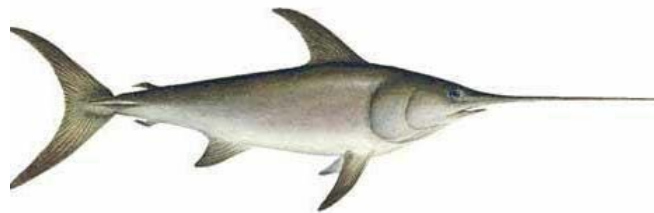
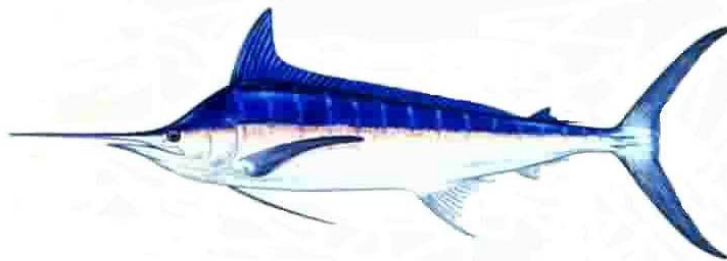




Review of size data for striped marlin (*Kajikia audax*) caught by
Japanese Commercial Fisheries in the North Pacific from 1970 to
2009

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Summary

To use for the stock assessment of striped marlin in the North Pacific, a total of 700,000 size data, in eye fork length (EFL, cm) and/or product weight (kg), of striped marlin caught by Japanese commercial fisheries in the North Pacific between 1970 and 2009 were reviewed in the present document. These size data were mainly collected from trawling, drift net, harpoon or longline, and size measurements were done by on boat as well as fishing ports in Katsuura, Yaizu, Shimizu, Tokyo and Kesenuma. The frequency distributions in EFL were different among types of fishery, e.g., fishes caught by trawling and harpoon were larger than by drift net and longline, and fishes smaller than 120cm were caught only by longline. Moreover, the length frequencies of striped marlin caught by longline were also different among areas and periods, which supposed to be influenced by growth-depend distribution of striped marlin, fishing behavior and change of the stock dynamics.

Aim of the present document

The present document aimed at examining size composition of striped marlin caught by Japanese fisheries for their stock assessment in the North Pacific.

Materials and Methods

In the present document, a total of 700,000 size data, in eye fork length (EFL, cm) and/or product weight of striped marlin caught in the North Pacific by Japanese commercial fisheries from 1970 to 2009, collected and compiled by National research institute of far seas fisheries (NRIFSF) were used (Table 1). These size data were obtained from striped marlin caught by trawling, purse seine, drift net, harpoon or longline fisheries, and measured on boat, in Katsuura, Yaizu, Shimizu, Tokyo or Kesenuma ports (Table 1). The product weight was measured in nearest 1kg, and all the weight data were converted to EFL using the formula, $y=59.946x^{0.2723}$, where x and y are product weight and EFL (Okamoto pers. comm.), respectively. The EFL data were measured in 1, 2 or 5cm unit. The frequency was depicted in 5 or 10 cm interval according to the measurement unit of the data used in each analysis. The North Pacific was divided into eleven areas to show the frequency of size data (Fig. 1).

Results and Discussion

Drift net

A total of 7,800 size data of striped marlin caught by drift net were mainly composed of data at unrecorded sampling site in 1980s, on boat sampling in 1990s, and port sampling at Kesennuma in 2000s (Table 2). Fig. 2 showed the frequency distribution in EFL of all striped marlin caught by drift net, which ranged between 110 and 210 cm with a mode between 160 and 170 cm. However the number of size data in the 1980s and the 1990s were smaller than that in the 2000s (Tables 1 and 2), the decennial frequency distribution of them had peak in the position between 155 and 165 cm over period analyzed (Fig. 3).

Harpoon

A total of 11,000 size data of striped marlin caught by harpoon were used in the present document (Table 1). The frequency ranged from 120 to 230 cm, and peaked in 180 cm size class (Fig. 2). Decennial frequency distribution shown in Fig. 4 suggested that the most caught size class was between 180 cm until 1990s, and it became slightly smaller to 160 cm in 2000s. Additionally, striped marlins smaller than 150 cm had been caught until 1990s, and they disappeared in 2000s. The observed difference of size would be attributed to the difference in geographical distribution of the data, but most of size data of the harpoon herein were obtained in the position out of areas defined in Fig. 1 (Table 2). Thus, the finer location of their sampling position was shown in Table 3. The geographical distributions of size data from harpoon fishery were different among decennial periods, e.g., more than half of size sample in the 2000s obtained in the northeastern size of Japan where only large sized fishes were caught. Harpoon fisheries in the south and southwestern side of Japan, where harpoon boats caught relatively smaller fishes, were almost disappeared in the 2000s. The length frequency distributions in the eastern and western side of 140E indicated that the both peaked in 180 and 190 cm, but fishes smaller than 150 cm were only caught in the west side (Fig. 5). Therefore, the observed difference of frequency distribution in EFL among periods could be related to the difference of fishing ground.

