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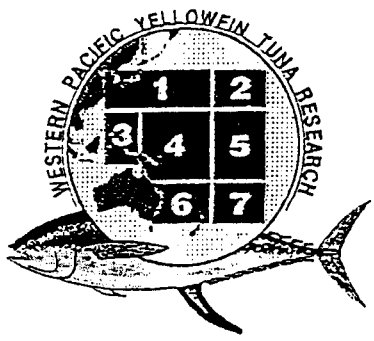

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Summary

Annual total catch of yellowfin tuna from both Korean longline and purse seine fisheries in the study area of WPYR, in general, indicated an increasing trend from year to year, reaching a peak of 76,900 t in 1992. In this area, annual CPUE values from the longline fishing have always been higher than those in the entire Pacific Ocean, showing large fluctuations between years. The values from the Korean purse seine fishing during the early 1990s remained at a parallel level with a value of 8 t per haul.

The Korean tuna longline fishery for yellowfin tuna in the Pacific Ocean concentrated its fishing activity in equatorial region of the western Pacific during summer season of the northern hemisphere. Korean purse seine fishing was conducted only in the statistical area, WPYF-4 and dense distribution area was located mainly in the northern part of Papua New Guinea. Vertical distribution of tunas observed from the Korean longline fishing suggested that yellowfin tuna inhabit mainly at a depth range of 150~250 m.

Length compositions of yellowfin tuna sampled from the Korean tuna fisheries showed a wide range of distribution from 72 to 168 cm fork length from longline and from 40 cm to 144 cm from purse seine, with a three separated modes, respectively. Body weight composition of yellowfin tuna from the purse seine fishery ranged from 2 to 54 kg.

Sex ratio of yellowfin tuna from samlpes of the purse seine catches was 51.2% for male and 48.8% for female. Fork length (FL, cm)-round weight of body (BW, kg) relationship was expressed by: $BW=2.551\times10^{-5}FL^{2.921}$.

Introduction

Korean tuna fishing in the Pacific Ocean was initiated by using longline gear in 1964 and by purse seine net in 1980, respectively. Korean longliners have operated in a wide area between 15^0 N and 15^0 S through the whole Pacific Ocean, targeting yellowfin, albacore and bigeye tunas. Fishing vessels used traditional longline fishing method to fish these species until the mid-1970s. In the early 1970s, it began to introduce deep longline fishing technique to Korean commercial fishing vessels. From 1977 onward, most of the fishing grounds where the Korean tuna longliners had used, were replaced by deep longline gear (Gong et al. 1989).

Despite the fact that Korea has a long history in the tuna fishing, very limited

research activity or little scientific information on tuna resources were provided from Korea so far, especially for those in the Pacific Ocean. This was probably attributed not only to long distance of fishing grounds from Korea but also to lack of manpower to conduct research. In very recent years, however, scientific observations on highly migratory species such as tunas and tuna-like species and Pacific saury in the Pacific Ocean have been carried out on board the Korean commercial fishing vessels by researchers of the National Fisheries Research and Development Agency (NFRDA) so as to collect fishery data and biological materials which are vital to stock assessment tasks.

Catch per hook of tunas including yellowfin tuna from the Korean longline fishery is compared between three Oceans (Lee et al. 1979). Monthly distribution maps for yellowfin tuna including albacore and bigeye tunas as main targeted species of the Korean tuna longline fishery are available in detail from 1975 through 1993 (Gong et al. 1980, 1981, 1985, 1993; Park et al. 1986, 1988, 1990).

This report describes long term trends in annual harvest and catch per effort, seasonal and vertical distributions, and some biological analyses of the yellowfin tuna stock in the study area of the western Pacific yellowfin tuna research (WPYR) based on fishery data and fish samples collected from the Korean tuna fisheries.

Materials and Methods

Korean tuna fishing in the Pacific Ocean uses basically two kinds of fishing gear: longline mainly for yellowfin, albacore and bigeye tunas, and purse seine for small skipjack and yellowfin tunas. In order to collect fishery data on catch and effort statistics required for fisheries evaluation and various quantitative analyses of fish stocks, a reporting system based on log-book method has been maintained by NFRDA since 1975. The detailed procedures to it and computation of coverage rate are explained by Lee et al.(1985). Because annual total catch of yellowfin tuna from the Korean longline fishery in the study area of WPYR is not known, it was estimated by a simple method of extrapolation using sampling data obtained from the log-book system, by dividing the yellowfin tuna catch within the WPYR area recorded in log-book by sum of the yellowfin tuna catch in the entire Pacific recorded in log-book, then multiplied by total catch of the fish species obtained by a census method.

