Received: 9 & 17 October, 2012
IOTC–2012–WPTT14–17 Rev_1

Review of Japanese fisheries and tropical tuna catch in the Indian Ocean

by

Takayuki Matsumoto and Keisuke Satoh

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

Summary

Introduction on the fishing efforts, tropical tuna catch, CPUE and body size was summarized for Japanese longline and purse seine fisheries operating in the Indian Ocean including recent trends. Japanese longline vessels have been targeting bigeye and yellowfin tunas along with albacore and southern bluefin tuna. The fishing effort for longline fishery fluctuated and has been sharply decreasing in recent years probably due to effect of piracy. Both bigeye and yellowfin tuna catch peaked in 1968, sharply decreased in 1970s especially as for yellowfin tuna, fluctuated after that, and is decreasing in recent years. In the early period, the effort was deployed mainly in the tropical area, and then expanded to the south. Fishing effort in the northwestern part (around Somalia) sharply decreased after 2009 due to pirates activities. Both bigeye and yellowfin tunas are main component of the catch especially during late 1980s and 1990s. High CPUE for bigeye and yellowfin tuna was observed mainly in the eastern and western Indian Ocean, respectively. Size data of bigeye and yellowfin tuna have been collected from on-board measurements by commercial and training longline vessels. Differences in fish size by season and area are partly observed for both species. Japanese purse seine vessels have been targeting skipjack, yellowfin and bigeye tuna since 1970s. Fishing effort of purse seine increased in 1990s and marked 2,400 sets in 1992, and then decreased rapidly to 170 sets in 2000, after that it showed stable trend in low level and around 100 sets in recent two years. The annual catch of the tropical tuna coincided with the trend of effort, which reached to 45,000 mt in 1992 and then decreased to 3,000 mt in 2000; it exhibited about 3,000 mt in 2011.

1. Introduction

There are two kinds of Japanese tuna fisheries in the Indian Ocean, i.e. longline and purse seine fisheries. Both fisheries catch tropical tunas. The longline fishery commenced in 1952 in the eastern equatorial waters in the Indian Ocean. The fishing effort of the longline first expanded westward, and then southward. In the late 1960s, the effort covered entire fishing ground of the longline in the Indian Ocean. The annual amount of the effort has changed since the late 1960s. Also, annual catch of bigeye and yellowfin tuna have considerably changed especially as for yellowfin, which varied from 2,100 t to 59,000 t (Table 1), as well as catches of other tunas.

The purse seine fishery commenced in 1950s. In the early period, as far as data exist, operations were conducted in the eastern equatorial waters in the Indian Ocean. After 1978 the fishery in the Indian Ocean gradually developed and from the late 1980s to the middle 1990s the effort covered entire the Indian Ocean. After that the fishery was considerably contracted and stable but low level in effort after 2000. The annual catch of the tropical tuna were coincided with the trend of effort (Table 2).

In this document, historical and spatial changes of tropical tuna catch and the fishing effort by longline and purse seine fisheries were described in conjunction with the catches of the other tunas and tuna-like species. In addition, the size of the fish caught by the longline is shown to see general information of fish size including difference of size by area and season.

2. Data source

In order to count the effort (number of hooks for longline and number of sets for purse seine) and catches (in number by longline and in weight by purse seine), basic data used here is the logbook data 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 and purse seine vessels larger than 20 gross ton (GRT). The data for longline fishery are so-called "raised" data, which is aggregated by month and 5˚x5° block, and then expanded with coverage rate of the logbook. The basic data is available for 1952-2011 for longline and 1973-2011 for purse seine. The geographical range as the "Indian Ocean" to count the amount of the effort and the catches from the basic data is shown in Fig. 1a. As for catch in weight by area for longline and purse seine fishery, IOTC database was used.

There were a few sources of the size data for the bigeye and yellowfin tuna caught by longline fishery, i.e. onboard measurement by training vessels and commercial vessels. The data are collected and compiled at NRIFSF and are available for 1965-2011. Data for 2011 are preliminary. Area stratification to compute the area-specific sample number of the measurement is shown in Fig. 1b and Fig. 1c for bigeye and yellowfin tuna, respectively. Size data for the fish caught by purse seine fishery are not available.

3. Trend of catch and effort

3.1. Longline fishery

Table 3 and Fig. 2a indicate that after the beginning of the exploitation by longline fishery in the Indian Ocean, annual fishing effort increased until 1967 and then fluctuated ranging from 40% to 99% of the peak year until 2009. However, fishing effort has been decreasing since 2007, and in 2011 (preliminary) it decreased to about 20% of the peak value. Main reason of the decrease in recent years is probably because of the effects of pirates in the western Indian Ocean (around Somalia). Yellowfin tuna catch (in number) peaked (1,714 thousands fish) in 1968, then sharply decreased to 85 thousands fish in 1977, corresponding to 5% of the level in peaked year, and then gradually increased with fluctuation. The catch in 2006 was 708 thousand fish, which corresponds to 41% of peak value and was highest since 1970. After that the catch decreased again with slight increase in 2011. Bigeye tuna catch (in number) peaked (541 thousands fish) in 1968, then sharply decreased to 61 thousands fish in 1976, corresponding to 11% of the level in peaked year, and then fluctuated between about 100 and 400 thousands fish. Bigeye tuna catch is also decreasing recently (after 2007). Following is the description for the temporal and spatial changes of the catch and the effort including detailed description in recent years.

Fig. 3 shows geographical distribution of effort (number of hooks), albacore catch and CPUE by each decade. In the 1950s, when the effort increased (Fig. 2a), the effort was deployed mainly in the region north of 15˚S. The main component of the catch was yellowfin tuna in this fishing ground (Fig. 2b).

Following this period, the effort continued to increase up to 130 million hooks until the late 1960s (Fig. 2a). In this period, the total catch of four species of tunas, i.e., yellowfin, albacore, southern bluefin and bigeye tunas was historical highest, and species-specific catches were also the highest for yellowfin, albacore and bluefin tunas (Fig. 2b). Of the four species, yellowfin tuna was the most dominant catch in this period, followed by albacore and southern bluefin tuna. Also the catch of bigeye tuna in this period increased compared to the catch in the 1950s. In this period, fishing ground of this fishery expanded to southward, in the west side and the east side of the Indian Ocean, excluding the southern central of the Indian Ocean. Bigeye CPUE was high in the tropical area and in the region between 25˚S and 35˚S. The CPUE of yellowfin tuna was also high in the tropical area especially in the western part. In the west side of this region, main component of the catch was yellowfin tuna (Fig. 4), on the other hand, yellowfin and bigeye tunas were caught comparatively equally in the eastern equatorial area.

In the period from the late 1960s to the late 1970s, the effort decreased to about 60 million hooks, about 50% of the peak year (Fig. 2a). In this period, catch of yellowfin and bigeye drastically decreased compared to that in the previous period (Fig. 2b). This decrease was due to withdrawing in the effort from the fishing ground in the tropical area as well as decrease in CPUE.

In the period from the late 1970s to the mid 1980s, the effort increased again and reached to 130 million hooks (Fig. 2a), the same level as the previous peak in the 1960s. This increase was seen in the regions off Somalia and the south of 35˚S, targeting bigeye tuna and high quality (=oily) southern bluefin tuna, respectively.

In the period from the mid-1980s to the early 1990s, the effort decreased again (Fig. 2a). This decrease was due to the decrease of the effort in the region south of 35˚S, corresponding to the fishing ground for southern bluefin tuna, by introduction of the TAC for southern bluefin tuna in 1986.

In the period from the early to late 1990s the effort increased (Fig. 2a). The increase was seen in the regions off west coast of Australia probably targeting bigeye tuna, and south of Madagascar Island where yellowfin, albacore and bigeye were mainly caught (Fig. 4). During 1980s - 1990s effort in the tropical area is higher in the western part than in the eastern part.

In the period of 2000s the effort kept high until 2007, and sharply decreased after that (Fig. 2a). The decrease has been seen especially in the regions off Somalia since 2010 (Fig. 5, Fig. 6). This is probably due to the effect of pirates in this area as mentioned above. However, high CPUE for bigeye and yellowfin tunas was seen in the eastern tropical area and in the area around Madagascar, respectively (Fig. 5). These may have caused similar level of CPUE for these species in the last few years compared with the previous period (Fig. 2c). Recent situation of the change in the proportion of effort by area due to pirates seems to be unusual.

3.2. Purse seine fishery

Table 4 and Fig. 7 indicate effort and catch by species caught by Japanese purse seine fishery in the Indian Ocean. Annual fishing effort (number of set) increased in 1990s and marked historical highest value (2,400 sets) in 1992, and then decreased rapidly to 170 sets in 2000, after that it showed stable trend in low level and around 100 sets in recent two years. The annual catch of the tropical tuna were coincided with the trend of effort, which reached to 45,000 mt in 1992 and then decreased to 3,000 mt in 2000, it exhibited about 3,000 mt in 2011. The number of Japanese purse seine vessels in the Indian Ocean from 1991 to 1992 was 11, and then sharply decreased to 2 in 2000, and then fluctuated from 1 to 5 after 2001.

Fig. 8 and Fig. 9 show geographical distribution of effort (number of sets) of each decade and nominal CPUE by species. Fig. 10 and Fig. 11 show geographical distribution of catch by species of each decade. From late 1980s to middle 1990s, when the effort increased (Table 4), the effort deployed in the whole tropical area of the Indian Ocean, and then the effort mainly distributed in the eastern area of the Indian Ocean. The CPUE and catch of bigeye tuna was relatively high in the east side of the Indian Ocean. After mid-1990s Japanese purse seine vessels mainly operated using FADs.

4. Size data

4.1. Longline fishery

Table 5 shows the number of measurement for bigeye and yellowfin tunas caught by the longline vessel by type of vessels. The annual number of samples for bigeye tuna peaked (about ten thousand individuals) in 1988, but then decreased to less than one thousand individuals. On-board measurements by training longline vessels had been main data source until early 1990s, but recently almost no training longline vessels are operating in the

Indian Ocean. As for yellowfin tuna, the annual number of samples ranged between one thousand and 12 thousand fish with the peak in 2000. Several fish are measured by on-board observers (not included in the table).

Fig. 12 shows length frequency of bigeye tuna stratified by decade, area and quarter. There was almost no change among decades, but the mode in 2010s was a bit larger than those in other decades. 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. 13 shows length distribution of bigeye tuna stratified by quarter and area. No distinct difference of fish size was observed, but a certain proportion of small fish (smaller than 100cm FL) were caught in Area 2 in the second to fourth quarter and in Area 4 in the first, third and fourth quarter, all of which show comparatively clear mode.

Fig. 14 shows length frequency of yellowfin tuna stratified by decade, area and quarter. There was almost no change among decades. The proportion of smaller fish (smaller than 110cm FL) in the Area 3 (around Madagascar) and Area 5 (eastern equatorial area) were a bit larger than those in the Area 2 (off Somalia) and Area 4 (southeastern area). The proportion of smaller fish (smaller than 110cm FL) in the second quarter was larger than those in the other quarters. Fig. 15 shows length distribution of yellowfin tuna stratified by quarter and area. No distinct difference of fish size was observed in the Area 2. In area 3, a certain proportion of small fish (smaller than 110cm FL) were caught in the second quarter. Also in the Areas 4 and 5, some smaller fish were caught in the first and second quarter.

Table 1. Catch in weight (t) for bigeye and yellowfin tuna caught by Japanese longline fishery. Western: FAO area No. 51 (mostly west of 80°E), eastern: FAO area No. 57 (mostly east of 80°E). Data source: IOTC database.