Longline

A total of 680,000 size data of striped marlin caught by longline from 1970 and 2009 were used in the present document (Table 1). These size data were collected by on boat, and by port sampling in Katsuura, Yaizu, Shimizu, Tokyo or Kesennuma market, but the sampling ports of all data in 1970s and some in 1980s were not recorded (Table 4). The number of size data by area and sampling site showed that approximately 94% of all size data in area 1 were collected in Katsuura, whereas more than 70% in areas 2 and 3 were from Kesennuma (Table 4). This result means that area 1, and areas 2 and 3 have been fishing grounds mainly for commercial vessels based on Katsuura and Kesennuma over periods, respectively. Striped marlin loaded in the Kesennuma fishing port can roughly be considered fishes caught by offshore surface longliners targeting swordfish and blue shark, fishes in Katsuura by coastal longliners targeting tunas, and fishes in Yaizu and Shimizu by offshore and far seas longliners targeting tunas.

The number of size sample obtained by other than Katsuura and Kesennuma becomes rather

small in the 2000s, which means that size information of striped marlin caught by offshore and distant-water longliners targeting tunas becomes poor.

The frequency distributions of striped marlin caught by longline in the whole North Pacific and by area were shown in Fig. 6. The EFLs of them were ranged between 90 and 240 cm, and the highest peaks observed between 150 and 170 cm in almost cases.

The decennial EFL distributions in area 1 showed that the ratio of striped marlin between 130 and 160 cm was increased after 1990s compare to before. Moreover, striped marlins in those size class were also increased in area 2 after 1980s. In area 3, the catch of striped marlin between 120 and 140 cm was decreased in 2000s. The striped marlins ranged 110 and 130 cm in areas 4 and 5 were decreased after 1980s and 1990s compared to before, respectively. Meanwhile, the frequencies in EFL were not so different among periods in areas 6 and 7. The striped marlins caught in area 8 was decreased after 1980s, which were caught a lot in 1970s. The size data between 110 and 130 cm in EFL were decreased after 1980s, but striped marlins larger than 200 cm, which were not caught at all before, were increased in area 9. The position of peak in length frequency of striped marlin in area 10 shifted from the size class between 160 and 180 cm in 1970s to between 160 and 170 cm after 1980s. In Area11, the position of peak in frequency distributions were not so different among periods, but striped marlin lager than 200 cm were caught in 2000s, which were not at all before that.

The observed change of the shape of size frequencies by area and period would be characterized by following three points. One is the growth-dependent distribution of striped marlin in the North Pacific, and second is the difference of fishing behavior, such as the target species and depth of fishing gear associated with them, among areas and/or periods. The last one is change of the stock dynamics, such as continuous failure of recruitment. Especially, observed ELF distributions in areas 1, 2 and 3 could be strongly affected by the fishing behavior of commercial vessels based on Katsuura and Kesenuma, because these areas have been fishing ground for them over periods. Further detailed study would elucidate mechanism.

Comparison among types of fisheries

Figure 2 showed frequency distributions in EFL by type of fishing, which suggested that the striped marlin caught by harpoon and trawling were larger than by longline and drift net. Furthermore, longline fisheries also caught striped marlins less than 120 cm in EFL which were not caught at all by other fisheries. This difference could be related to the differences in fishing ground, term, target species, depth of fishing gear and size selectivity by gear.

Table 1. Annual number of length or weight data by type of fishery for striped marlin caught by Japanese commercial fisheries between 1970 and 2009