Daily fishery data on catch and effort statistics were pooled by month and calendar year, then catch per effort in number (per 100 hooks for longline and per haul for purse seine) was calculated in every month and year. These data were used to demonstrate long term trends in catch per effort. The daily data were also compiled according to the statistical sea-block, 5° lat. x 5° long. for longline and 1° lat. x 1° long. for purse seine in every month and year. These refined data were used to portray distribution patterns. In this report, the monthly distribution of yellowfin tuna from the Korean longline fishery was only described for 1993, because other years' patterns did not differ much from the distribution map of 1993. But the distribution patterns of

yellowfin tuna from the purse seine fishery were made on the yearly basis for the comparison purpose between years during 1990~1993. Vertical distribution of yellowfin tuna including albacore and bigeye tunas was determined together with water temperature at each 10 m deep during research monitoring period from 13th September to 1st October 1992 aboard a Korean commercial fishing vessel in the central Pacific Ocean.

Size compositions of yellowfin tuna were also obtained on board the Korean tuna longliners during scientific observations of January~February and September 1992 and June 1993, respectively. On the other hand, approximately 370 yellowfin tuna were sampled from the Korean purse seine fishery during October 1993 to May 1994, when the catches were landed at domestic factories from fishing sites for production of fishery products like canned fish, fish meals etc. The sampled individuals were sexed, then fork length (FL) and round weight of fish body (BW) were measured. An empirical relationship between length and weight ($BW=aFL^b$) was established.

Results and Discussion

Catch History

Since 1964 when the Korean tuna fishery was commenced in the Pacific Ocean, annual catches of tunas and bycatch species have been published for fishing gear used. According to Statistical Yearbook of Fisheries published by Fisheries Administration (former Office of Fisheries), a species by species catch from 1964 to 1970 was not compiled.

During 1970s, yellowfin tuna was one of main target species of the Korean tuna longline fishery in the Pacific Ocean, reaching a peak catch of 23,700 metric tons (t) in 1980 (Table 1). From 1981 onward, annual catch of yellowfin tuna from the longline fishing gear fluctuated, on an average, in the vicinity of 10,000 t.

It is important to consider fishing efficiency between the traditional longline and deep longline fishing methods. In a comparison study (Gong et al. 1989), it was resulted that deep longline was more efficient on bigeye tuna than on yellowfin tuna. As a matter of fact, annual yellowfin tuna catch from the Korean tuna longline fisheries in the Pacific showed a bit fluctuation even though the deep longline gear have been exclusively used since 1981 (Table 1).

Using annual total catch statistics by species and temporal/spatial catch by species recorded in log-book, annual catch of yellowfin tuna from the Korean longline fishing in the study area of WPYR was estimated from 1981 to 1993 (Table 1) (due to computerization of fishery data in 1981). The proportion of yellowfin tuna catch in the WPYR area to that of the entire Pacific varied from 62% to 88% annually except both years of 1986 and 1991 (about 52% and 43%, respectively). During the early 1990s, its percentage decreased a little bit compared with the previous year's figures. This might be caused by expansion and/or movement of fishing grounds to the eastern Pacific Ocean. The averaged catch composition by statistical area within the WPYR area during

1988~1993 indicated that the majority of yellowfin tuna catch from this fishing gear was from the statistical areas, WPYF-4 and WPYF-5, accounting for 30.0% and 69.5%, respectively (see Fig. 2).

In 1980, two Korean purse seiners participated first in fishing for yellowfin and skipjack tunas in the western Pacific where now belongs to the WPYF-4. Since then, this area has been important fishing grounds of the Korean purse seine fishery. From 1980 to 1986, yellowfin tuna were caught at low levels with a peak catch of about 2,400 t in 1986 (Table 1). The catch increased rapidly from 17,400 t in 1987 to 67,000 t in 1992 but in 1993 it was down 21.3% to 52,700 t from the previous year's figure.

Annual yellowfin tuna catch from the Korean tuna fisheries in the study area of WPYR, in general, showed an increasing trend from year to year, reaching a peak of 76,900 t in 1992 (Table 1).

Trends in Relative Abundance

A series of catch per unit of effort (CPUE) statistics on the Pacific yellowfin tuna was derived from data recorded in log-book of the Korean longline fishery (Fig. 1). CPUE of yellowfin tuna from the Korean longline fishery in the entire Pacific Ocean had large variations between years during 1975~1983, showing a high of more than 0.8 individual per 100 hooks in 1977~1980 (Fig. 1). From 1984 onward, that has remained nearly unchanged at a value of 0.5~0.6 individual per 100 hooks, even though very recent year's values fluctuated somewhat. In the WPYR area, annual CPUE values have always been higher than those in the entire Pacific Ocean, showing large fluctuations between years. CPUEs for each statistical area had a high value of over 0.6 individual per 100 hooks in the areas, WPYF-4 and WPYF-5 (Fig. 2). Monthly CPUEs of yellowfin tuna from the Korean longline fishery in the areas of WPYF-4 and WPYF-5 during 1993 were much higher in a period from June to September (or November) than those in other months (Fig. 3). It is likely to imply that main fishing season of the Korean longline fishery for yellowfin in this area is summer season.