	Bigeye tuna			Yellowfin tuna		
Year	Western	Eastern	Total	Western	Eastern	Total
1952		280	280		3,683	3,683
1953		1,653	1,653		6,757	6,757
1954	592	6,158	6,750	5,660	16,006	21,666
1955	4,045	5,494	9,539	32,404	11,759	44,163
1956	5,481	6,764	12,245	42,805	16,680	59,485
1957	3,811	7,279	11,090	15,291	16,573	31,864
1958	4,782	5,371	10,153	12,273	10,371	22,644
1959	4,056	4,310	8,366	14,379	7,803	22,182
1960	7,903	6,910	14,813	24,107	11,948	36,055
1961	5,918	7,130	13,048	24,862	7,868	32,730
1962	7,878	9,401	17,279	28,874	15,317	44,191
1963	5,296	6,304	11,600	16,052	5,929	21,981
1964	7,536	8,473	16,009	15,412	6,751	22,163
1965	9,100	8,467	17,567	18,522	6,404	24,926
1966	14,887	6,500	21,387	33,543	7,219	40,762
1967	13,102	8,697	21,799	22,223	7,940	30,163
1968	15,489	8,125	23,614	42,349	5,977	48,326
1969	10,860	3,493	14,353	19,625	3,489	23,114
1970	4,973	7,736	12,709	4,569	5,771	10,340
1971	6,901	4,285	11,186	9,793	3,577	13,370
1972	6,701	1,647	8,348	6,171	1,713	7,884
1973	3,395	1,767	5,162	2,472	1,462	3,934
1974	3,464	3,422	6,886	2,904	2,045	4,949
1975	2,972	2,552	5,524	4,304	2,116	6,420
1976	1,175	933	2,108	1,903	876	2,779
1977	2,030	1,107	3,137	1,656	444	2,100
1978	7,637	3,268	10,905	3,880	740	4,620
1979	2,297	1,910	4,207	2,583	712	3,295
1980	3,433	2,466	5,899	1,944	1,292	3,236
1981	5,860	1,915	7,775	3,855	1,062	4,917
1982	8,955	2,439	11,394	6,034	1,246	7,280
1983	13,744	4,588	18,332	5,979	1,814	7,793
1984	9,313	4,709	14,022	5,295	2,608	7,903
1985	13,647	3,592	17,239	7,205	2,260	9,465
1986	12,114	3,644	15,758	8,276	2,428	10,704
1987	11,179	4,330	15,509	5,723	2,586	8,309
1988	9,481	2,773	12,254	6,885	2,370	9,255
1989	6,269	1,432	7,701	3,443	1,149	4,592
1990	5,837	2,385	8,222	4,395	1,941	6,336
1991	4,915	2,853	7,768	3,487	901	4,388
1992	4,011	1,618	5,629	5,193	548	5,741
1993	4,243	4,074	8,317	5,349	365	5,714
1994	9,946	7,536	17,482	8,903	814	9,717
1995	7,742	9,469	17,211	6,265	1,761	8,026
1996	8,090	8,364	16,454	11,396	1,411	12,807
1997	10,741	8,063	18,804	13,942	1,658	15,600
1998	11,103	6,021	17,124	15,347	1,457	16,804
1999	6,234	7,762	13,996	11,990	2,673	14,663
2000	6,540	7,019	13,559	12,602	2,873	15,475
2001	5,441	7,601	13,042	11,858	2,082	13,940
2002	6,360	7,521	13,881	12,763	1,170	13,933
2003	6,715	3,251	9,965	16,598	560	17,159
2004	7,382	3,263	10,645	15,556	479	16,034
2005	10,840	1,704	12,544	21,178	314	21,492
2006	9,455	4,465	13,920	21,698	612	22,310
2007	13,072	5,096	18,168	17,800	792	18,592
2008	8,390	5,349	13,739	10,010	415	10,425
2009	3,761	5,232	8,993	4,437	441	4,878
2010	1,090	3,155	4,244	3,274	199	3,473
2011	764	2,517	3,281	3,992	139	4,131

Table 2. Tropical tunas (skipjack tuna, yellowfin tuna and bigeye tuna) and other tuna like species catch in weight (t) caught by Japanese purse seine fishery in the Indian Ocean. Western: FAO area No. 51, eastern: FAO area No. 57.

Year	Western	Eastern	Total
1972	0	1	1
1973	0	0	0
1974	0	0	0
1975	0	0	0
1976	0	0	0
1977	0	1	1
1978	0	1,138	1,138
1979	0	678	678
1980	0	555	555
1981	0	85	85
1982	0	605	605
1983	530	315	845
1984	961	220	1,181
1985	570	0	570
1986	868	0	868
1987	649	636	1,284
1988	2,741	249	2,990
1989	4,986	0	4,986
1990	15,754	0	15,754
1991	22,177	65	22,242
1992	45,061	165	45,226
1993	41,202	3,406	44,608
1994	7,828	21,812	29,640
1995	625	23,649	24,274
1996	605	12,346	12,951
1997	3,311	7,285	10,596
1998	350	8,264	8,614
1999	668	6,331	6,999
2000	565	3,477	4,042
2001	385	2,642	3,027
2002	1,275	1,758	3,033
2003	952	2,954	3,906
2004	80	2,230	2,310
2005	545	4,347	4,892
2006	135	2,660	2,795
2007	125	6,117	6,242
2008	100	5,217	5,317
2009	0	5,562	5,562
2010	5	3,075	3,080
2011	760	2,397	3,157

Table 3. Annual fishing effort (number of hooks) for the Japanese longline fishery and its catch in number by species.

	#of hooks	Catch in number (thousand)							
	(thousand)	SBT	ALB	BET	YFT	SWO	STM	BUM	BKM
1952	2,021	6	3	21	131	0	3	9	6
1953	7,071	50	57	53	240	2	7	27	17
1954	12,557	31	142	137	472	4	21	47	25
1955	16,109	24	157	173	972	5	19	51	24
1956	30,064	119	258	281	1,245	10	45	74	41
1957	26,609	193	232	215	728	8	50	57	36
1958	23,269	120	301	191	556	12	46	62	30
1959	34,021	693	524	169	598	12	56	64	28
1960	52,554	1,072	574	314	962	15	52	56	41
1961	59,807	910	777	270	869	17	65	49	35
1962	65,755	432	1,010	419	1,331	22	48	46	45
1963	56,453	649	722	264	655	17	34	27	26
1964	68,342	490	1,010	334	594	21	38	43	34
1965	80,372	459	630	386	767	25	81	50	30
1966	93,511	428	752	479	1,156	29	105	50	31
1967	129,496	787	850	517	903	40	114	51	35
1968	124,438	689	623	541	1,714	30	63	34	44
1969	108,171	674	589	378	771	31	59	26	35
1970	89,731	454	304	342	375	27	45	17	25
1971	96,596	411	228	290	480	24	28	14	16
1972	80,158	467	100	212	294	21	21	14	6
1973	82,768	442	145	138	148	17	15	8	5
1974	88,397	476	182	190	200	18	38	13	10
1975	90,236	322	79	179	249	19	25	10	11
1976	80,284	452	99	61	95	9	14	4	4
1977	62,583	365	33	98	85	6	13	4	2
1978	69,281	259	32	312	170	23	44	13	7
1979	67,728	254	32	122	133	12	25	6	3
1980	91,661	357	47	161	106	13	24	8	4
1981	88,407	294	87	191	159	16	21	10	4
1982	88,257	238	105	283	228	22	15	15	4
1983	116,631	367	141	428	239	26	16	22	6
1984	118,289	296	136	346	245	28	25	19	11
1985	128,438	250	176	410	281	47	25	20	8
1986	123,252	181	204	382	311	30	24	17	5
1987	109,888	152	160	382	238	30	16	13	4
1988	93,254	141	99	295	266	33	6	10	3
1989	82,513	143	68	182	129	21	3	5	2
1990	52,576	86	68	199	175	23	2	4	1
1991	62,434	98	61	208	122	20	4	3	1
1992	59,284	102	127	133	142	25	3	3	1
1993	52,337	80	96	214	172	24	2	4	1
1994	81,657	90	141	393	253	39	5	8	1
1995	92,232	69	148	395	222	27	5	5	1
1996	107,875	79	179	384	326	33	6	7	1
1997	126,309	97	275	433	382	46	7	15	1
1998	124,226	136	237	407	443	39	6	16	2
1999	107,647	119	157	348	410	26	6	11	2
2000	103,463	65	200	336	433	26	7	12	1
2001	109,752	92	226	321	400	21	3	6	1
2002	105,990	62	221	328	397	23	3	6	1
2003	78,269	35	152	246	535	18	1	5	1
2004	98,237	91	281	260	497	20	2	6	1
2005	113,861	104	364	296	666	26	2	6	1
2006	118,365	71	481	342	708	33	3	10	2
2007	117,675	51	399	456	596	45	2	11	2
2008	89,373	22	362	336	332	33	4	8	2
2009	64,951	37	240	233	160	22	1	6	1
2010	37,037	31	283	122	121	12	5	3	1
2011	26,314	36	185	92	136	9	6	2	1

Table 4. Annual fishing effort (number of sets) for the Japanese purse seine fishery and its catch in weight (t) by species.

		Catch (mt)			
Year	Number of set	SKJ	YFT	BET	Others
1972	1	0	1	0	0
1973	1	0	0	0	0
1974	1	0	0	0	0
1975	0	0	0	0	0
1976	0	0	0	0	0
1977	1	1	0	0	0
1978	107	918	215	5	0
1979	56	566	103	1	8
1980	50	421	122	8	4
1981	8	46	32	1	7
1982	45	453	120	21	11
1983	120	592	198	54	1
1984	129	696	242	215	28
1985	45	315	75	168	12
1986	84	562	160	142	3
1987	168	884	260	122	18
1988	184	2250	389	277	74
1989	365	3449	883	581	73
1990	849	11187	3222	1225	120
1991	1397	15877	5061	1269	36
1992	2432	31400	11746	1732	348
1993	2254	31479	11082	1984	64
1994	1681	20110	5343	4182	5
1995	1228	15972	4719	3576	7
1996	658	7515	4035	1386	15
1997	526	6713	2612	1251	20
1998	412	5748	1949	915	2
1999	376	4588	1501	899	11
2000	171	2332	953	747	10
2001	161	1830	603	592	2
2002	142	1937	445	649	2
2003	167	2443	651	812	0
2004	89	1459	327	524	0
2005	141	3149	894	849	0
2006	59	1982	266	547	0
2007	178	4297	958	987	0
2008	239	3133	1175	1009	0
2009	185	3434	557	1571	0
2010	92	1731	481	868	0
2011	105	1675	352	1130	0

Table 5. Number of size data for bigeye and yellowfin tuna caught by longline fishery.

Year	Bigeye tuna			Yellowfin tuna		
	Commercial vessel	Training Vessel	Total	Commercial vessel	Training Vessel	Total
1965	0	0	0	0	0	0
1966	7	0	7	20	0	20
1967	0	0	0	0	0	0
1968	0	0	0	0	0	0
1969	0	0	0	0	0	0
1970	0	0	0	0	0	0
1971	0	0	0	0	0	0
1972	0	0	0	0	48	48
1973	0	41	41	0	0	0
1974	0	175	175	0	0	0
1975	0	266	266	0	216	216
1976	0	383	383	0	1312	1,312
1977	0	2603	2,603	0	1729	1,729
1978	33	2562	2,595	0	1757	1,757
1979	0	1895	1,895	0	2294	2,294
1980	0	3250	3,250	0	1608	1,608
1981	0	2236	2,236	0	2068	2,068
1982	0	3747	3,747	0	3710	3,710
1983	0	4989	4,989	0	3053	3,053
1984	0	9953	9,953	0	9058	9,058
1985	0	8337	8,337	0	5246	5,246
1986	2670	0	2,670	1493	0	1,493
1987	2319	0	2,319	1831	0	1,831
1988	2266	10503	12,769	2139	2776	4,915
1989	6993	9070	16,063	4019	2356	6,375
1990	6252	8710	14,962	4429	2185	6,614
1991	4412	6666	11,078	2811	2026	4,837
1992	1972	2359	4,331	550	587	1,137
1993	3069	1213	4,282	2656	632	3,288
1994	4078	313	4,391	3858	152	4,010
1995	3251	1166	4,417	5057	415	5,472
1996	1277	1315	2,592	3087	255	3,342
1997	4288	3330	7,618	6215	655	6,870
1998	4629	748	5,377	8597	368	8,965
1999	924	118	1,042	4695	160	4,855
2000	7394	284	7,678	11952	884	12,836
2001	1771	197	1,968	4037	436	4,473
2002	2061	44	2,105	1418	25	1,443
2003	725	43	768	855	19	874
2004	325	41	366	905	19	924
2005	498	0	498	1042	0	1,042
2006	205	0	205	1281	0	1,281
2007	366	0	366	1140	0	1,140
2008	0	0	0	0	0	0
2009	0	0	0	0	0	0
2010	2	0	2	0	0	0
2011	156	0	156	38	0	38