year	longline	trawling	purse seine	dfirt net	harpoon	others	unrecorded	total
1970	10876	0	0	0	0	0	0	10876
1971	16790	0	0	0	0	0	0	16790
1972	8627	0	0	0	179	0	0	8806
1973	10533	0	0	0	41	0	0	10574
1974	5829	0	15	0	182	0	0	6026
1975	4951	0	0	0	0	0	0	4951
1976	6135	0	0	0	85	0	0	6220
1977	4788	51	0	0	488	0	0	5327
1978	3755	55	0	0	149	0	0	3959
1979	9479	206	4	0	652	0	0	10341
1980	9449	118	0	80	176	0	0	9823
1981	5983	5	0	352	430	1	0	6771
1982	9418	15	0	92	854	0	0	10379
1983	9160	123	0	466	692	0	0	10441
1984	11175	77	1	0	1401	0	0	12654
1985	16894	126	7	0	2557	0	0	19584
1986	38368	12	1	0	759	0	0	39140
1987	34160	69	0	0	275	0	0	34504
1988	34355	46	3	0	368	0	0	34772
1989	26625	21	11	0	1134	0	0	27791
1990	16847	17	7	0	72	0	5	16948
1991	20402	3	1	210	0	0	23	20639
1992	26442	5	9	0	95	0	0	26551
1993	33500	3	13	0	245	0	0	33761
1994	27457	4	1	0	84	0	0	27546
1995	38993	1	112	0	21	0	0	39127
1996	28014	0	11	0	6	0	0	28031
1997	32538	1	21	0	4	0	0	32564
1998	48688	0	7	0	0	0	0	48695
1999	30067	0	9	0	0	0	0	30076
2000	17719	1	7	32	62	0	0	17821
2001	20590	0	13	0	0	0	0	20603
2002	14713	0	4	0	0	0	0	14717
2003	15220	0	4	0	0	0	0	15224
2004	103	0	1	0	0	0	0	104
2005	8069	0	0	15	0	0	0	8084
2006	5496	1	1	0	0	0	0	5498
2007	6975	2	5	0	0	0	0	6982
2008	5377	6	11	4023	0	0	0	9417
2009	2994	3	34	2602	0	2	0	5635
total	677554	971	313	7872	11011	3	28	697752

Table 2. Decennial number of length or weight data by type of fishery, sampling site and area of striped marlin caught by Japanese commercial fisheries between 1970 and 2009

types of fisheries	sampling sites	areas	periods				total	
			1970s	1980s	1990s	2000s		
drift net	unrecorded	out of area	0	466	0	0	466	
		area 2	0	524	0	0	524	
		area 3	0	0	0	0	0	
		area 6	0	0	0	0	0	
	on-boat	out of area	0	0	0	0	0	
		area 2	0	0	104	0	104	
		area 3	0	0	85	0	85	
		area 6	0	0	21	0	21	
	Yaizu	out of area	0	0	0	0	0	
		area 2	0	0	0	32	32	
		area 3	0	0	0	0	0	
		area 6	0	0	0	0	0	
	Kesenuma	out of area	0	0	0	2588	2588	
		area 2	0	0	0	4052	4052	
		area 3	0	0	0	0	0	
		area 6	0	0	0	0	0	
	total			0	990	210	6672	7872
	harpoon	unrecorded	out of area	1776	4728	0	0	6504
			area 2	0	1382	0	0	1382
			area 3	0	0	0	0	0
area 6			0	0	0	0	0	
on- boat		out of area	0	0	0	0	0	
		area 2	0	0	0	0	0	
		area 3	0	0	0	0	0	
		area 6	0	0	0	0	0	
Yaizu		out of area	0	2451	521	8	2980	
		area 2	0	85	6	54	145	
		area 3	0	0	0	0	0	
		area 6	0	0	0	0	0	
Kesenuma		out of area	0	0	0	0	0	
		area 2	0	0	0	0	0	
		area 3	0	0	0	0	0	
		area 6	0	0	0	0	0	
total			1776	8646	527	62	11011	

Table 3. Decennial number of length or weight data in both side of 140°E for striped marlin caught by harpoon between 1970 and 2009

periods		130E	140E	total
1970s	30N	1776	0	1776
	35N	0	0	0
1980s	30N	7179	1467	8646
	35N	0	0	0
1990s	30N	521	0	521
	35N	0	6	6
2000s	30N	8	22	30
	35N	0	32	32
total		9484	1527	11011

Table 4. Decennial number of length or weight data by area and sampling site of striped marlin caught by Japanese commercial longline between 1970 and 2009

