1,357	11,625	0	12,982	1,886	15,938	0	17,824
1975	2,362	12,978	0	15,340	1,873	20,925	0	22,798
1976	1,779	9,904	0	11,683	355	26,168	0	26,523
1977	1,851	11,406	0	13,257	805	25,300	0	26,105
1978	2,210	18,833	0	21,043	1,418	18,996	0	20,414
1979	5,702	26,058	0	31,760	1,014	17,429	0	18,443
1980	2,269	27,297	0	29,566	455	10,905	0	11,360
1981	945	30,057	0	31,002	721	14,561	0	15,282
1982	787	37,518	0	38,305	4,749	14,245	0	18,994
1983	6,963	40,679	0	47,642	3,859	17,003	0	20,862
1984	17,870	26,421	0	44,291	16,586	18,572	0	35,158
1985	22,258	30,458	0	52,716	17,667	14,280	0	31,947
1986	20,737	28,405	0	49,142	16,444	6,785	0	23,229
1987	14,513	13,984	0	28,497	6,675	5,188	0	11,863
1988	15,371	14,105	0	29,476	11,306	3,852	0	15,158
1989	16,322	9,070	0	25,392	11,916	2,356	0	14,272
1990	10,135	8,710	0	18,845	15,035	2,185	0	17,220
1991	8,663	6,666	0	15,329	7,491	2,026	0	9,517
1992	7,658	2,359	265	10,282	5,132	587	11	5,730
1993	4,349	1,213	24	5,586	6,347	632	0	6,979
1994	4,267	313	112	4,692	5,007	152	0	5,159
1995	3,697	1,166	15	4,878	6,727	415	17	7,159
1996	1,358	1,315	73	2,746	4,869	255	5	5,129
1997	4,288	3,330	128	7,746	6,215	655	14	6,884
1998	7,440	748	278	8,466	11,615	368	18	12,001
1999	2,729	118	564	3,411	11,108	160	60	11,328
2000	7,560	326	582	8,468	15,442	942	1,666	18,050
2001	2,217	216	343	2,776	4,831	512	94	5,437
2002	1,995	44	71	2,110	1,377	25	49	1,451
2003	299	43	729	1,071	570	19	299	888
2004	874	41	1,198	2,113	1,333	19	284	1,636
2005	790	0	2,258	3,048	1,182	0	1,036	2,218
2006	246	0	2,621	2,867	1,302	0	1,670	2,972
2007	366	0	2,004	2,370	1,140	0	263	1,403
2008	96	0	466	562	1,677	0	75	1,752
2009	0	0	1,093	1,093	0	0	312	312
2010	2	0	2,672	2,674	0	0	192	192
2011	62	0	1,694	1,756	38	0	193	231
2012	3	0	6	9	0	0	0	0

Table 2. Number of size data for bigeye and yellowfin tuna caught by Japanese longline fishery for each category by quarter and area. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

Bigeye tuna

Qt	Area	Total	Com-mercial vessel	Training Vessel	Scientific observer
1	1	24,049	4,948	19,101	0
1	2	168,000	1,711	164,269	2,020
1	3	1,721	990	728	3
1	4	3,816	234	3,526	56
2	1	5,437	1,145	3,973	319
2	2	65,225	363	64,862	0
2	3	23,274	13,313	8,975	986
2	4	2,163	98	1,799	266
3	1	7,242	1,121	6,093	28
3	2	66,675	570	65,658	447
3	3	43,085	28,897	9,831	4,357
3	4	14,997	1,023	11,717	2,257
4	1	18,682	4,051	14,631	0
4	2	104,286	615	98,562	5,109
4	3	5,914	4,007	1,169	738
4	4	16,053	1,306	14,141	606

Qt	Total	Com-mercial vessel	Training Vessel	Scientific observer
1	197,586	7,883	187,624	2,079
2	96,099	14,919	79,609	1,571
3	131,999	31,611	93,299	7,089
4	144,935	9,979	128,503	6,453

Area	Total	Com-mercial vessel	Training Vessel	Scientific observer
1	55,410	11,265	43,798	347
2	404,186	3,259	393,351	7,576
3	73,994	47,207	20,703	6,084
4	37,029	2,661	31,183	3,185

Yellowfin tuna

Qt	Ar-ea	Total	Com-mercial vessel	Training Vessel	Scientific observer
1	2	26,898	5,875	21,023	0
1	3	16,826	12,943	3,818	65
1	4	16,554	57	16,378	119
1	5	115,419	528	114,666	225
2	2	10,599	1,760	8,378	461
2	3	35,980	26,135	8,572	1,273
2	4	3,034	48	2,931	55
2	5	59,308	1,360	57,948	0
3	2	11,203	1,677	9,517	9
3	3	33,699	21,158	9,667	2,874
3	4	16,391	72	16,236	83
3	5	22,142	110	21,951	81
4	2	30,910	4,249	26,661	0
4	3	19,650	14,019	5,232	399
4	4	24,560	29	24,411	120
4	5	42,563	167	41,935	461

Qt	Total	Com-mercial vessel	Training Vessel	Scientific observer
1	175,697	19,403	155885	409
2	108,921	29,303	77829	1,789
3	83,435	23,017	57371	3,047
4	117,683	18,464	98239	980

Ar-ea	Total	Com-mercial vessel	Training Vessel	Scientific observer
2	79,610	13,561	65579	470
3	106,155	74,255	27289	4,611
4	60,539	206	59956	377
5	239,432	2,165	236500	767

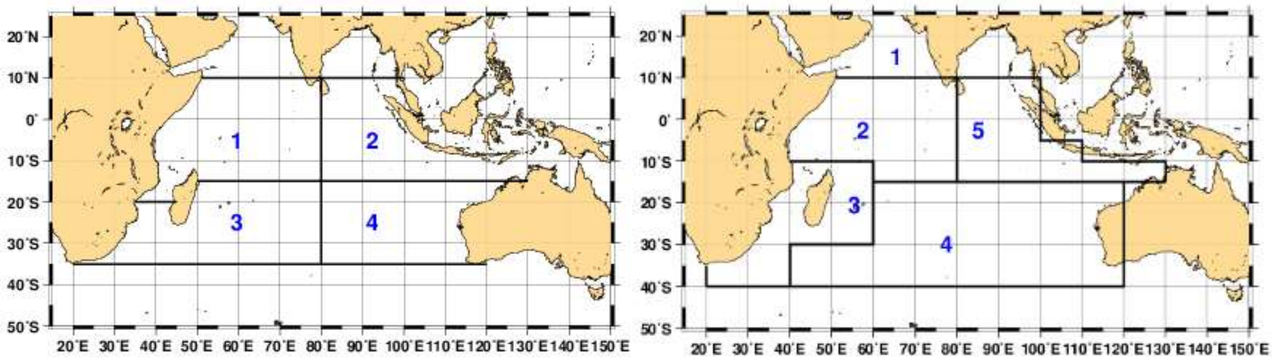

Fig. 1. Area definition to compile the length data for bigeye (left) and yellowfin tuna (right).