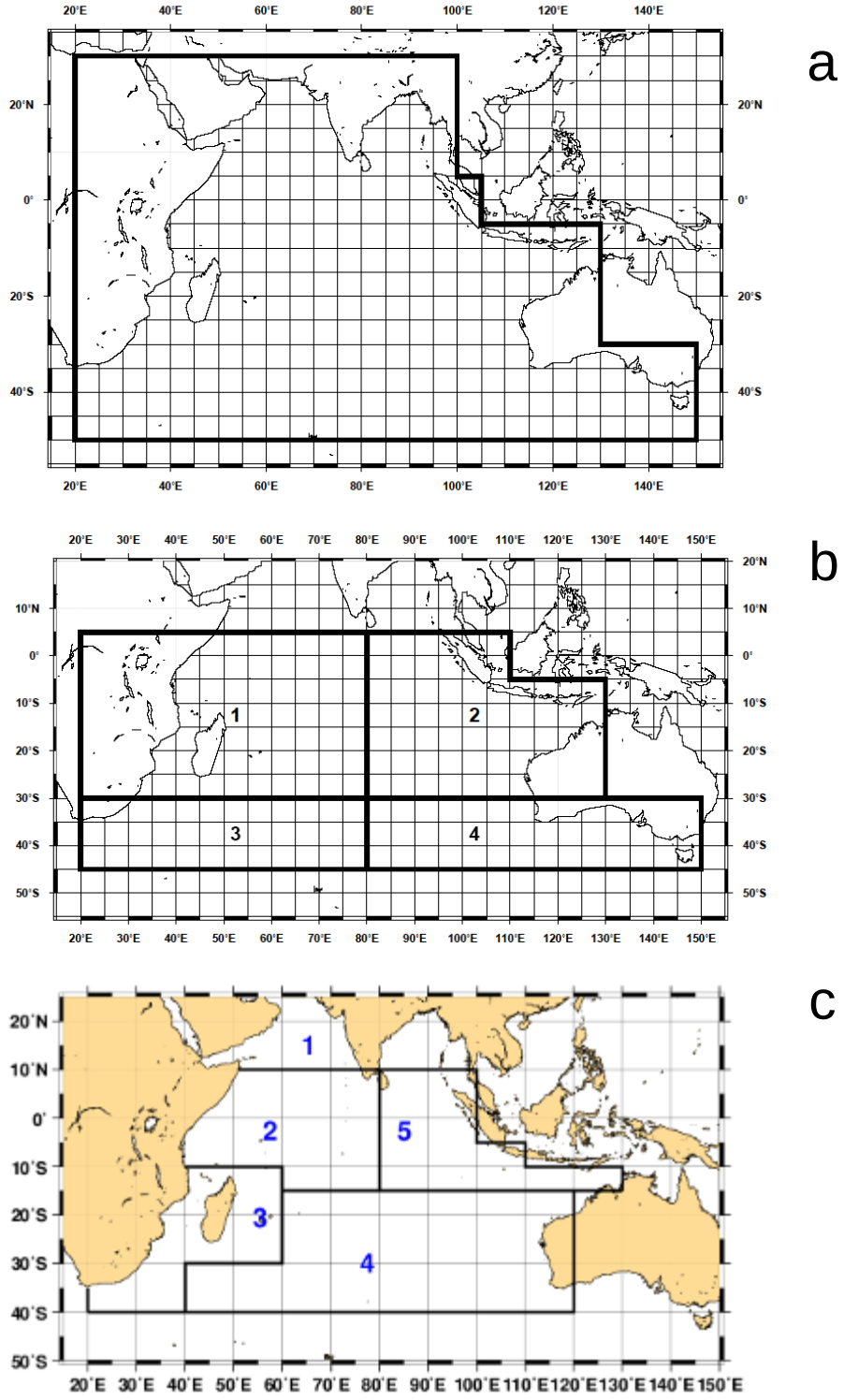

Fig. 1. The geographical range to count the amount of the effort and the catches (a), area definition to count the number of sample of length data for bigeye tuna (b) and yellowfin tuna (c).

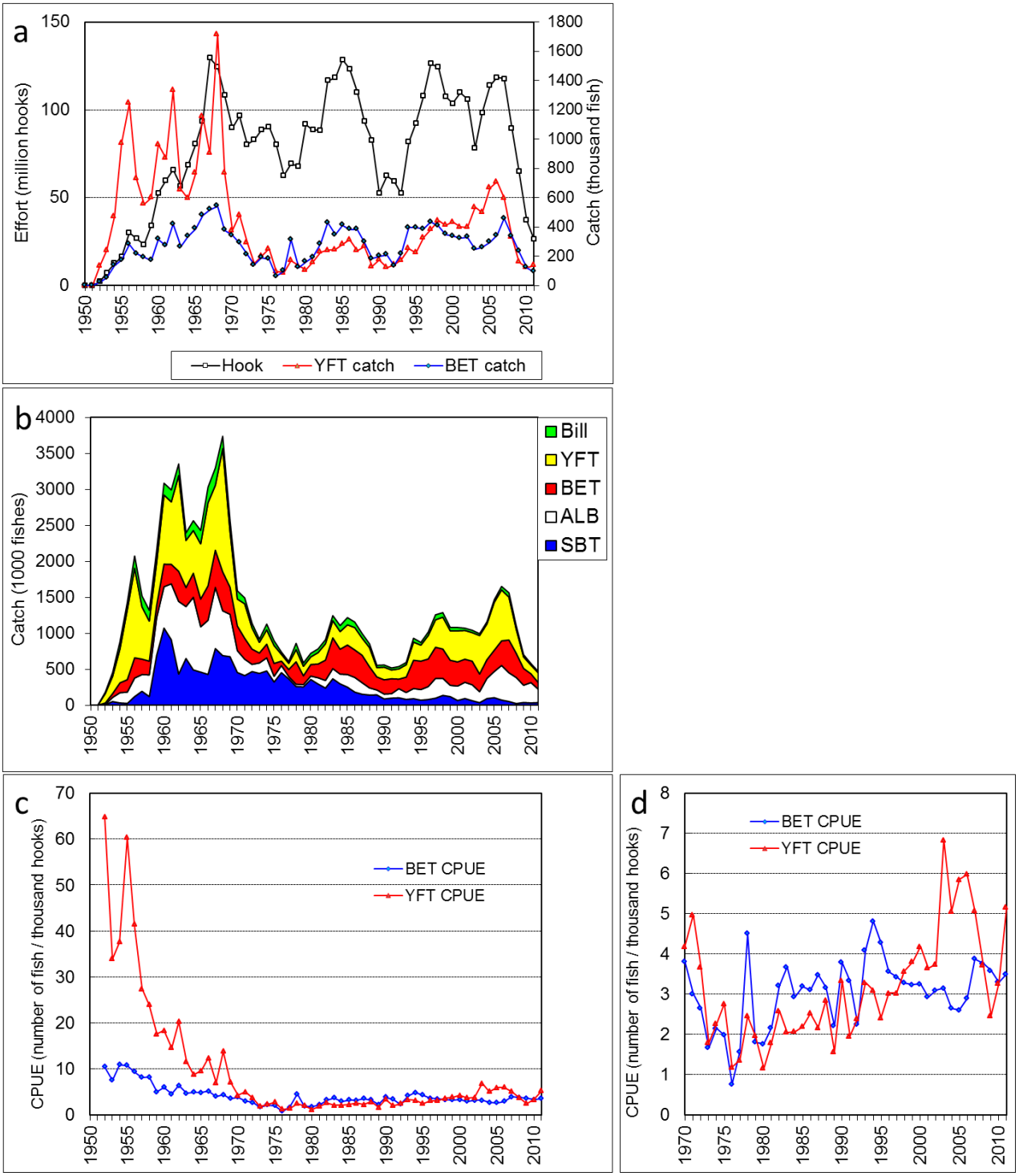

Fig. 2. The number of hooks employed and catch of bigeye and yellowfin tuna (a), species composition (b), and nominal CPUE of bigeye and yellowfin tuna for 1952-2011 (c) and for 1970-2011 (d) caught by Japanese longline fishery.

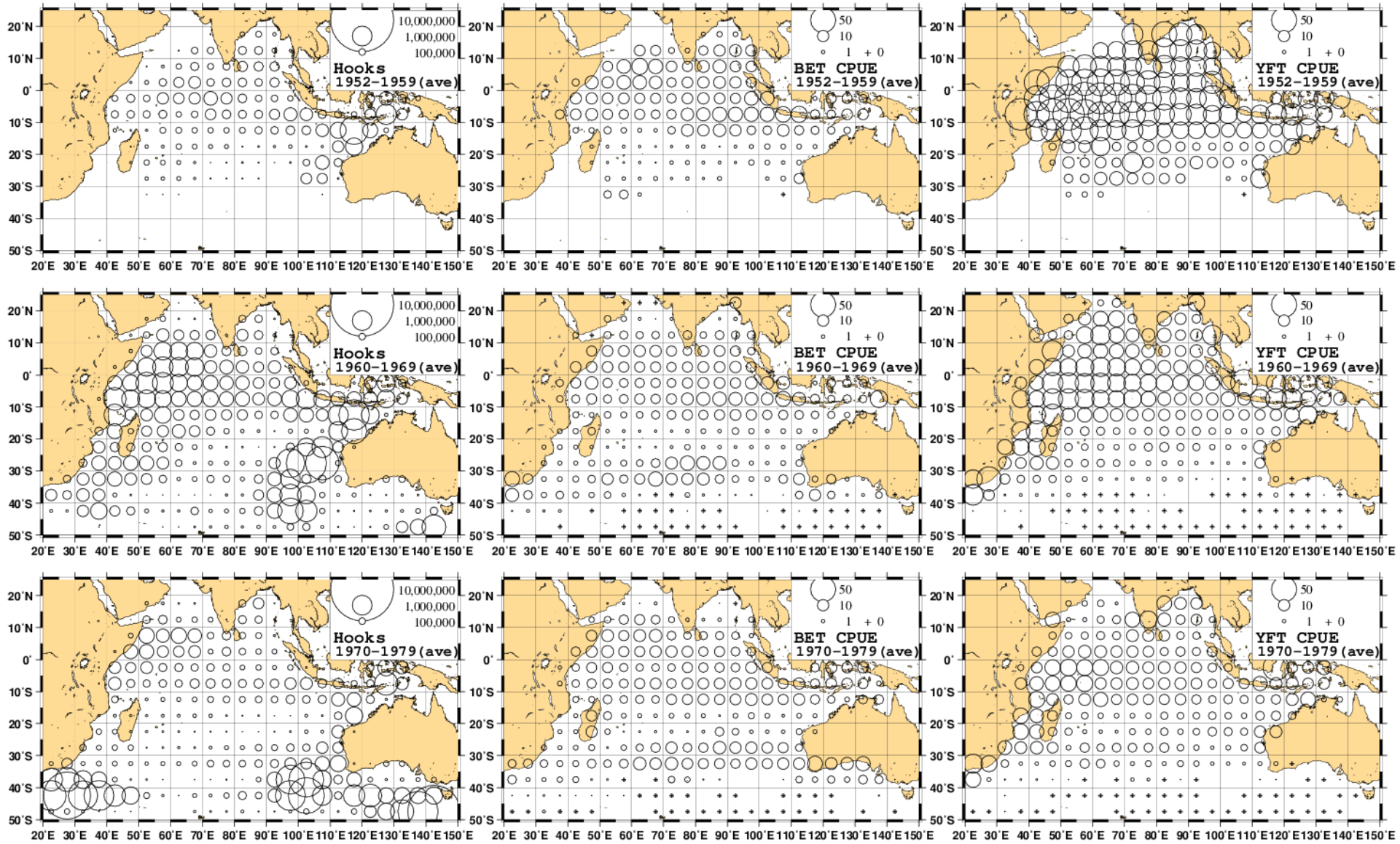

Fig. 3. The average distribution of the effort (number of hooks) and bigeye and yellowfin tuna CPUE (number of fish/1000hooks) for each decadal period.