periods	sampling sites	out of area	area 1	area 2	area 3	area 4	area 5	area 6	area 7	area 8	area 9	area 10	area 11	total
1970s	on-boat	0	0	0	0	0	0	0	0	0	0	0	0	0
	Katsuura	0	0	0	0	0	0	0	0	0	0	0	0	0
	Yaizu	0	0	0	0	0	0	0	0	0	0	0	0	0
	Shimizu	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tokyo	0	0	0	0	0	0	0	0	0	0	0	0	0
	Kesennuma	0	0	0	0	0	0	0	0	0	0	0	0	0
	unrecorded	9461	870	3903	5723	3441	2488	9289	11191	9664	5690	14644	5399	81763
	total	9461	870	3903	5723	3441	2488	9289	11191	9664	5690	14644	5399	81763
1980s	on-boat	28	0	21	0	59	32	355	30	767	108	5044	1332	7776
	Katsuura	1454	3947	1843	4762	1790	393	0	0	0	0	0	0	14189
	Yaizu	211	271	1411	1980	680	1041	1401	156	3501	304	468	20	11444
	Shimizu	0	0	115	0	91	239	0	0	0	0	0	0	445
	Tokyo	273	0	1625	480	1834	219	4267	606	4993	355	1217	144	16013
	Kesennuma	722	387	29556	52132	329	63	0	0	452	0	0	0	83641
	unrecorded	1925	1457	13415	17156	3007	1334	11325	878	7196	1378	1589	1419	62079
	total	4613	6062	47986	76510	7790	3321	17348	1670	16909	2145	8318	2915	195587
1990s	on-boat	261	0	50	1	34	19	1337	838	666	310	1153	1797	6466
	Katsuura	22568	42933	6643	20050	3571	918	0	0	0	0	17	0	96700
	Yaizu	393	538	1450	3073	256	20	10	0	0	3	411	0	6154
	Shimizu	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tokyo	0	0	178	0	0	0	78	0	104	0	68	0	428
	Kesennuma	2113	404	91287	96118	3038	165	50	0	25	0	0	0	193200
	unrecorded	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	25335	43875	99608	119242	6899	1122	1475	838	795	313	1649	1797	302948
2000s	on-boat	2	0	0	0	0	0	5	200	19	135	118	495	974
	Katsuura	13496	21852	4252	8050	3162	150	0	0	0	0	0	0	50962
	Yaizu	102	58	37	127	0	0	0	0	0	0	0	0	324
	Shimizu	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tokyo	0	0	0	0	0	0	0	0	0	0	0	0	0
	Kesennuma	5332	36	27039	9117	2113	9	1350	0	0	0	0	0	44996
	unrecorded	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	18932	21946	31328	17294	5275	159	1355	200	19	135	118	495	97256
total	58341	72753	182825	218769	23405	7090	29467	13899	27387	8283	24729	10606	677554	