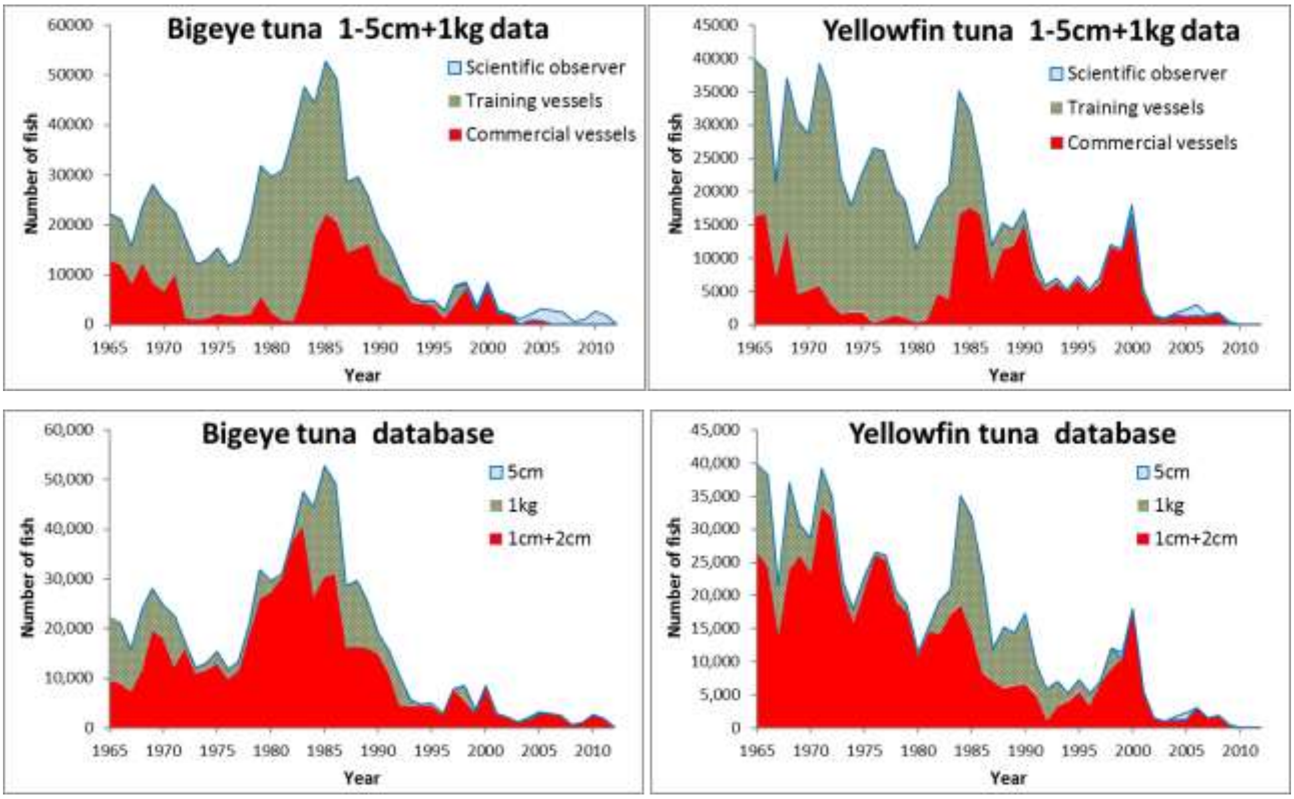

Fig. 2. Annual change in the number of size data by Japanese longline fishery. Upper: by sampling category, lower: by measurement unit.

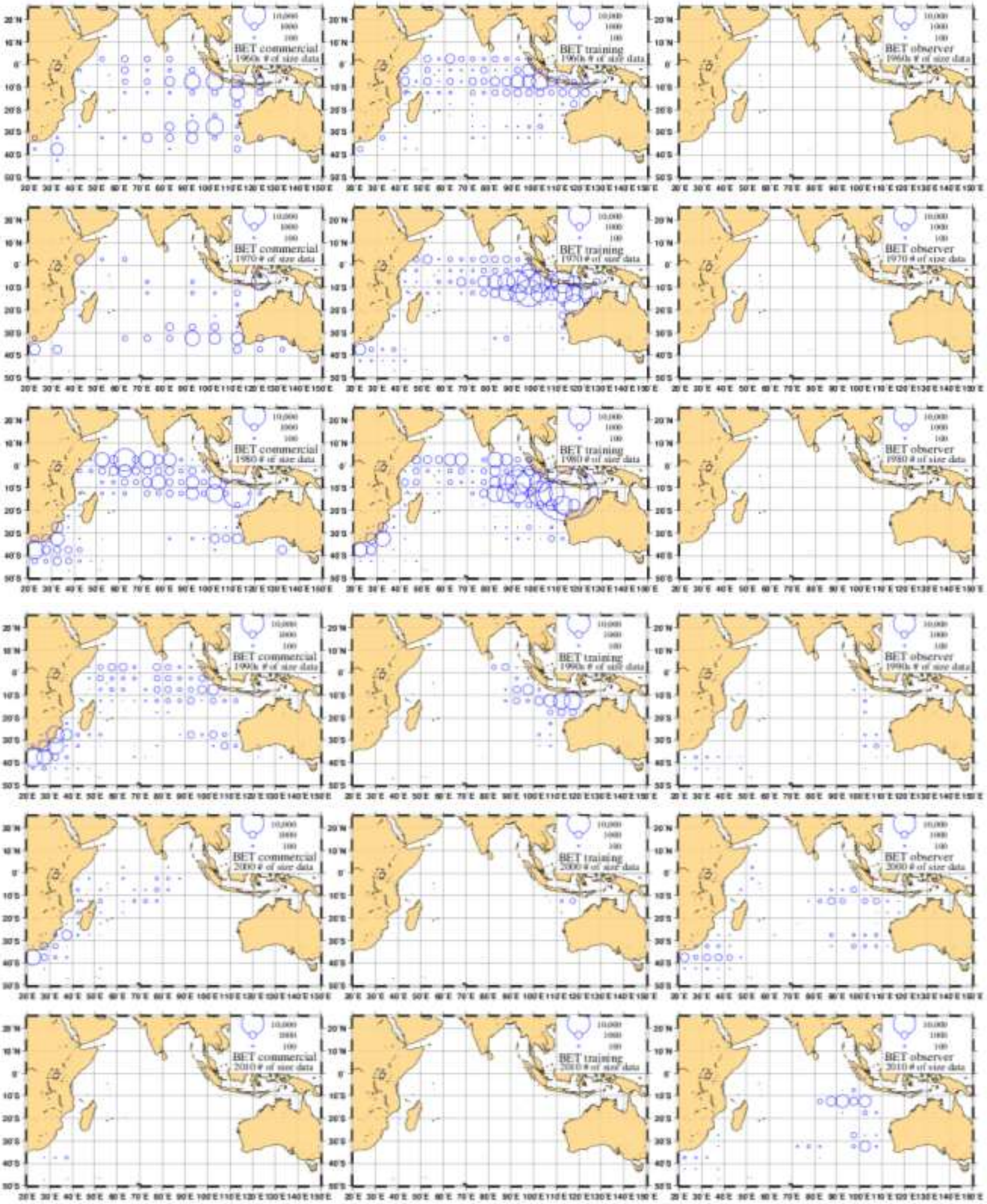

Fig. 3. Geographical distribution of size sampling (annual average for number of fish) for bigeye tuna by sampling method and decade.