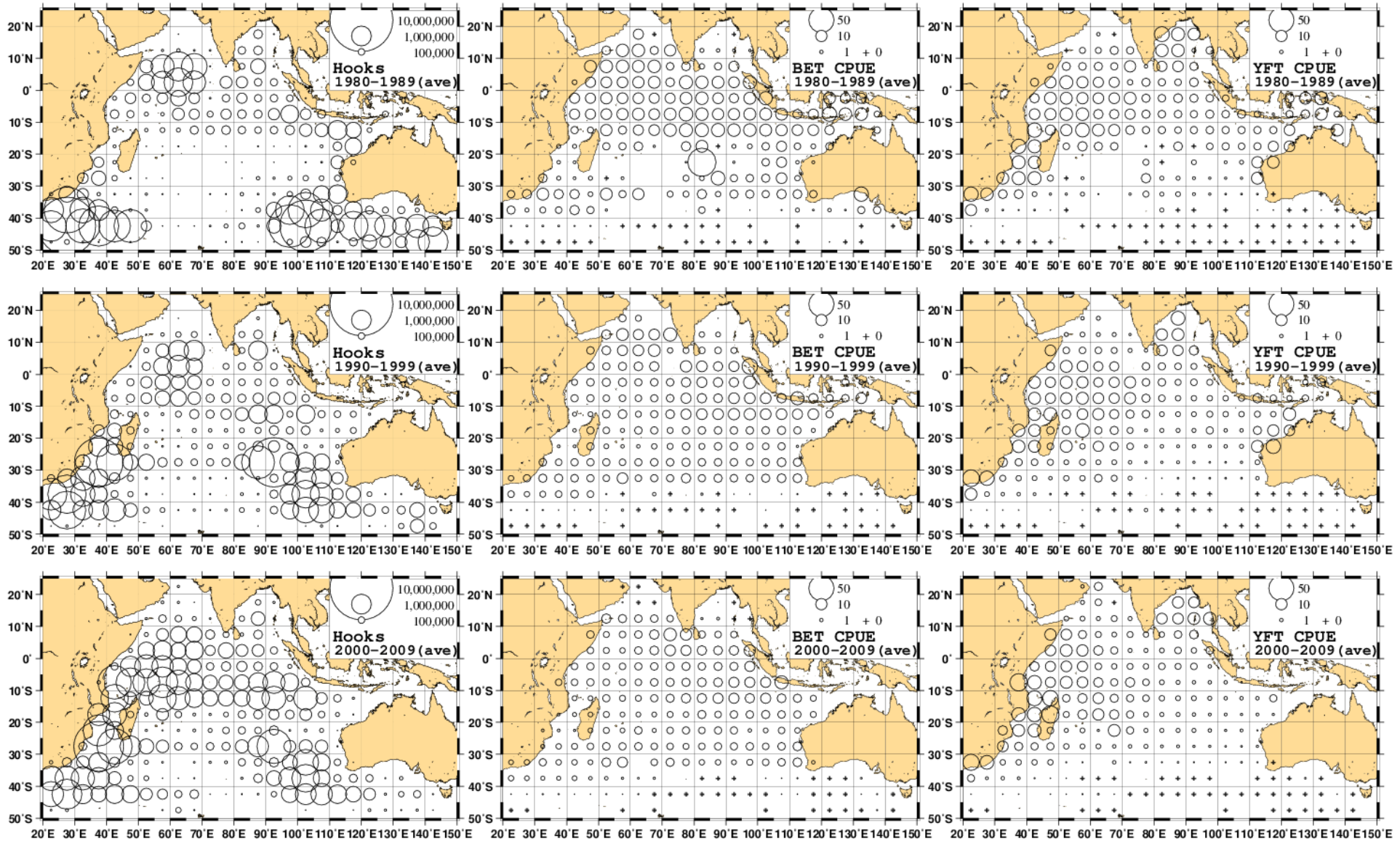

Fig. 3. The average distribution of the effort (number of hooks) and bigeye and yellowfin tuna CPUE (number of fish/1000hooks) for each decadal period.(continued)

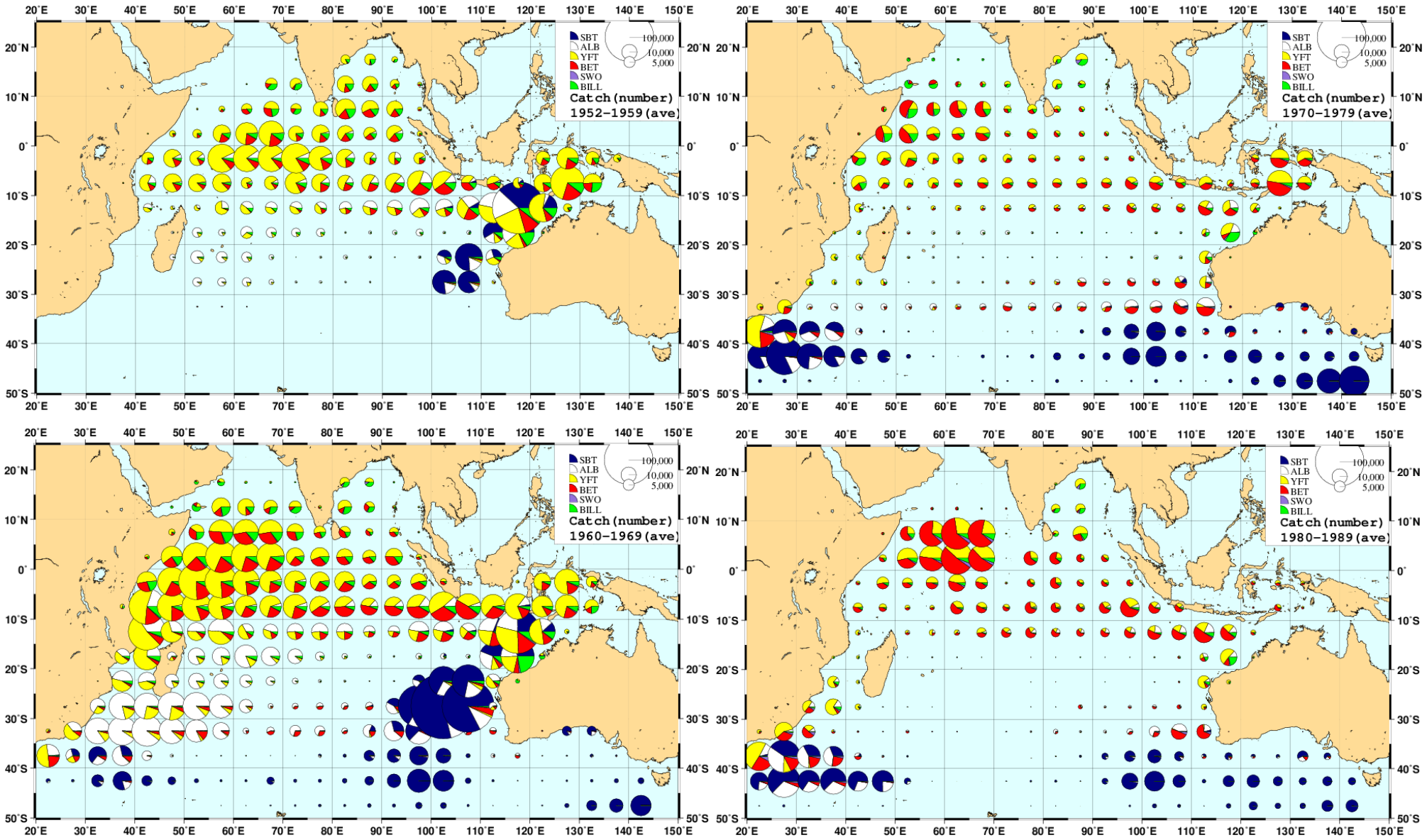

Fig. 4. The averaged distribution of amount of catch in number by species for each decade. Size of circle shows amount of total of catches i.e. southern bluefin tuna (SBT), albacore (ALB), bigeye tuna (BET), yellowfin tuna (YFT), swordfish (SWO) and billfishes (BILL).

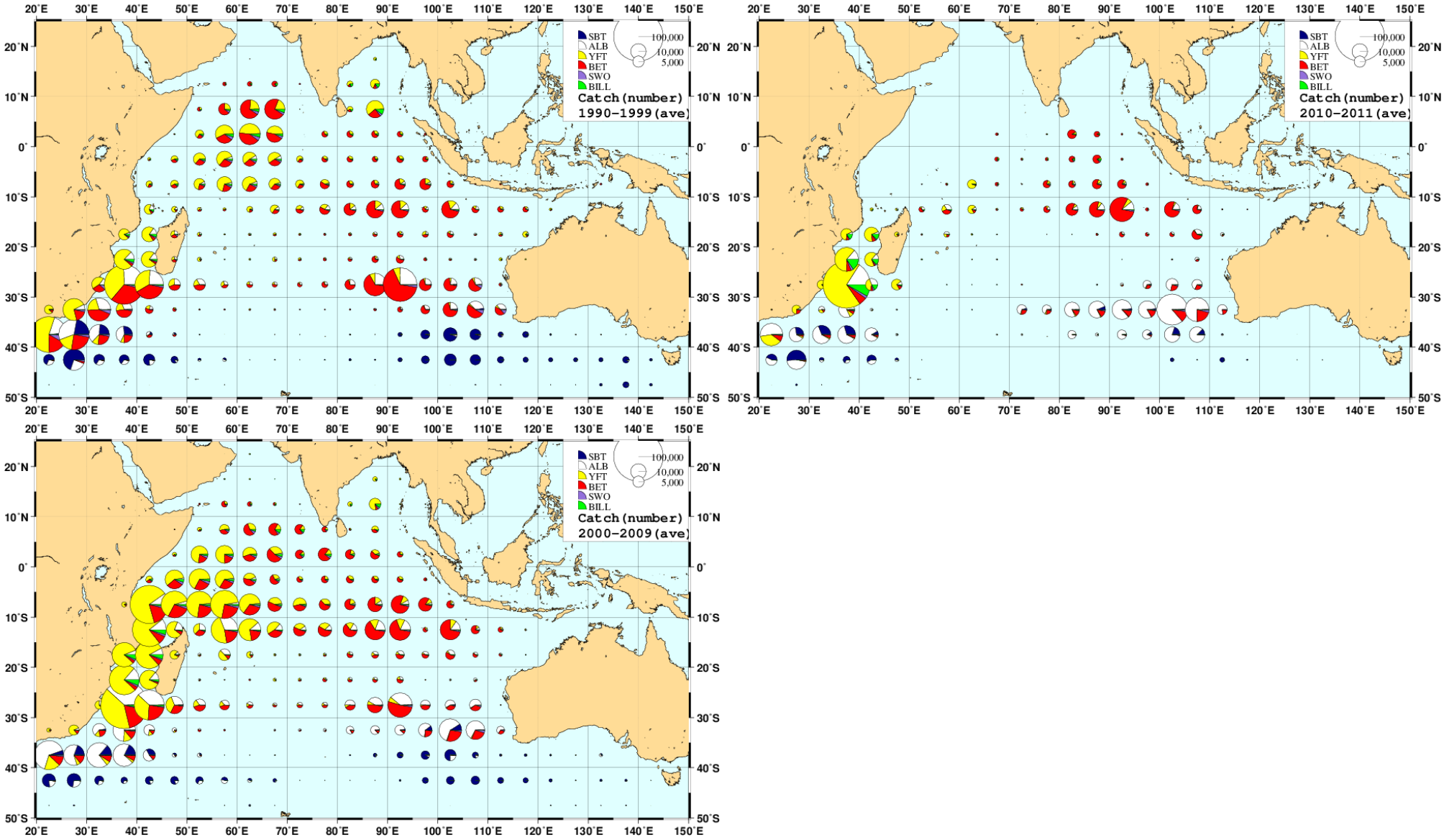

Fig. 4. The averaged distribution of amount of catch in number by species for each decade. Size of circle shows amount of total of catches i.e. southern bluefin tuna (SBT), albacore (ALB), bigeye tuna (BET), yellowfin tuna (YFT), swordfish (SWO) and billfishes (BILL). (continued)