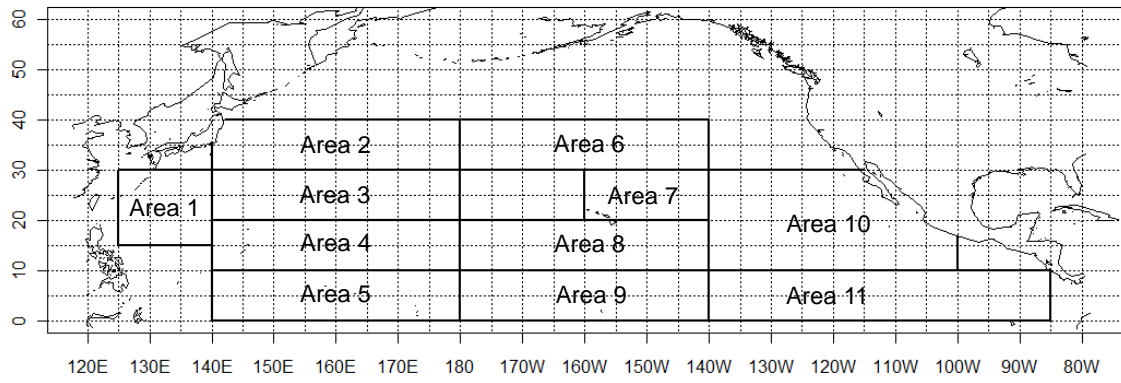


Fig. 1 Area stratification used in the present document

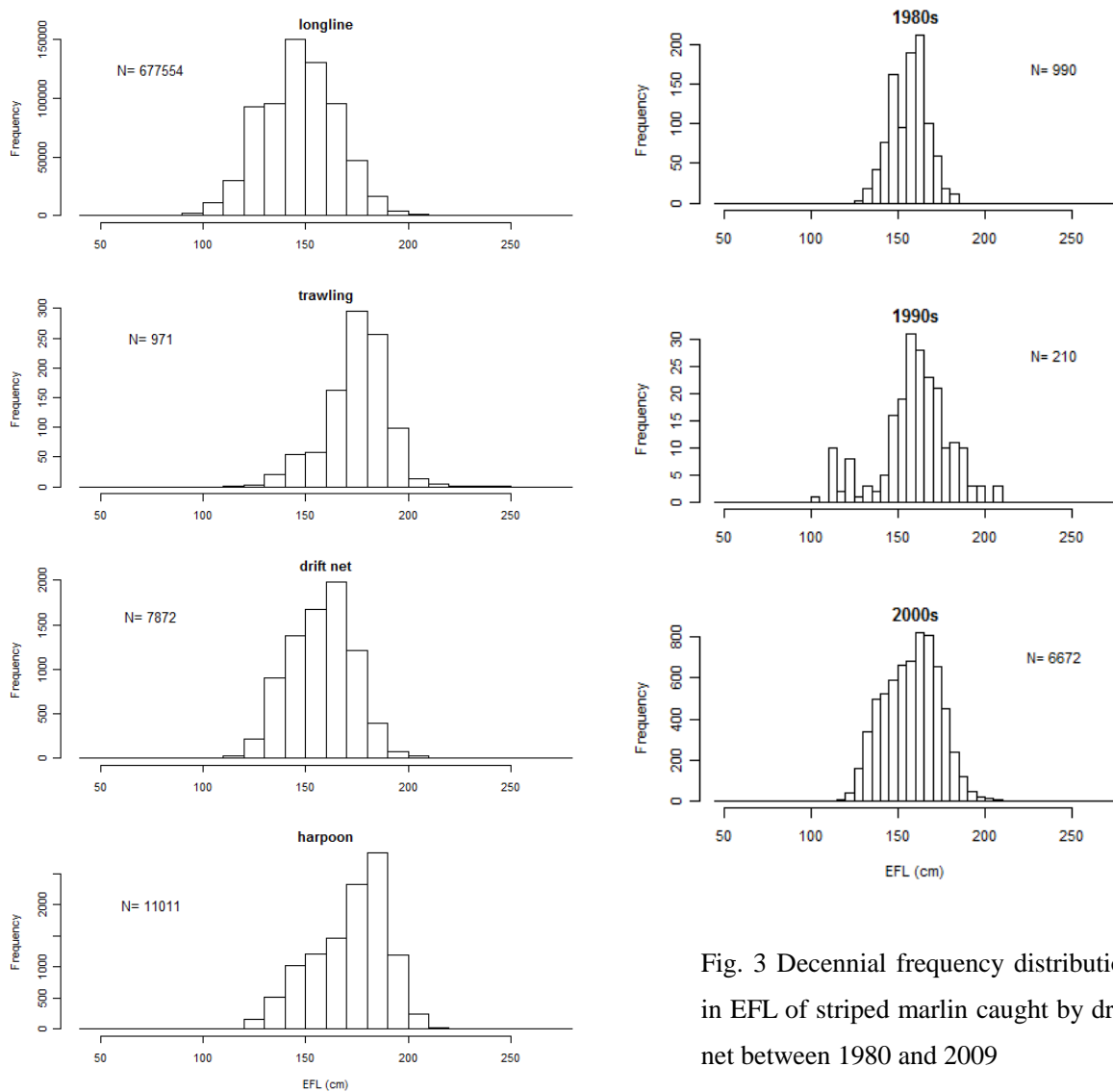


Fig. 3 Decennial frequency distribution in EFL of striped marlin caught by drift net between 1980 and 2009

Fig. 2 Frequency distribution in EFL by type of fishery for striped marlin caught by Japanese fisheries between 1970 and 2009