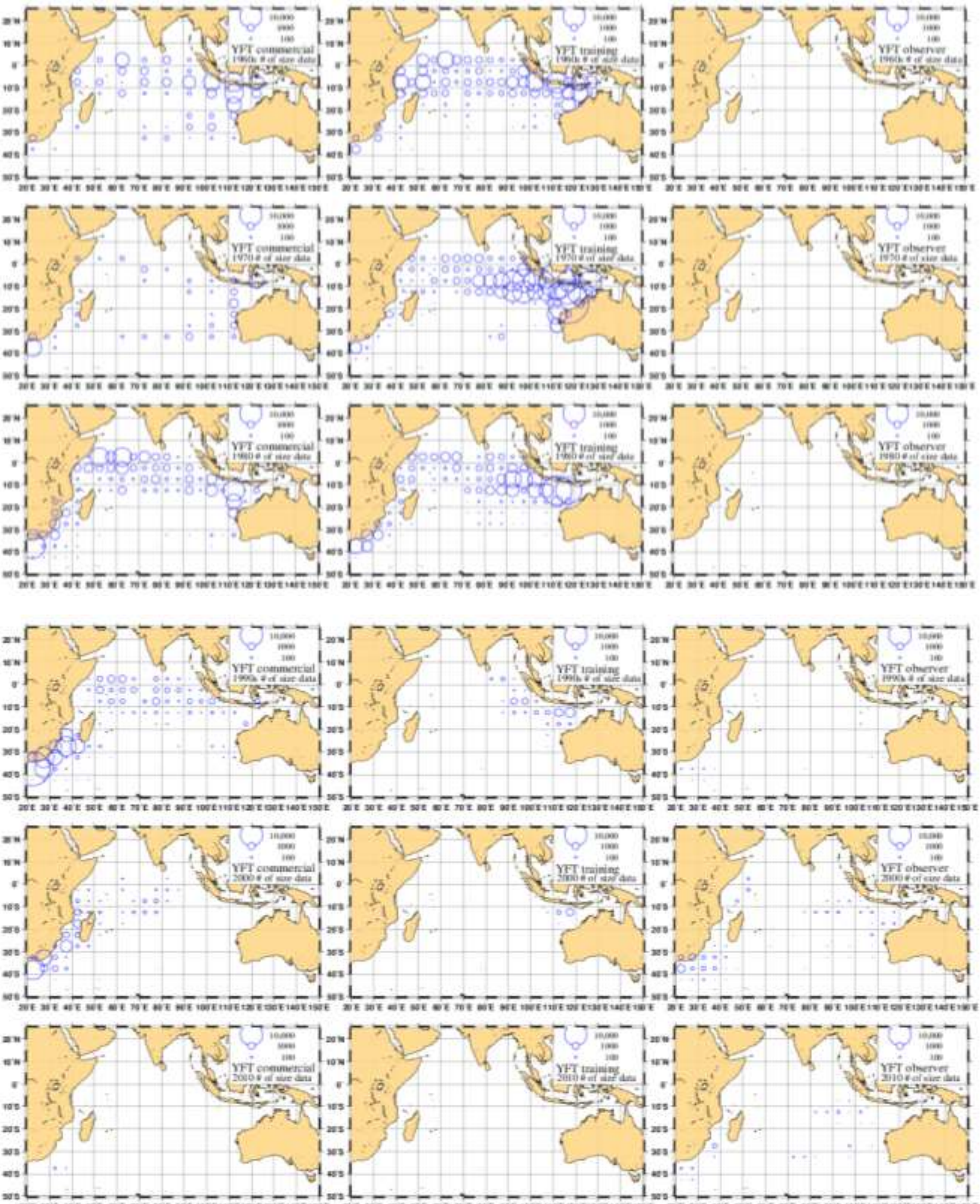

Fig. 4. Geographical distribution of size sampling (annual average for number of fish) for yellowfin tuna by sampling method and decade.