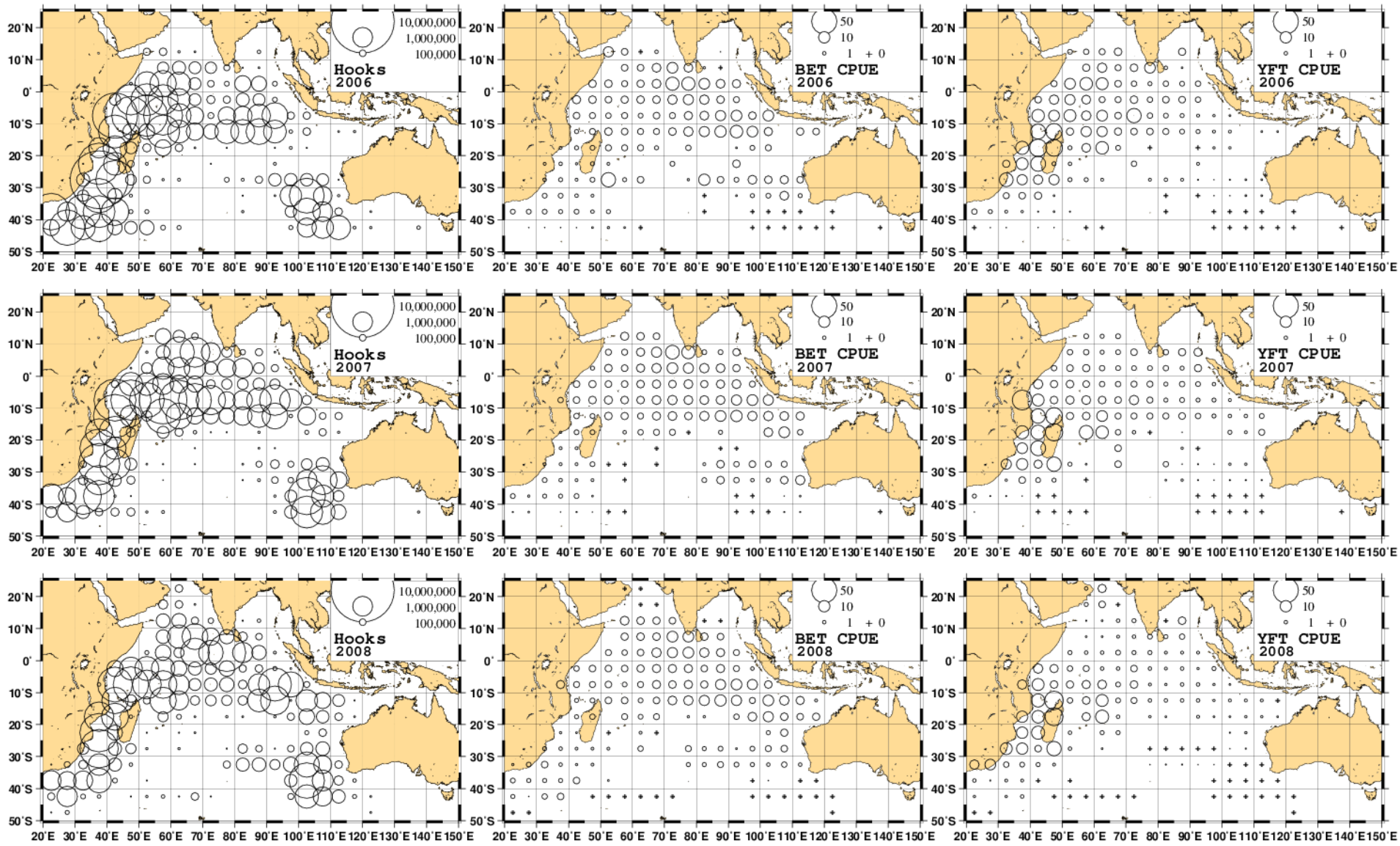

Fig. 5. The geographical distribution of the effort (number of hooks) and bigeye and yellowfin tuna CPUE (number of fish/1000hooks) in recent years.

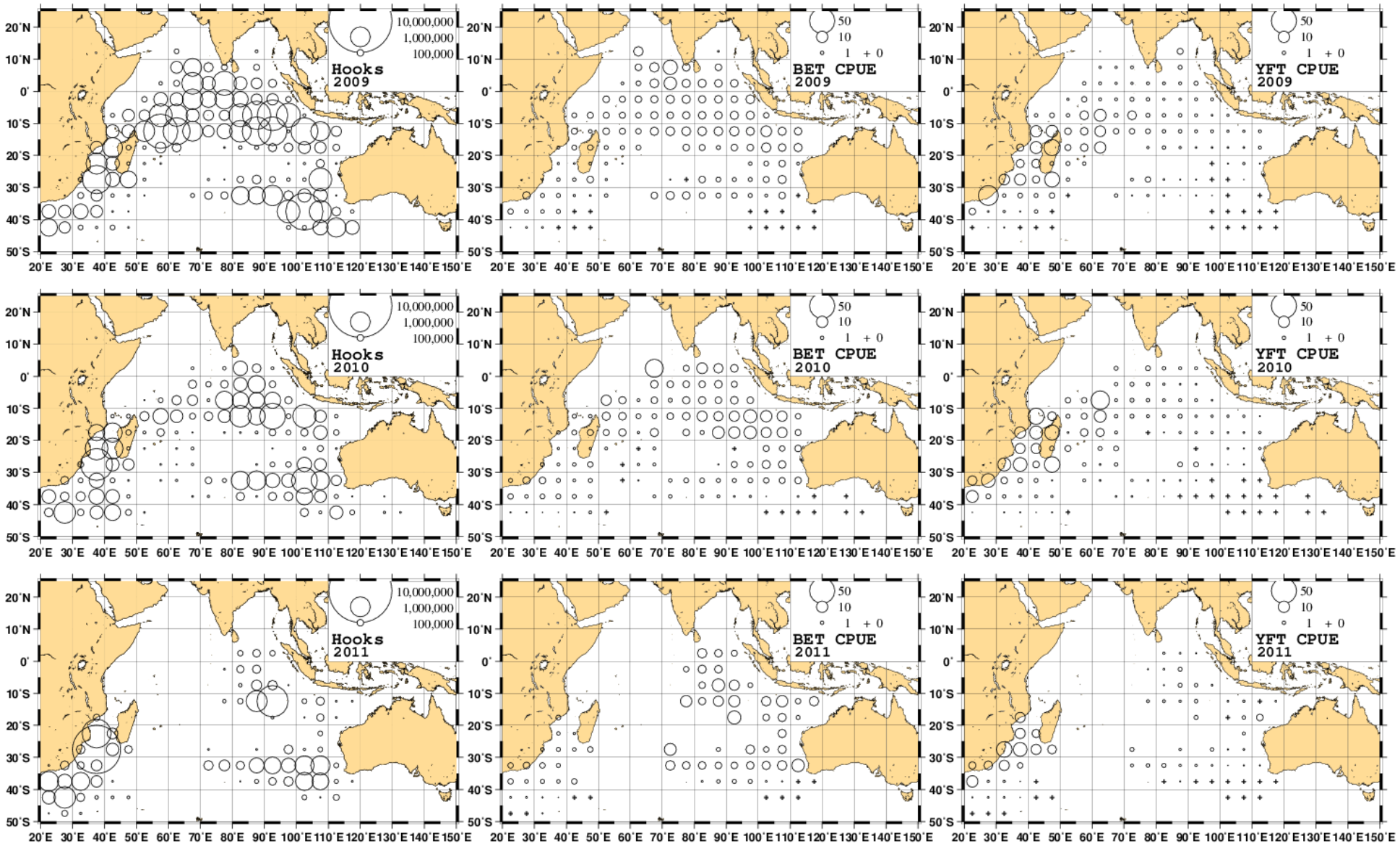

Fig. 5. The geographical distribution of the effort (number of hooks) and bigeye and yellowfin tuna CPUE (number of fish/1000hooks) in recent years. (continued)

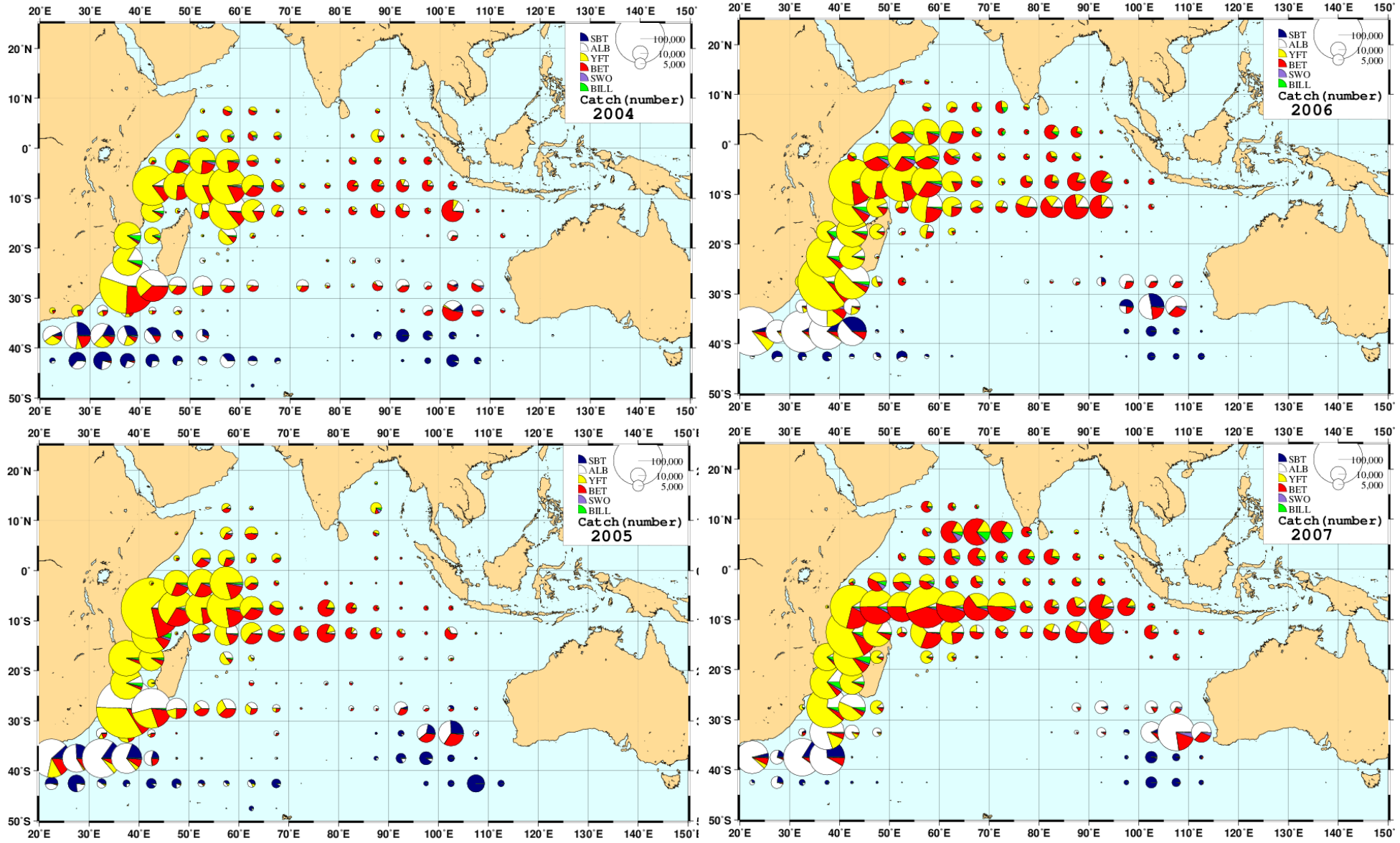

Fig. 6. Annual recent distribution of amount of catch in number by species. Size of circle shows amount of total of catches i.e. southern bluefin tuna (SBT), albacore (ALB), bigeye tuna (BET), yellowfin tuna (YFT), swordfish (SWO) and billfishes (BILL).