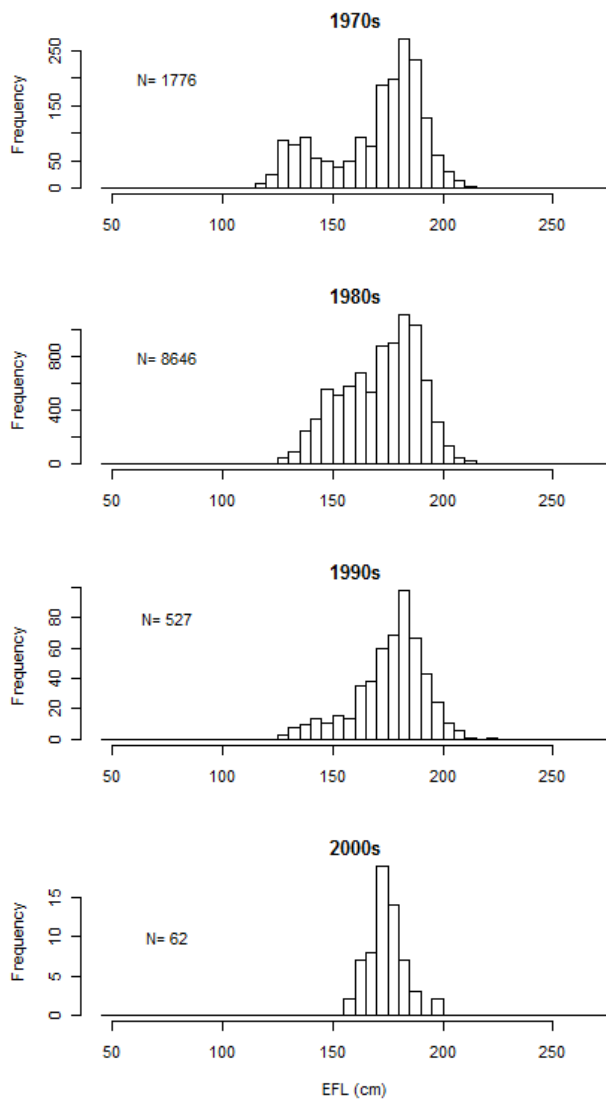
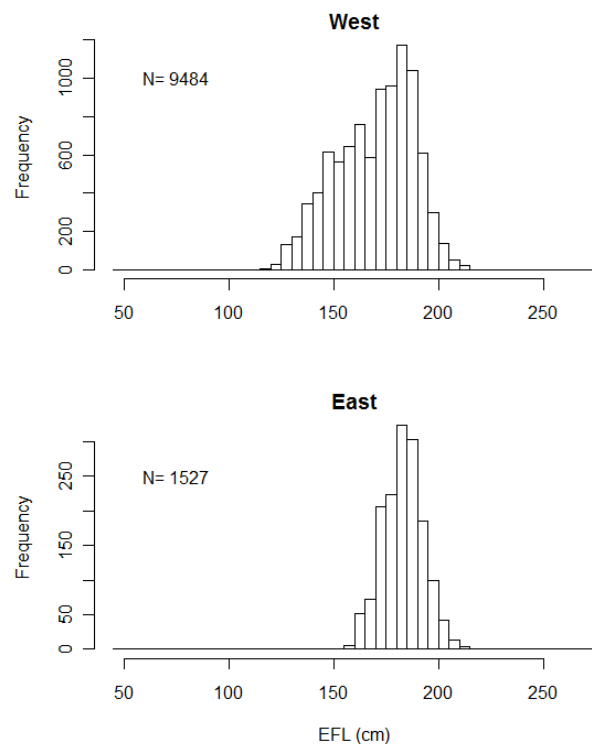


Fig. 4 Decennial frequency distribution in EFL of striped marlin caught by harpoon between 1970 and 2009

Fig. 5 Frequency distribution in EFL of striped marlin caught by harpoon in the both side of 140°E between 1970 and 2000