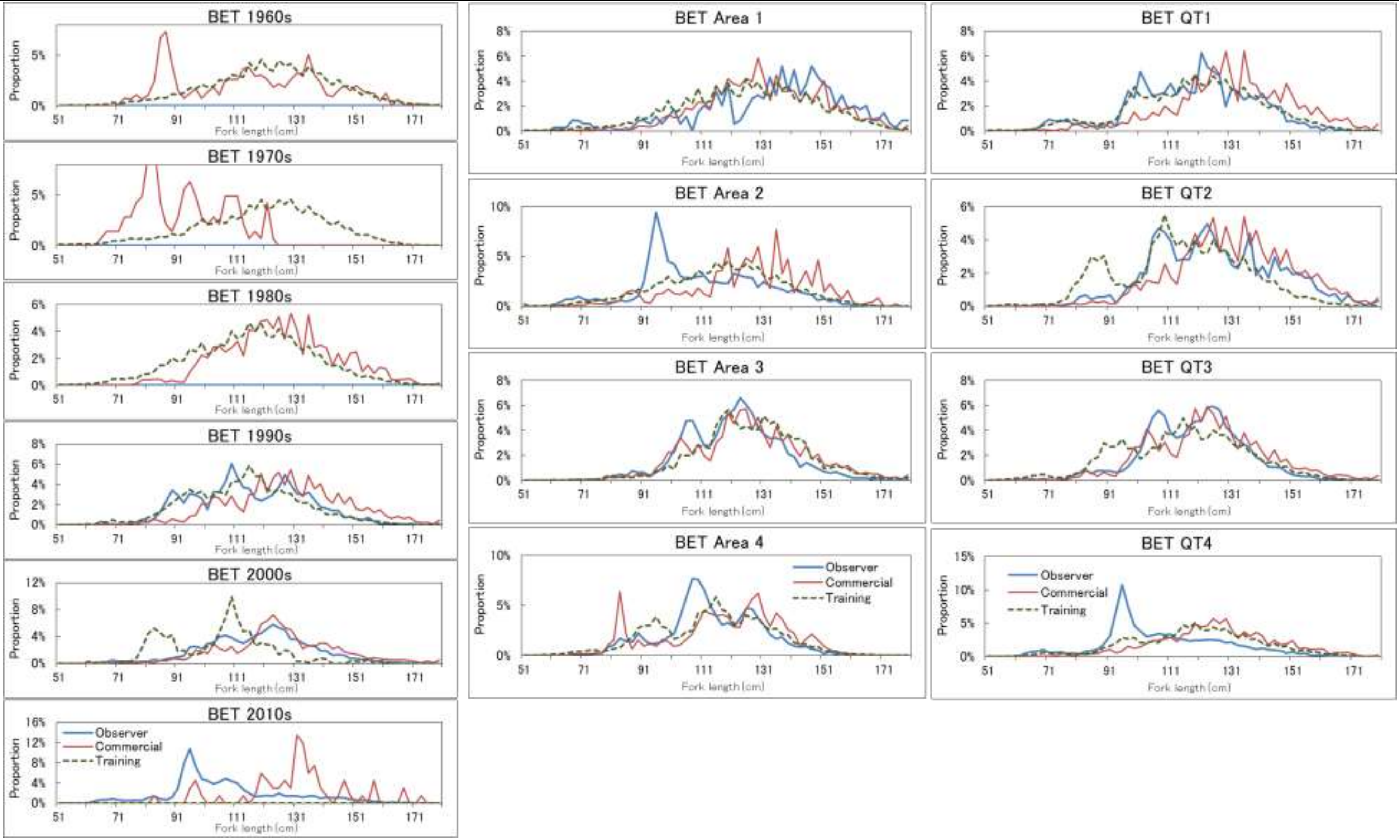

Fig. 5. Length frequency of bigeye tuna in the Indian Ocean caught by Japanese longline by decade (left), area (middle) and quarter (right). Area is shown in Fig. 1. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

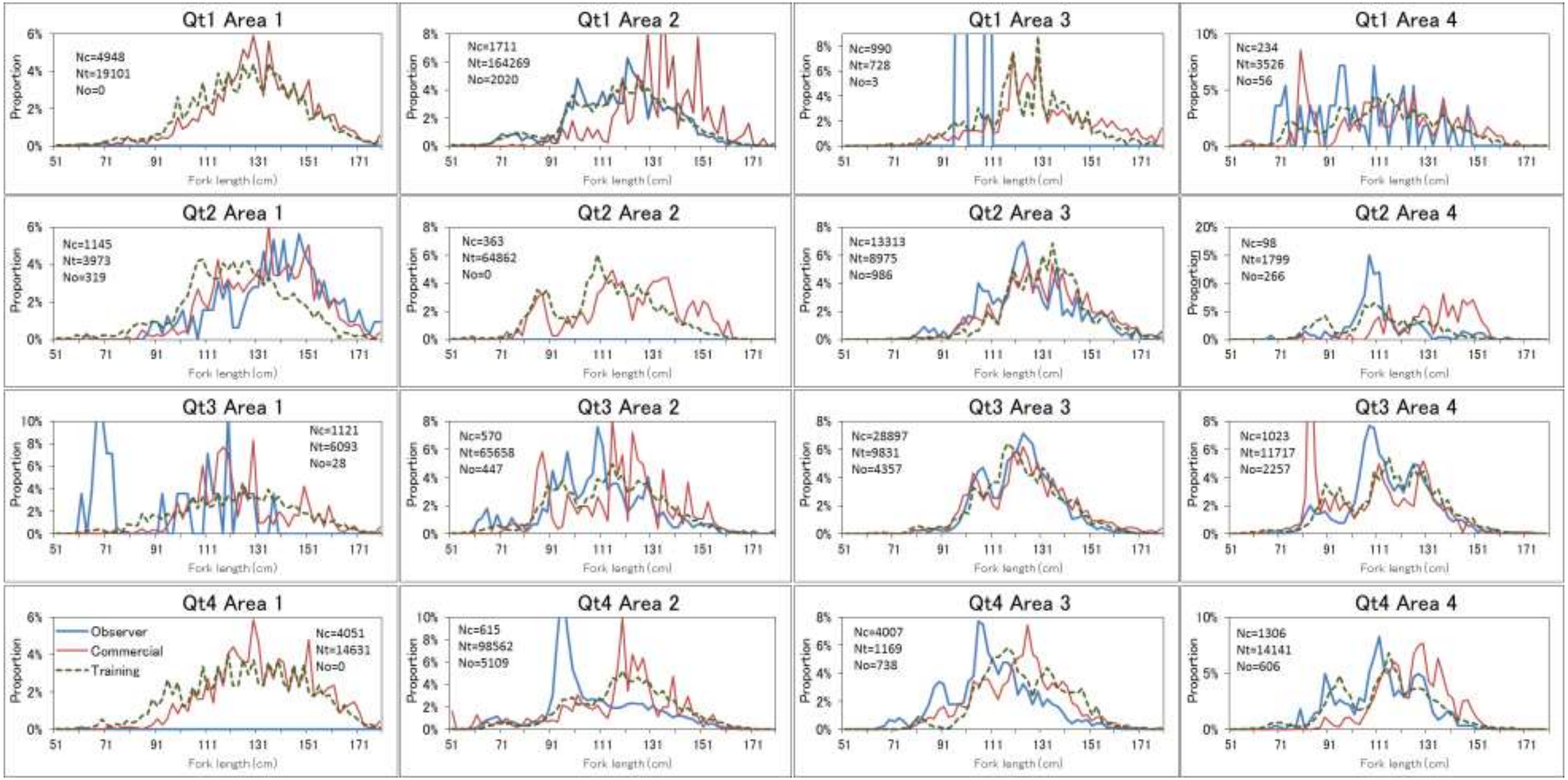

Fig. 6. Length frequency of bigeye tuna in the Indian Ocean caught by Japanese longline by quarter and area. Nc, Nt and No indicate number of fish for commercial vessels, training vessels and scientific observer, respectively. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