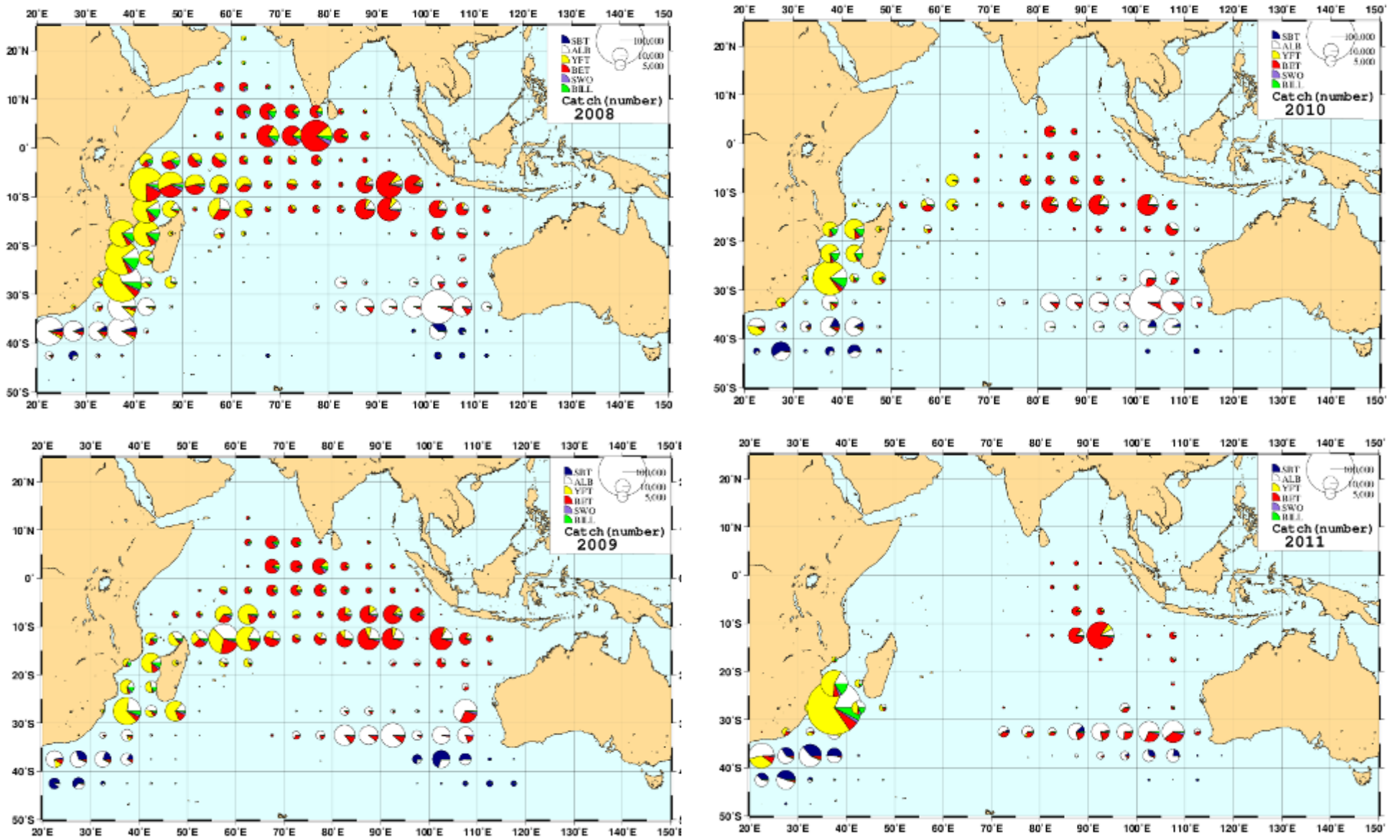

Fig. 6. Annual recent distribution of amount of catch in number by species. Size of circle shows amount of total of catches i.e. southern bluefin tuna (SBT), albacore (ALB), bigeye tuna (BET), yellowfin tuna (YFT), swordfish (SWO) and billfishes (BILL).(continued)

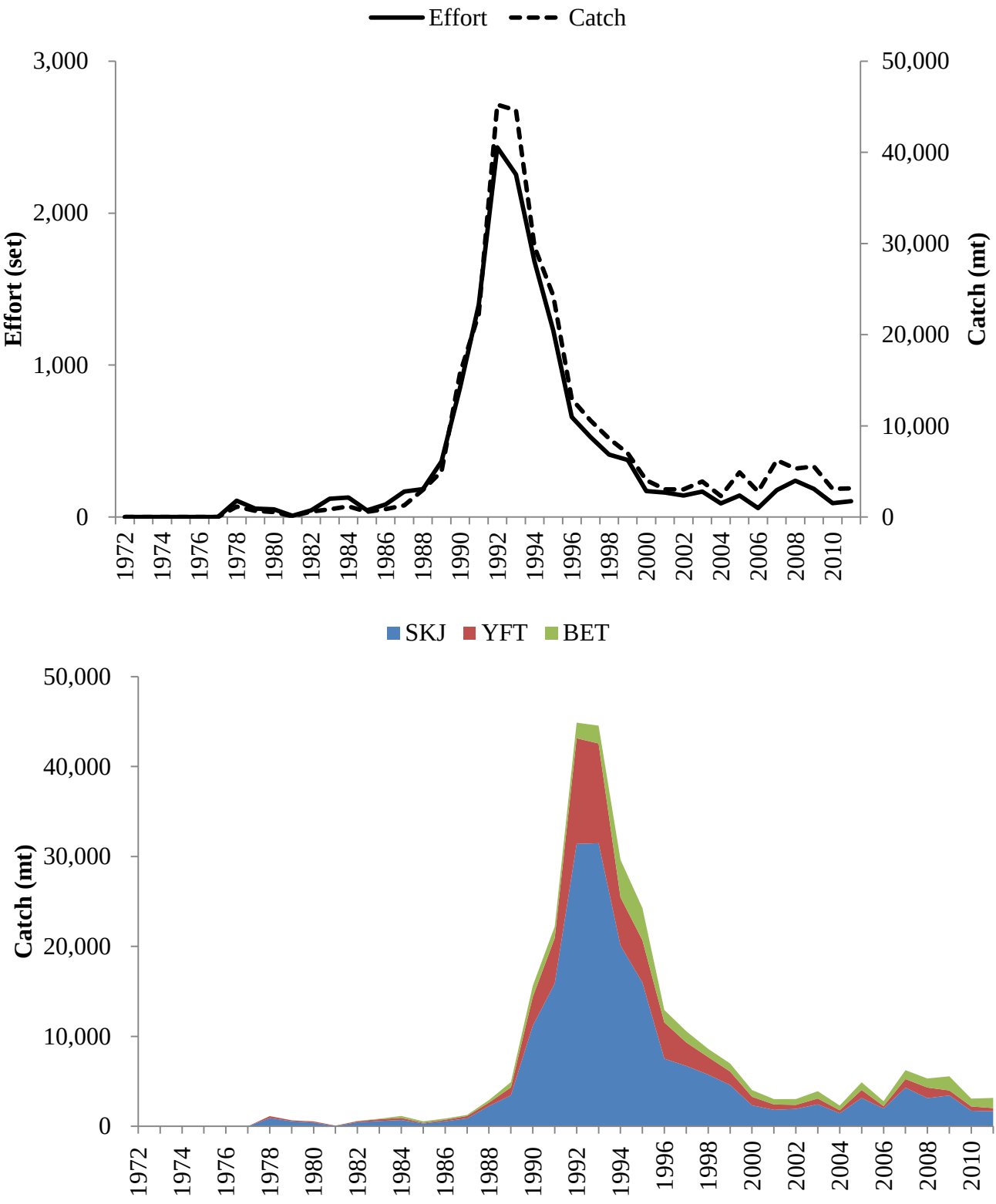

Fig. 7. The number of purse seine sets and catch of tropical tunas (skipjack tuna, yellowfin tuna and bigeye tuna) (upper panel), species composition (lower panel) caught by Japanese purse seine fishery in the Indian Ocean.

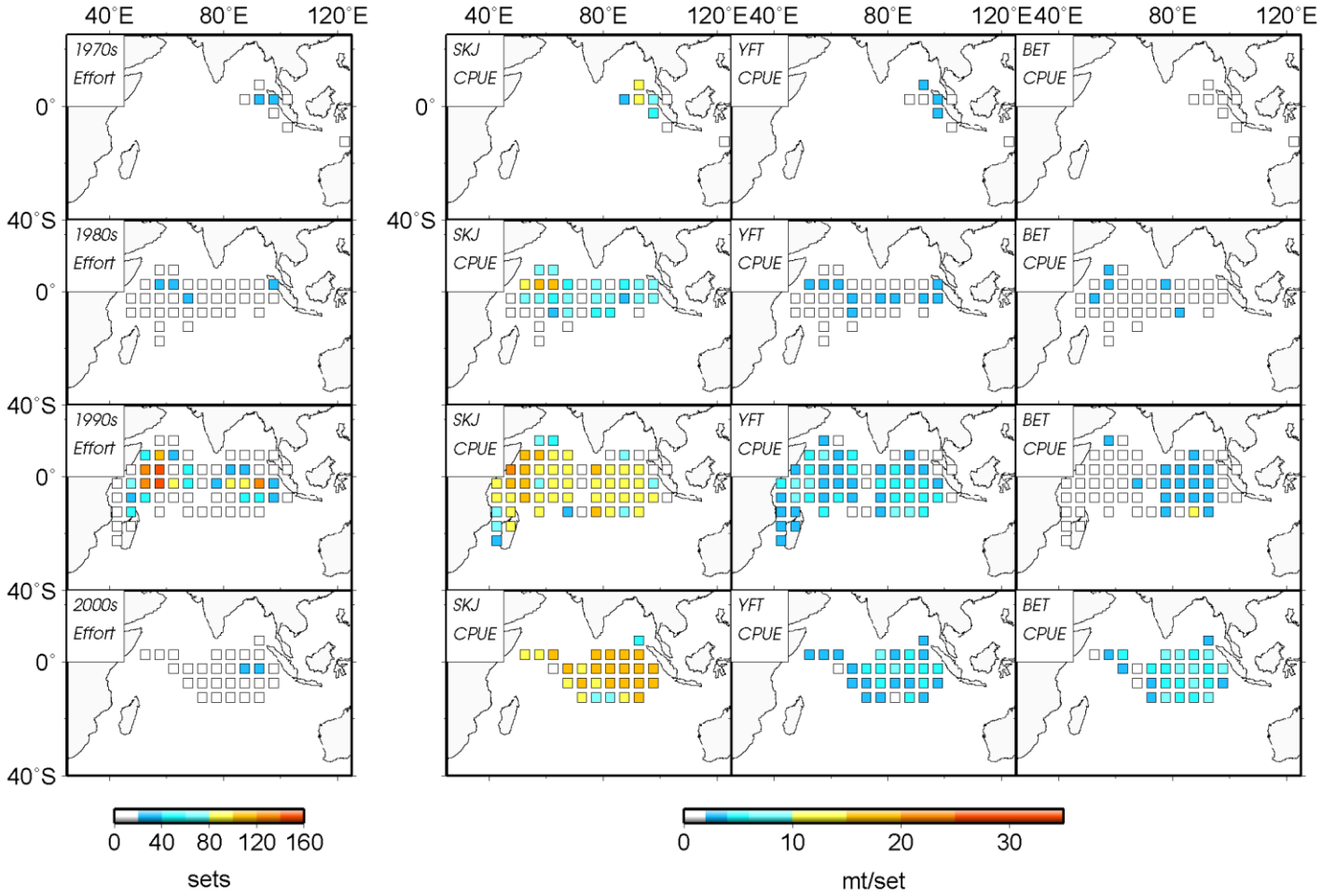

Fig. 8. The average distribution of the Japanese purse seine effort (number of sets), nominal CPUE (weight (metric ton) per set) for tropical tunas (SKJ; skipjack tuna, YFT; yellowfin tuna, BET; bigeye tuna) for each decadal period.