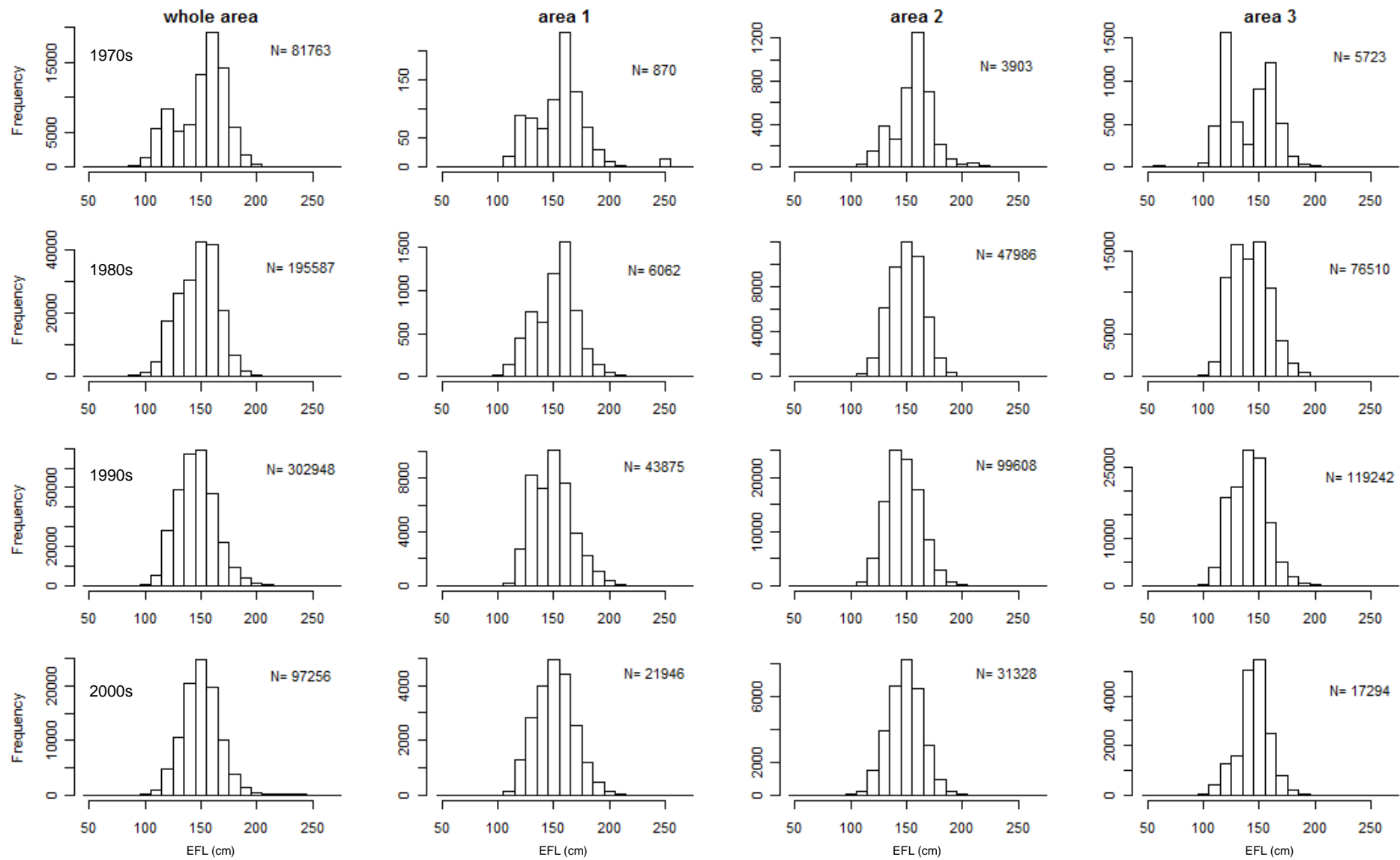


Fig. 6 Decennial frequency distribution in EFL of striped marlin caught by longline between 1970 and 2009