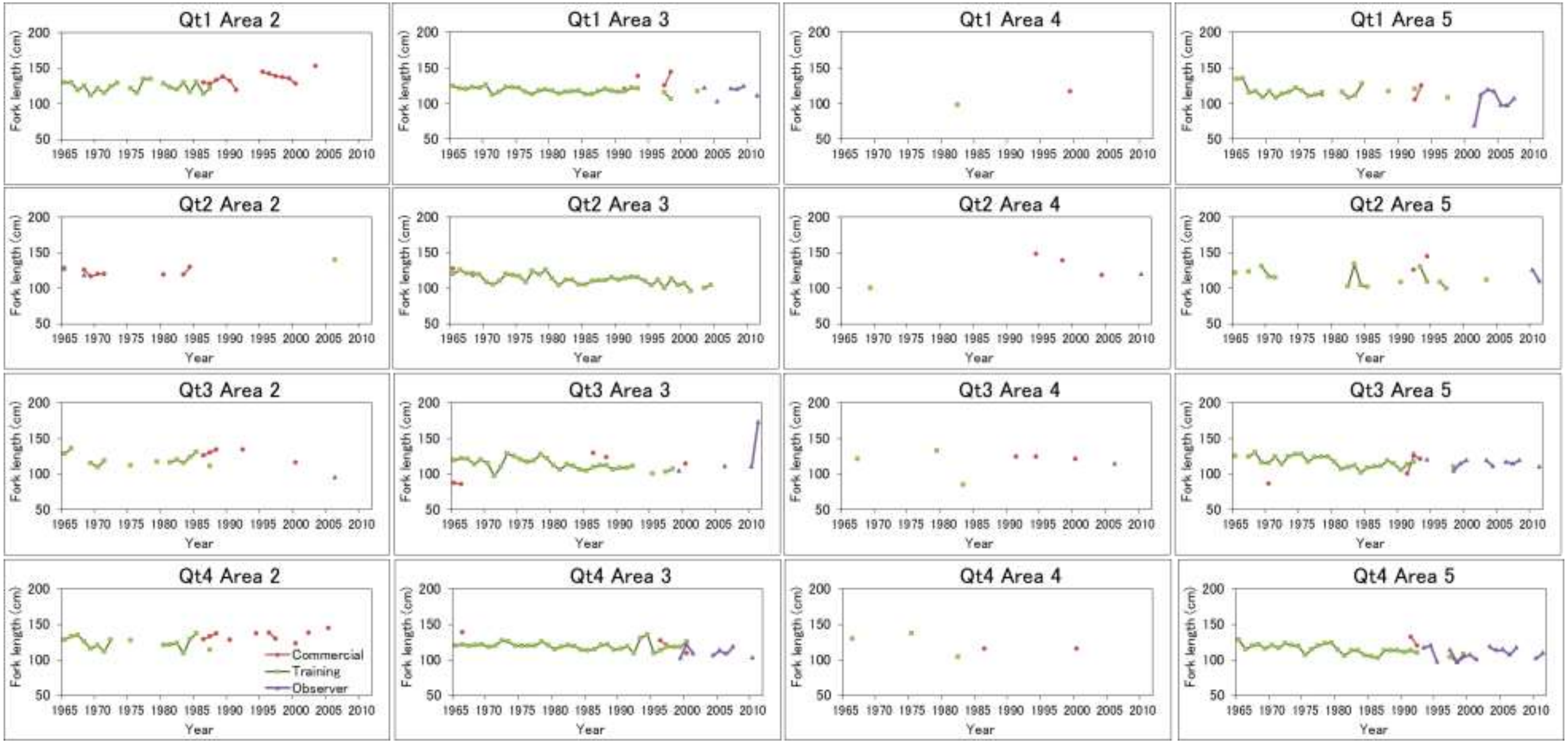

Fig. 7. Annual change in average length of bigeye tuna in the Indian Ocean caught by Japanese longline by quarter and area. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

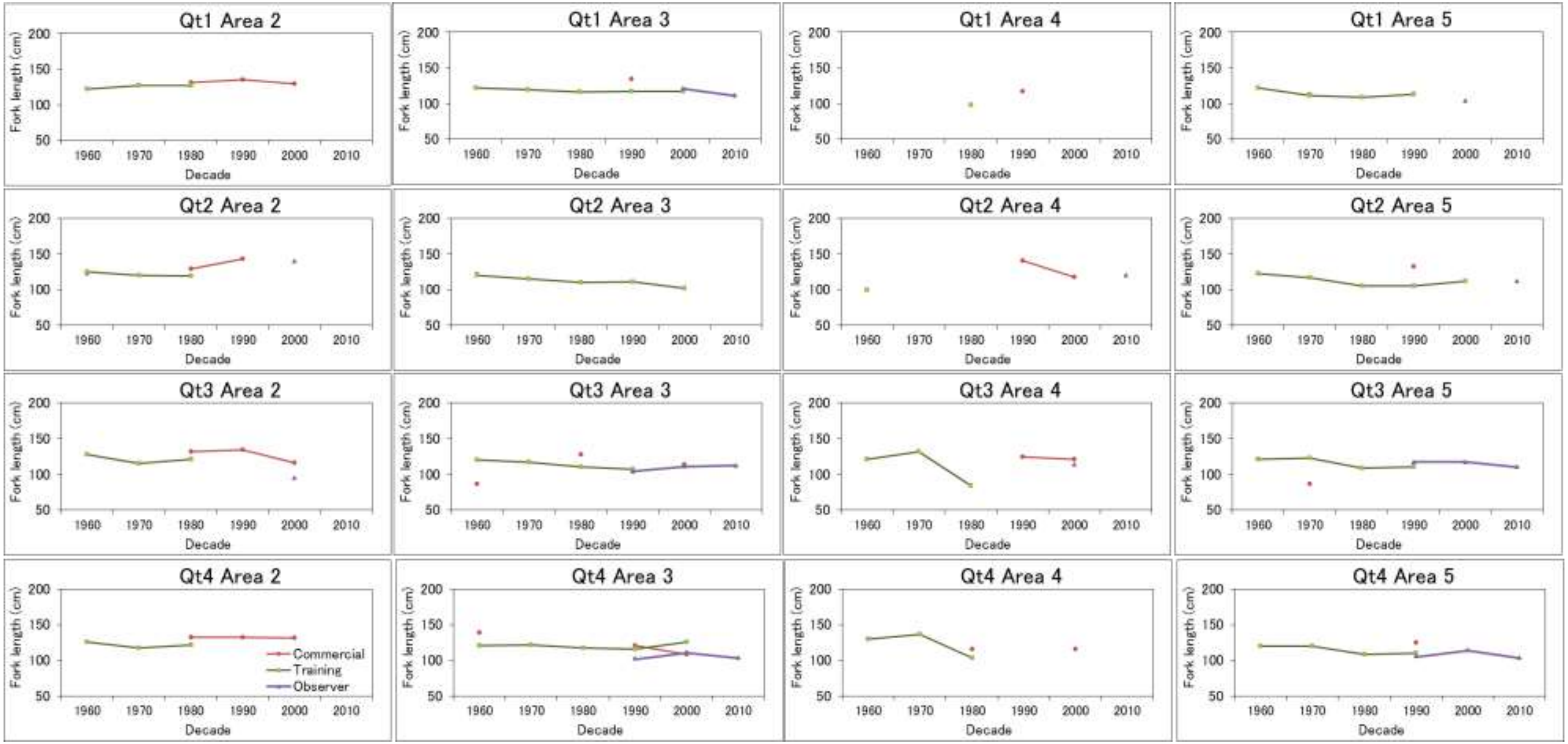

Fig. 8. Decadal change in average length of bigeye tuna in the Indian Ocean caught by Japanese longline by quarter and area. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