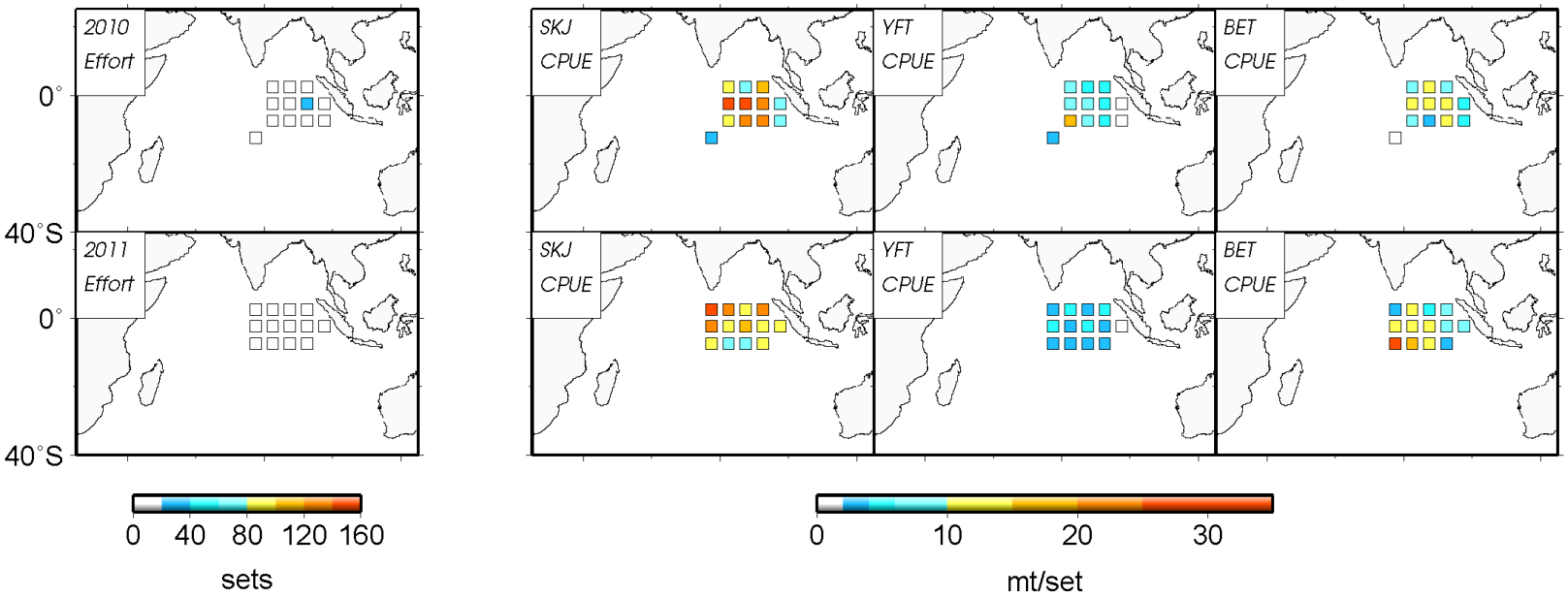

Fig. 9. The average distribution of the Japanese purse seine effort (number of sets), nominal CPUE (weight (metric ton) per set) for tropical tunas (SKJ; skipjack tuna, YFT; yellowfin tuna, BET; bigeye tuna) in recent two years.

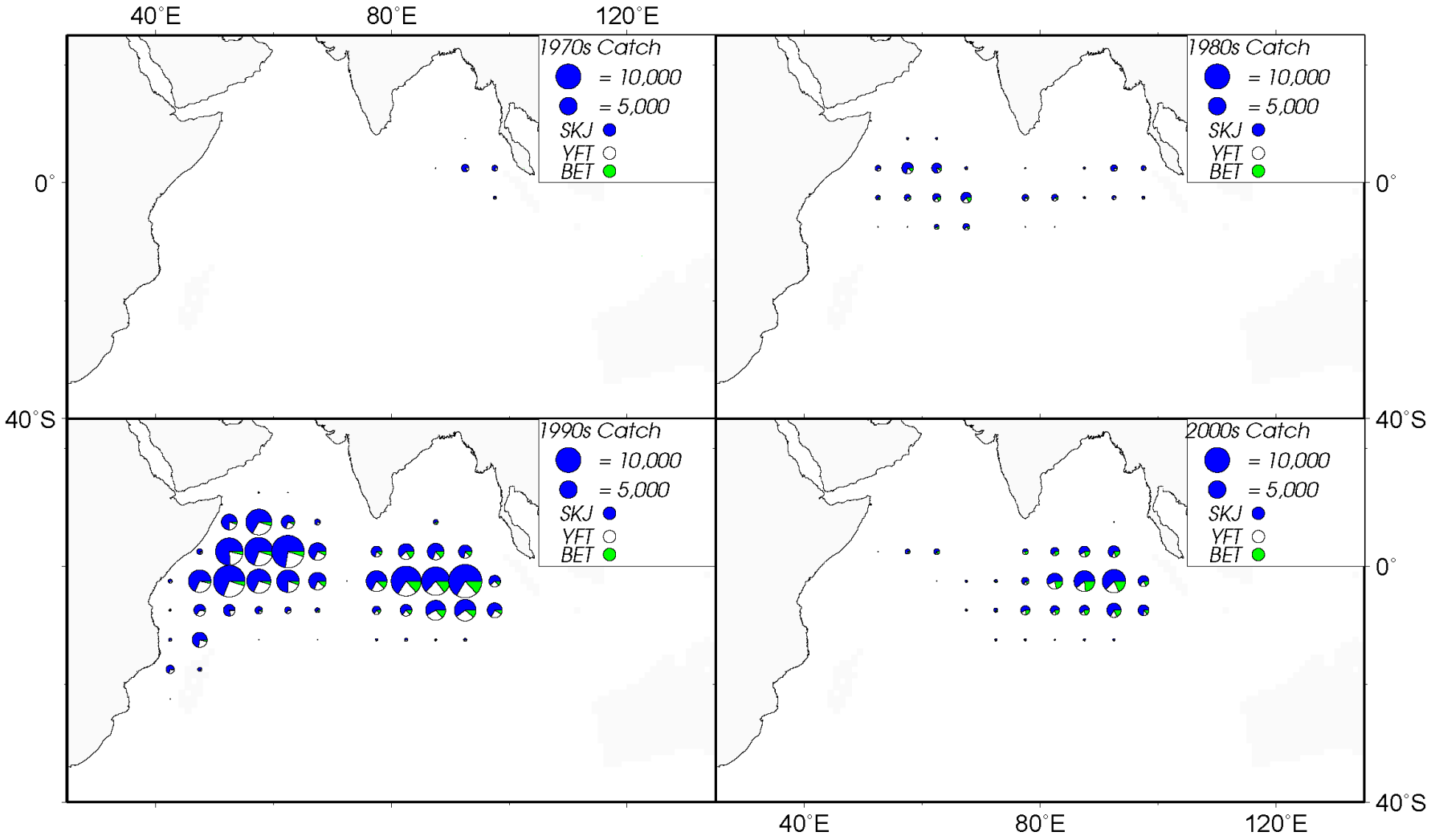

Fig. 10. The average distribution of amount of catch in weight of the Japanese purse seine by species (SKJ; skipjack tuna, YFT; yellowfin tuna, BET; bigeye tuna) for each decade. Size of circles shows amount of total of catches.

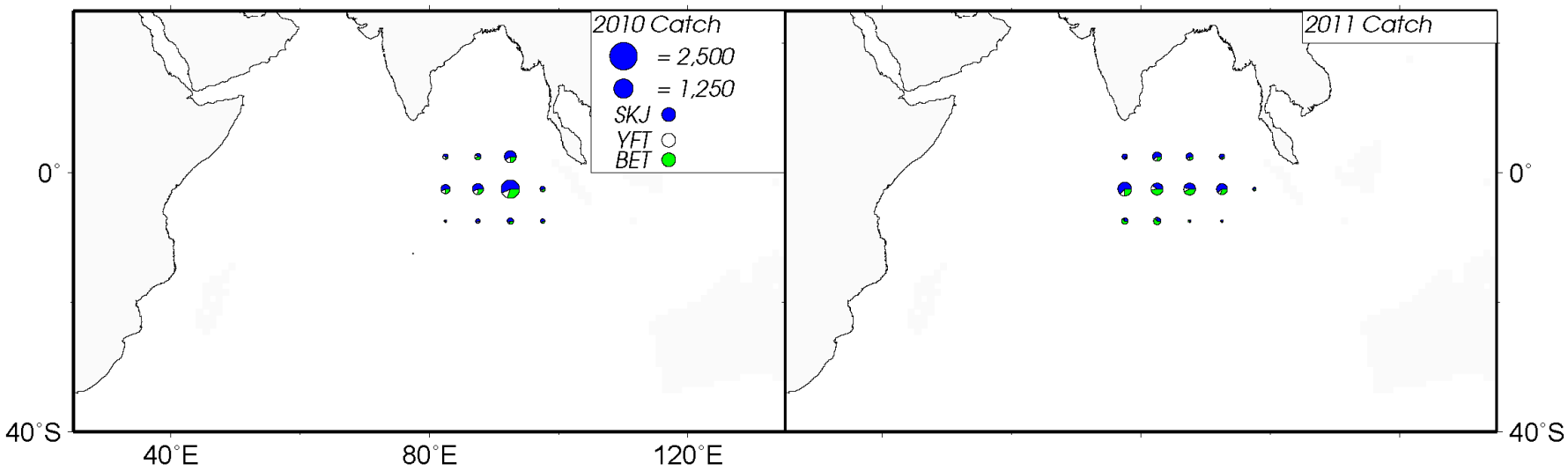

Fig. 11. The averaged distribution of amount of catch in weight of the Japanese purse seine by species (SKJ; skipjack tuna, YFT; yellowfin tuna, BET; bigeye tuna) for recent two years. Size of circles shows amount of total of catches.

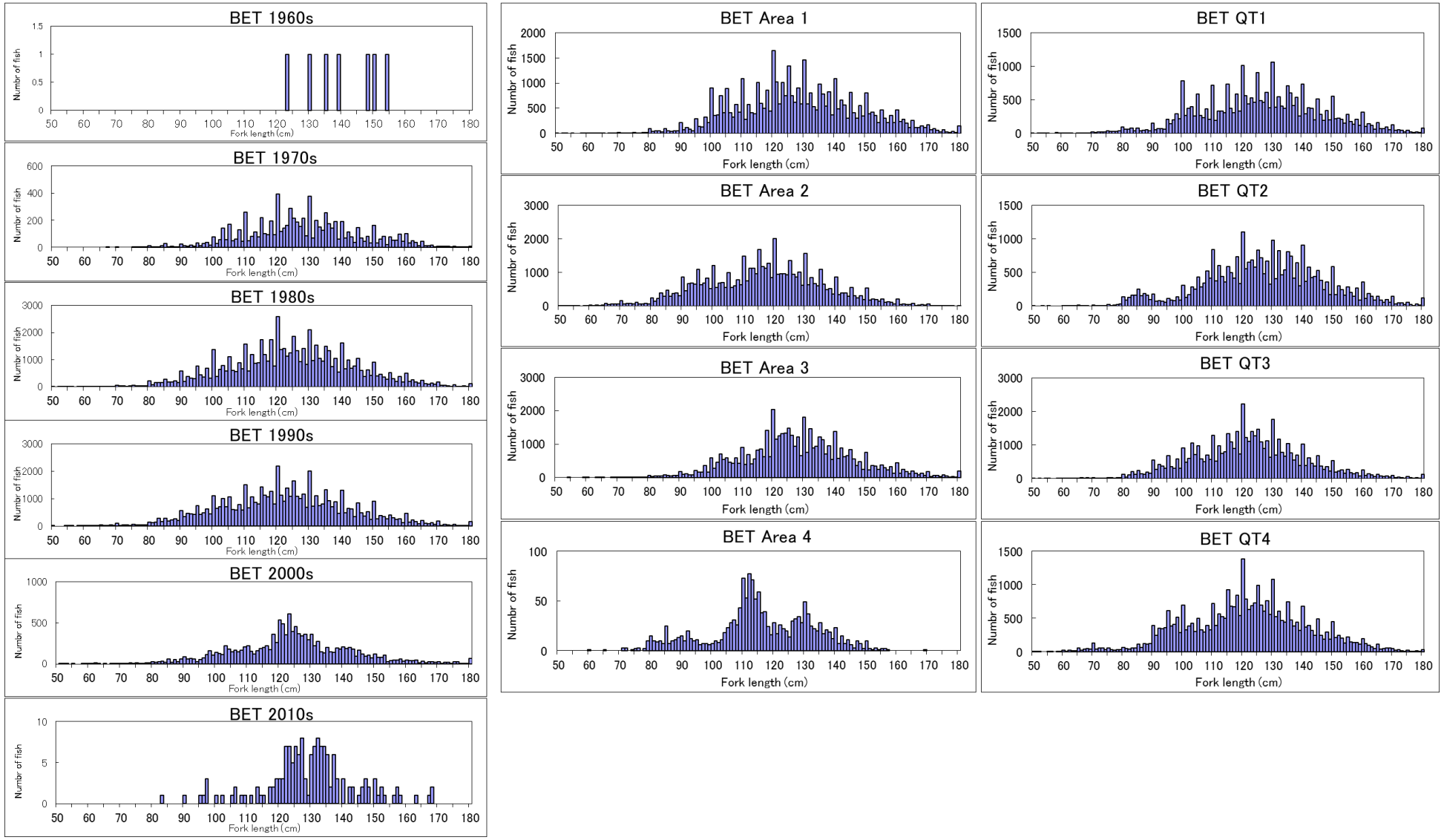

Fig. 12. Length frequency of bigeye tuna in the Indian Ocean caught by Japanese longline by decade (left), area (middle) and quarter (right). Area is shown in Fig. 1b.