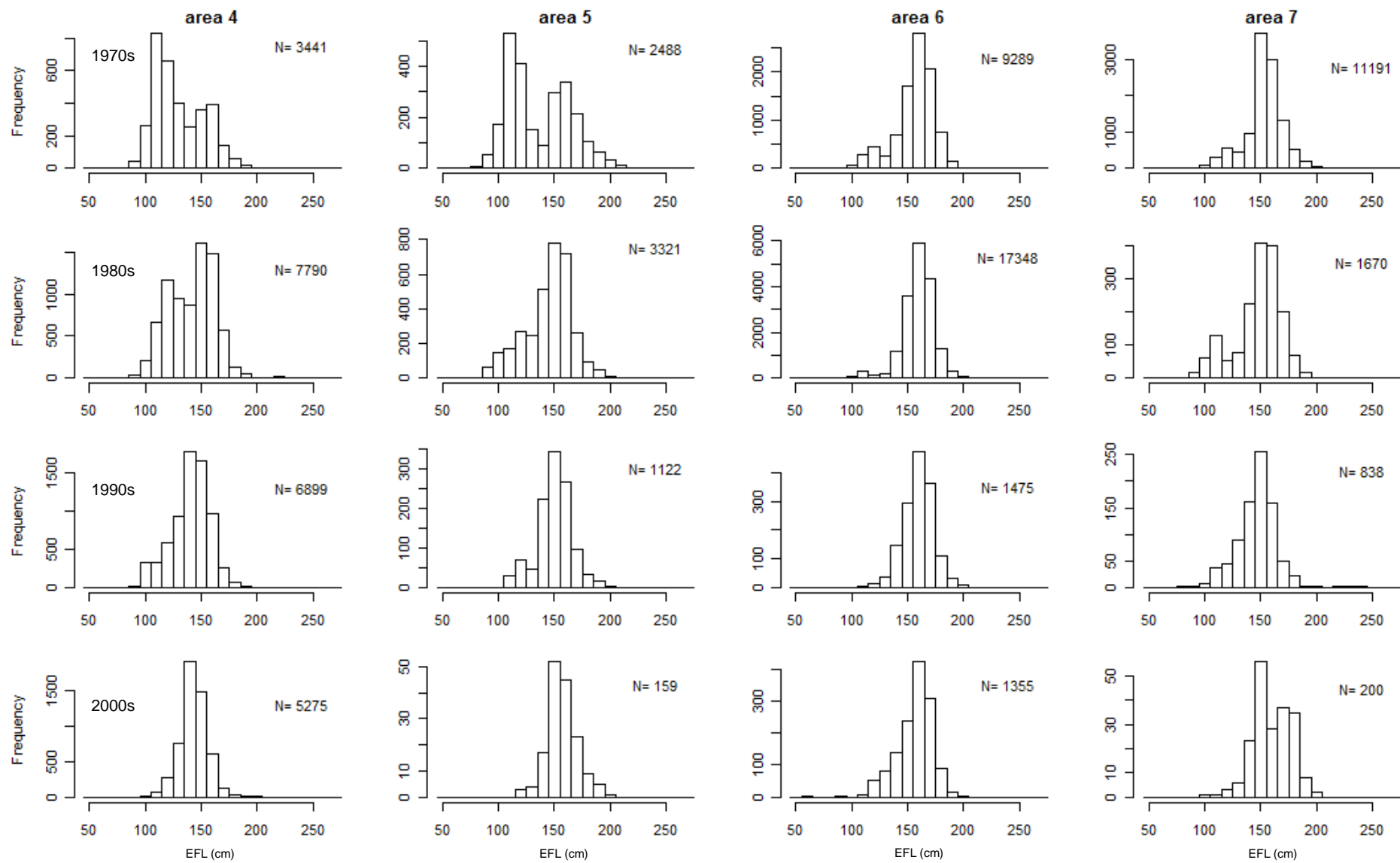


Fig. 6 Continued

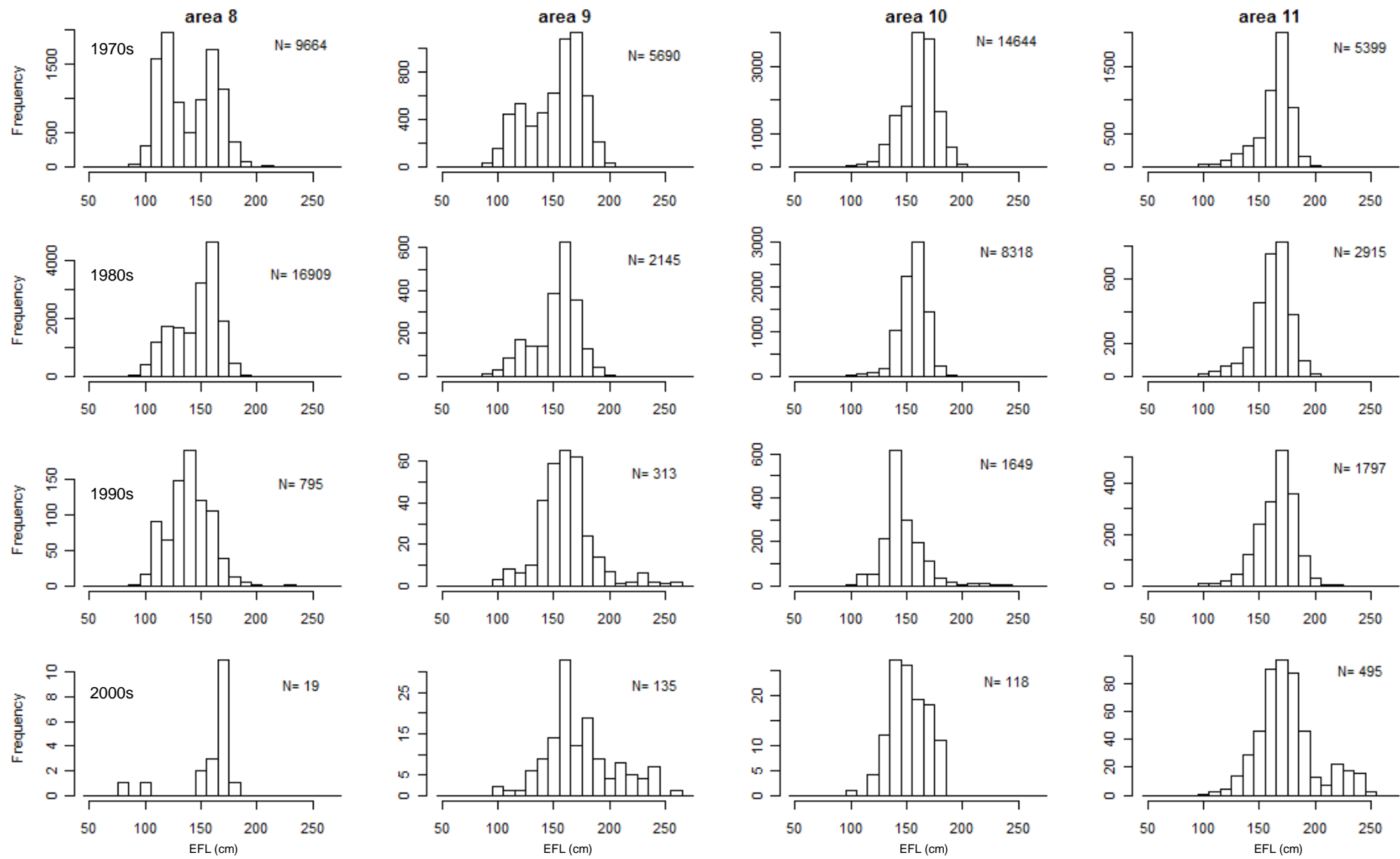


Fig. 6 Continued