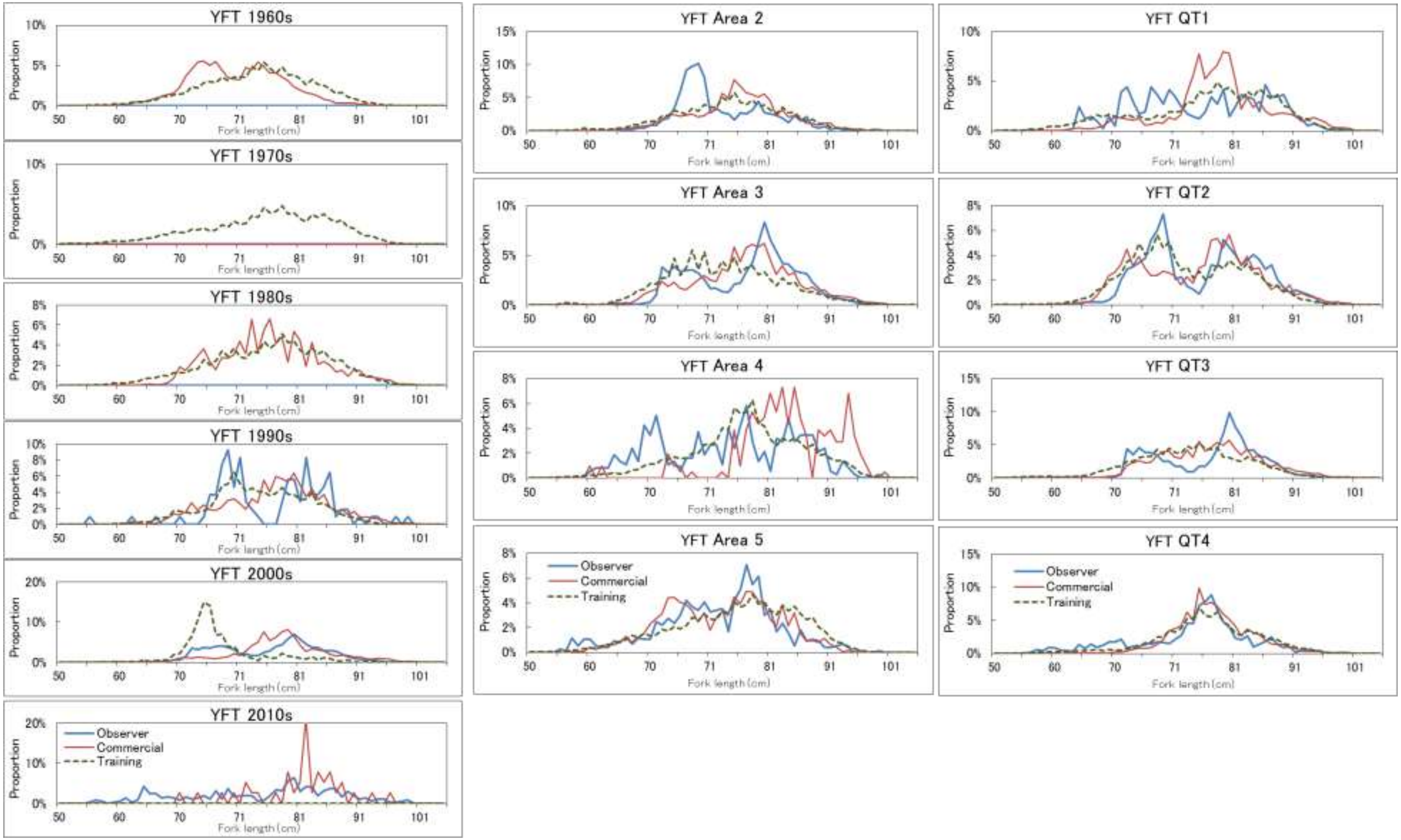

Fig. 9. Length frequency of yellowfin tuna in the Indian Ocean caught by Japanese longline by decade (left), area (middle) and quarter (right). Area is shown in Fig. 1. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