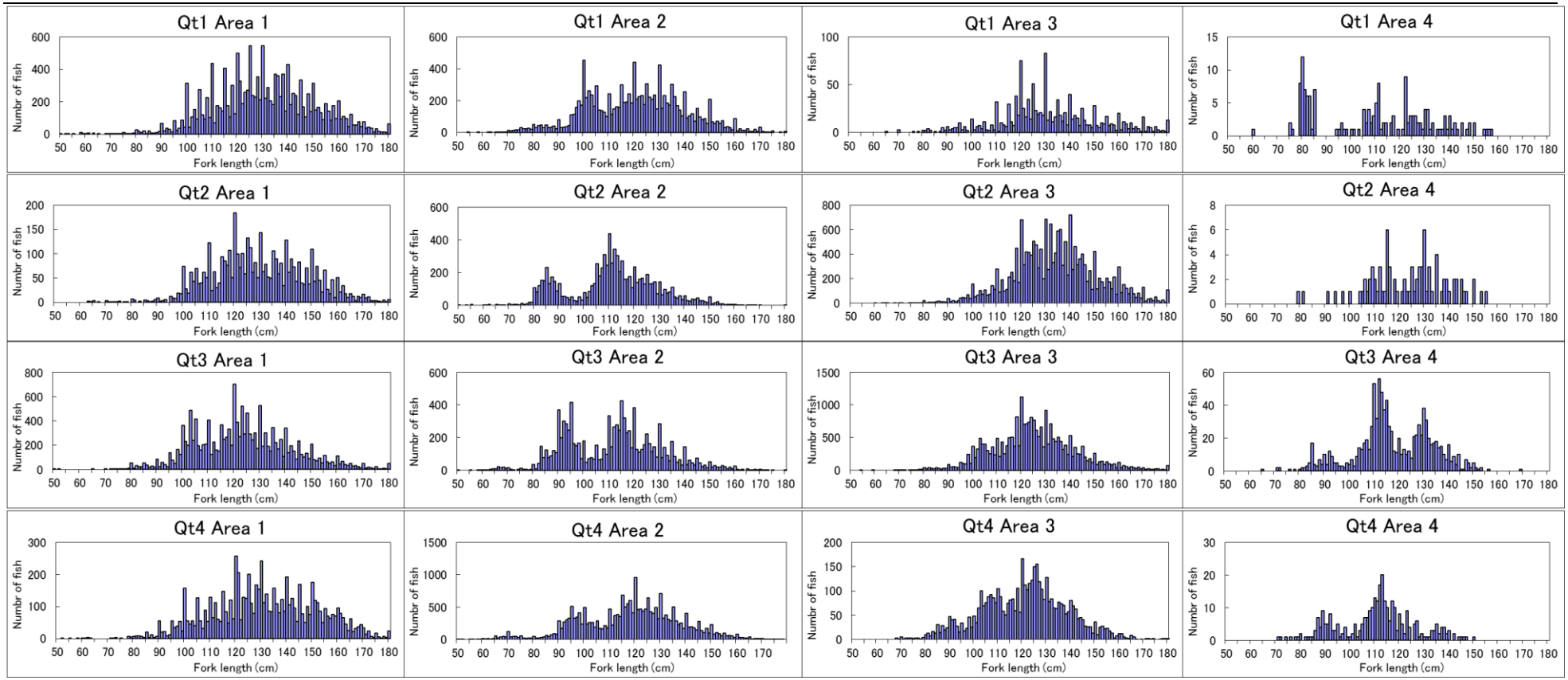

Fig. 13. Length frequency of bigeye tuna in the Indian Ocean caught by Japanese longline by quarter and area.

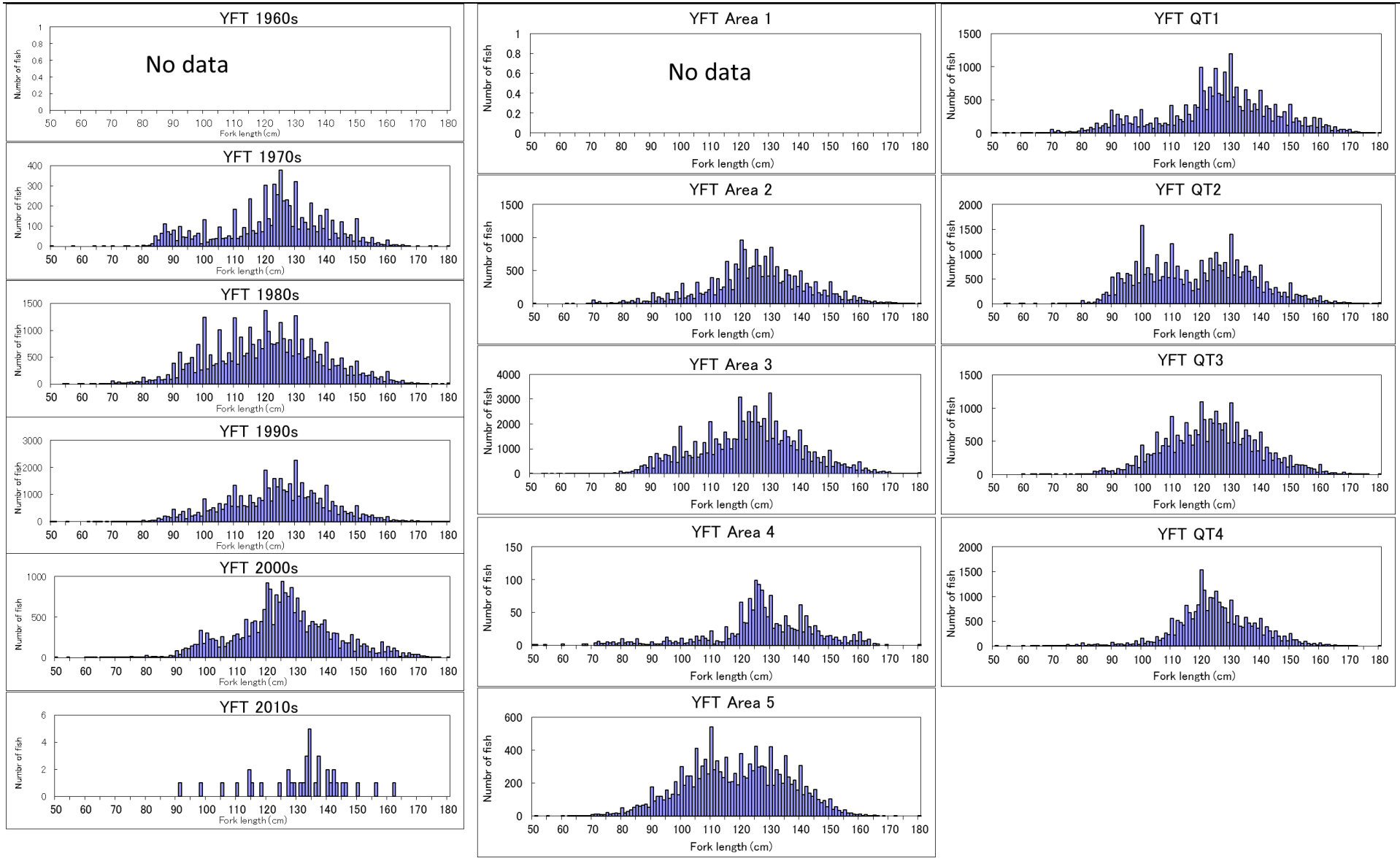

Fig. 14. Length frequency of yellowfin tuna in the Indian Ocean caught by Japanese longline by decade (left), area (middle) and quarter (right). Area is shown in Fig. 1c.

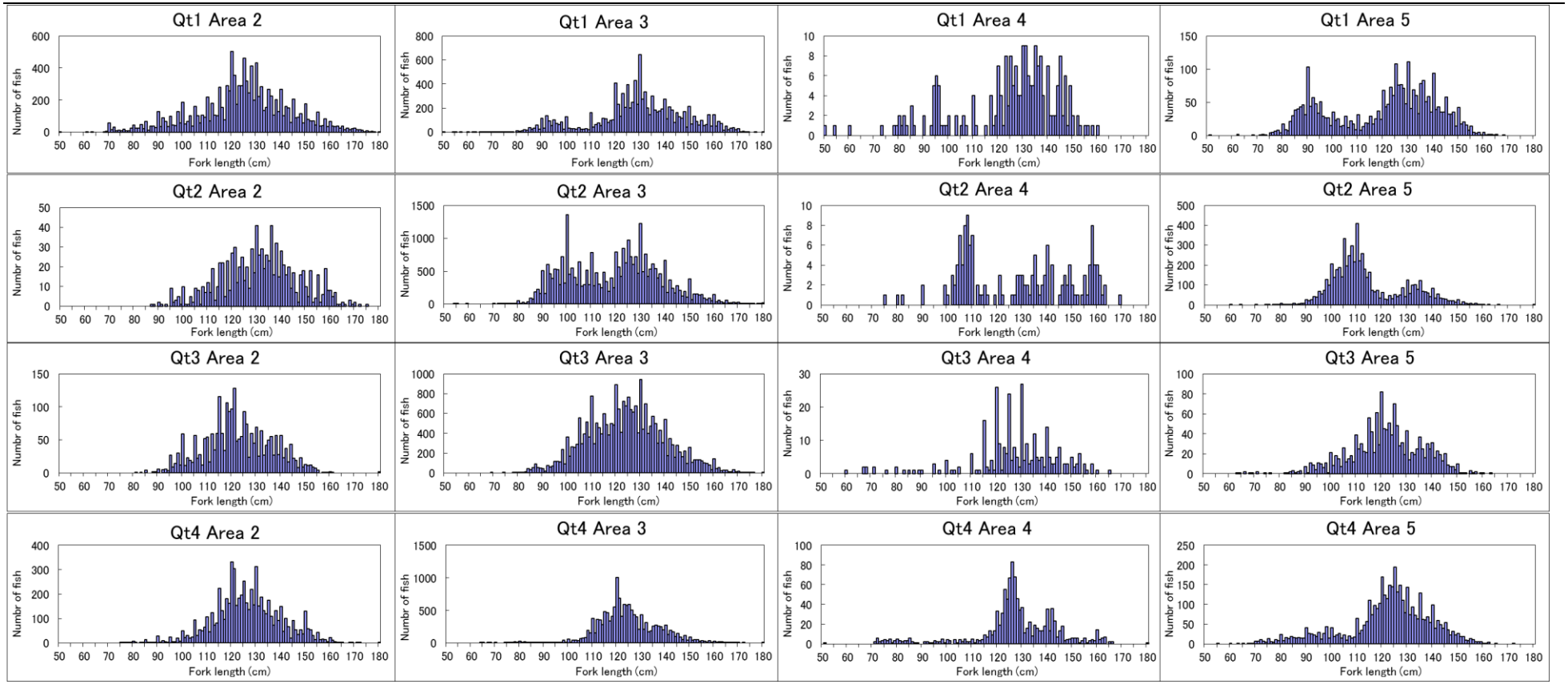

Fig. 15. Length frequency of yellowfin tuna in the Indian Ocean caught by Japanese longline by quarter and area.