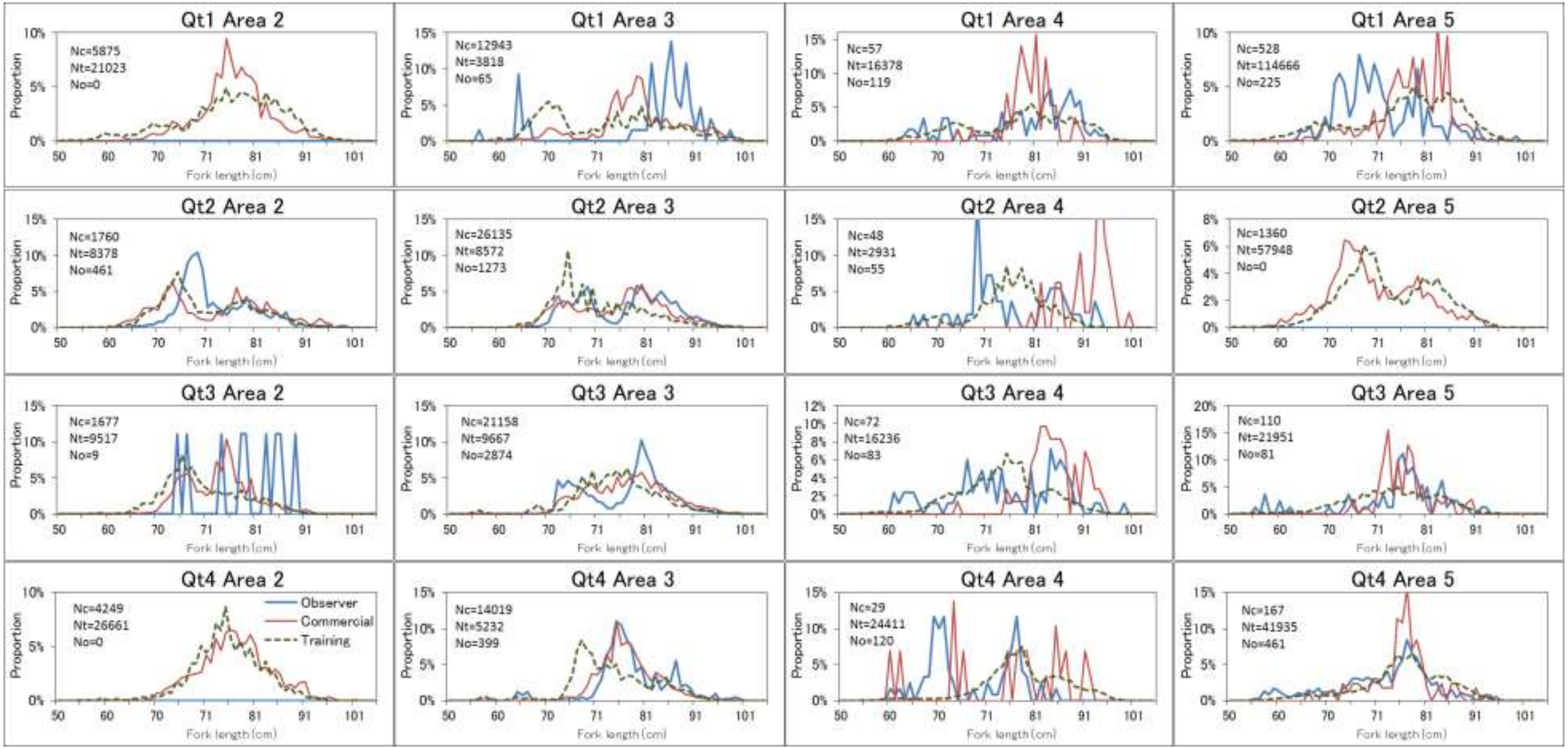

Fig. 10. Length frequency of yellowfin tuna in the Indian Ocean caught by Japanese longline by quarter and area. Nc, Nt and No indicate number of fish for commercial vessels, training vessels and scientific observer, respectively. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

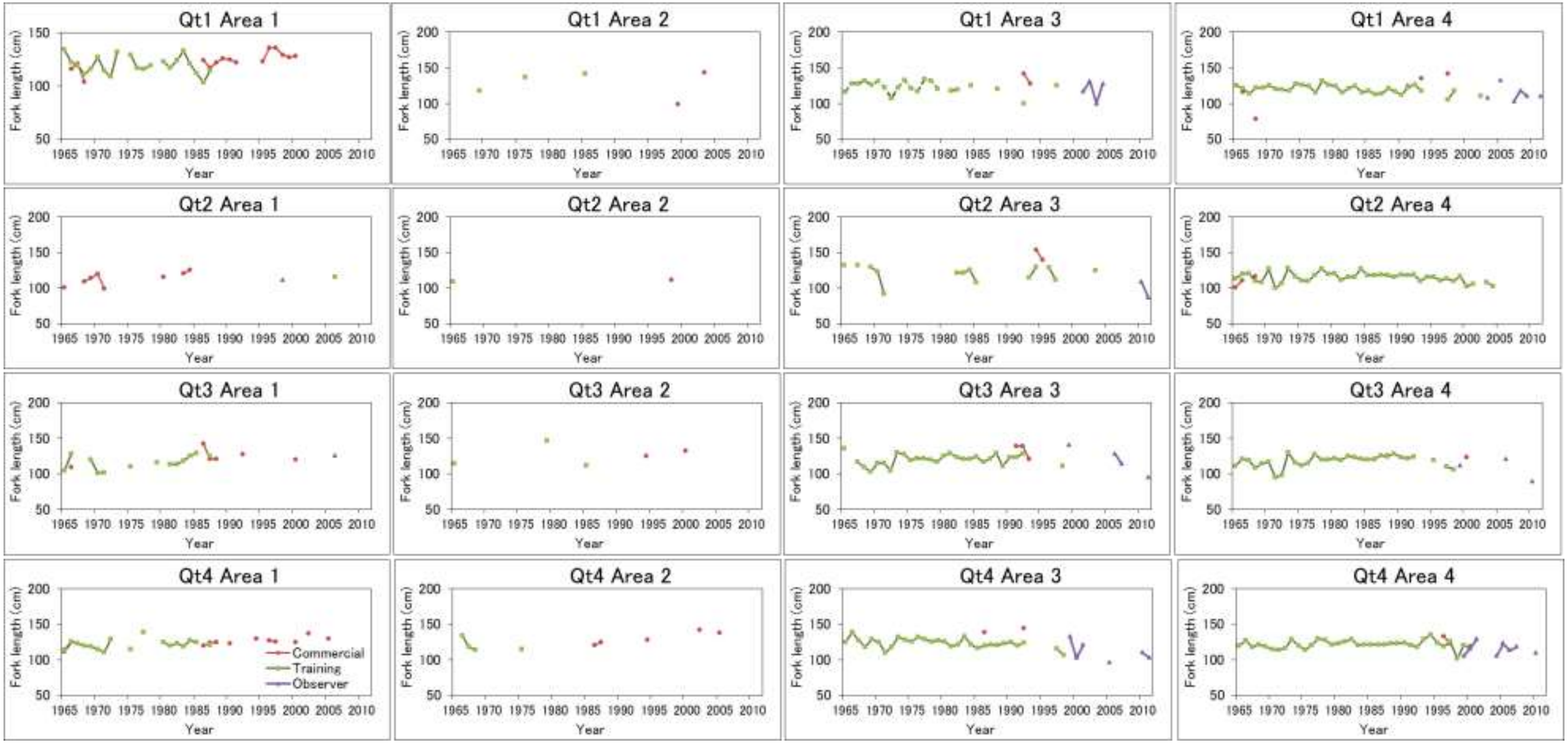

Fig. 11. Annual change in average length of yellowfin tuna in the Indian Ocean caught by Japanese longline by quarter and area. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

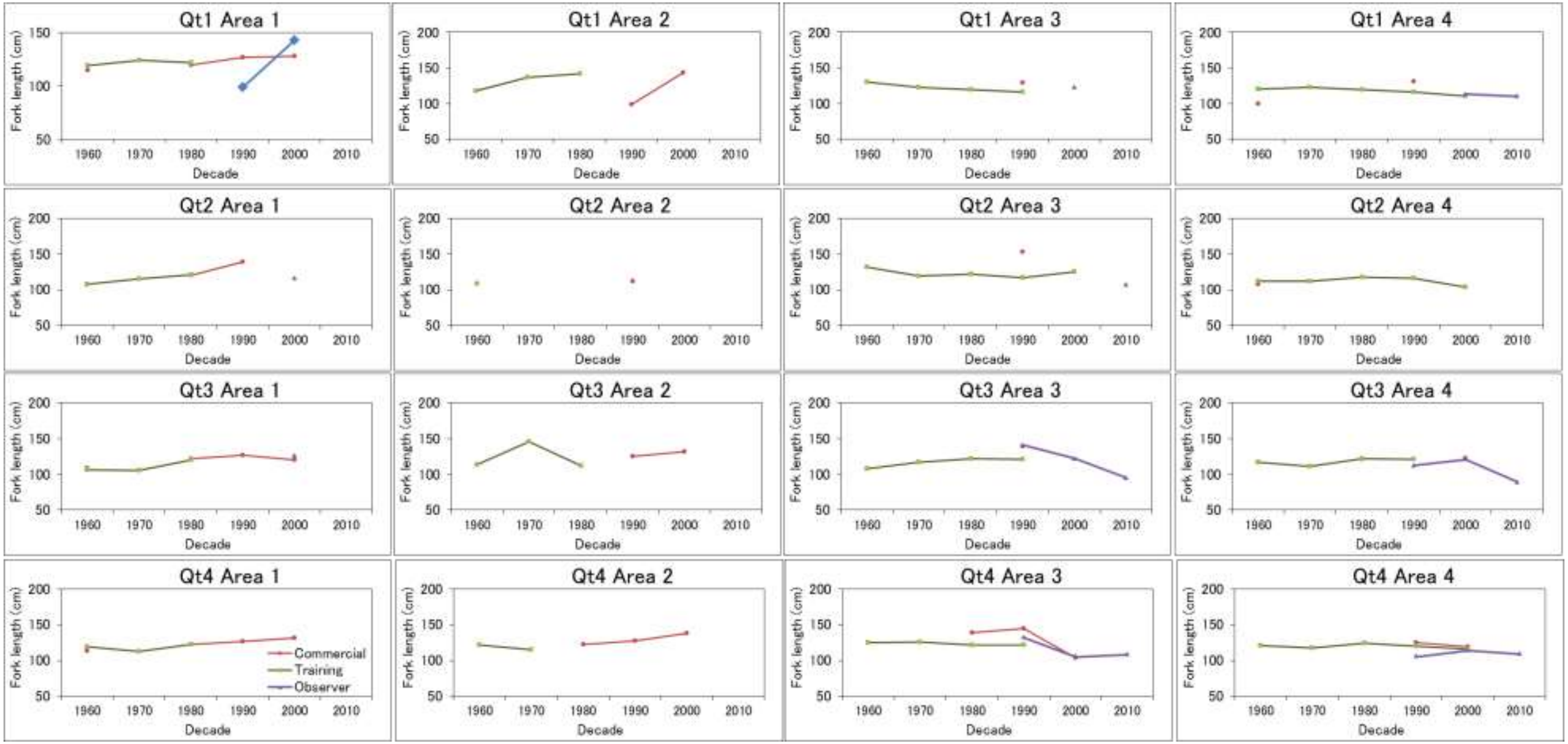

Fig. 12. Decadal change in average length of yellowfin tuna in the Indian Ocean caught by Japanese longline by quarter and area. Only the data for the fish whose length was measured at 1cm or 2cm interval are used.

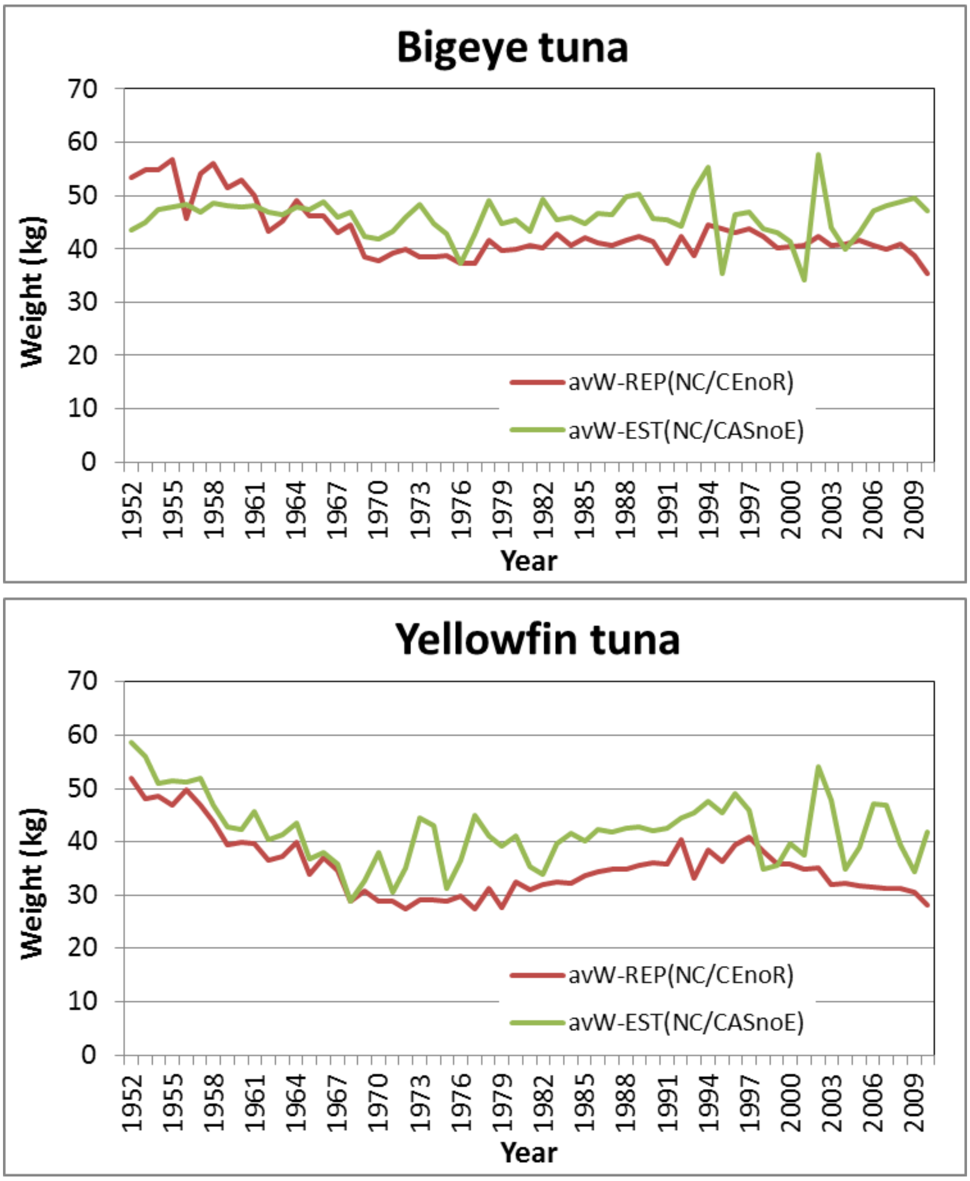

Fig. 13. Comparison of annual average weight of bigeye and yellowfin tuna caught by Japanese longline fishery based on catch and effort and size data. "avW-REP(NC/CEnoR)": average weight of the fish estimated using the total weight recorded as nominal catch divided by the number of fish recorded in CE. "avW-EST(NC/CASnoE)": average weight estimated by the IOTC Secretariat using the available NC, CE, and SF data for each fleet and year.