Annual CPUE trend of yellowfin tuna from the Korean purse seine fishery in the study area of WPYR is shown in Fig. 4. The values varied between 2 and 6 t per haul during the first half of 1980s. From the second half of 1980s, annual CPUEs kept a high value of more than 7 t per haul, peaked in 1989 at 13 t per haul. In the early 1990s, its values maintained nearly parallel level with a value of 8 t per haul (Fig. 4).

Seasonal and Vertical Distributions

Monthly distribution of yellowfin tuna in CPUE (number per 100 hooks) for statistical sea-block (5° lat.x 5° long.) based on fishery data from the Korean tuna longliners in the Pacific Ocean in 1993 is given in Fig. 5. The Korean longliners operated mainly in the waters between 15° N and 15° S through the whole Pacific Ocean. Fishing areas with high CPUEs occurred mainly waters between 5° N and 10° S, and 160° E and 150° W in the study area of WPYR from May and this pattern existed until September (or October). Accordingly, it is estimated that the Korean tuna longline

fishery for yellowfin tuna in the Pacific Ocean concentrated its fishing activity in equatorial region of the western Pacific during summer season of the northern hemisphere. The Korean purse seine fishing for yellowfin tuna was conducted only in the statistical area, WPYF-4, through the whole years from 1990 to 1993 (Fig. 6). Dense distribution area was located mainly in the northern part of Papua New Guinea.

Vertical distribution of yellowfin tuna including both albacore and bigeye tunas based on CPUE values (number of fish per 100 hooks) was studied from hanging depth of longline hooks where these fish species were caught, together with water temperature. During scientific monitoring duration in the western Pacific Ocean from 13th September to 1st October 1992, two survey sites were selected at random (Fig. 7). Water temperature in depth from surface to 120 m changed hardly at 29~30°C with no distribution of fish from fishing. Water temperature from 120 m to 240 m deep decreased gradually by 10 to 8°C with increase in water depth. Yellowfin, albacore and bigeye tunas showed a distribution range from the water depth of 120~140 m to about 300 m. CPUE values of yellowfin tuna were high particularly at a depth range between 150 and 250 m, and albacore from 150 to 180 m and bigeye tuna at 250~300 m (Fig. 7).

It is likely to suggest from the vertical distribution patterns among them that albacore inhabit in upper layer, and both yellowfin and bigeye tunas deeper layer than albacore.

Size Composition and Length-Weight Relationship

Fork length distributions of yellowfin tuna determinded on board the Korean longliners and measured at domestic landing site of catches from the Korean purse seine fishery are given in Figs. 8a and 8b. Length frequency distributions from the longline fishery showed different compositions between survey periods (Fig. 8a). The mode appeared at the length of 126~127 cm in the January~February 1992 distribution and at the length of 106~107 cm in the September 1992 distribution. In the June 1993 distribution, however, the two modes existed in a range of 96~102 cm and 130~134 cm fork length, respectively, with a wide range of distribution from 72 to 168 cm. It was regarded that appearance of small-sized yellowfin tuna in the distribution of June 1993 was because fish samples were from WPYF-4 known as main area occupied by small yellowfin tuna.

Length composition of yellowfin tuna from the Korean purse seiners revealed a distribution range from 40 cm to 144 cm FL with a three separated distribution patterns as a whole: a range group of 40~70 cm, 70~90 cm and over 90 cm groups (Fig. 8b). However, the composition indicated that majority of yellowfin tuna consisted of large size fish more than 100 cm fork length. Body weight composition of yellowfin tuna from the purse seine fishery ranged from 2 to 54 kg (Fig. 9). The composition also showed a three separated distribution patterns, having a range of 2~10 kg, 11~23 kg and over 24 kg that dominated in the body composition.

Sex ratio of yellowfin tuna from samples of the purse seine catches was 51.2% for male and 48.8% for female with no significant difference at the 5% level. Relationship

between fork length (FL, cm) and round weight of body (BW, kg) was fitted to an empirical exponential function and was expressed by (Fig. 10): $BW=2.551\times10^{-5}FL^{2.921}$ ($r^2=0.98$).

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Table 1. Annual number of vessels and catch(mt) taken by Korean tuna fisheries in the Pacific Ocean, 1975-1993

Year	Vessels		Catch (mt)					
			Pacific Ocean			WPYF area*		
	LL	PS	LL	PS	Sum	LL	PS	Sum
1975	253	-	10,366	-	10,366		-	
76	257	-	15,613	-	15,613		-	
77	217	-	16,580	-	16,580		-	
78	223	-	14,072	-	14,072		-	
79	216	-	18,538	-	18,538		-	
1980	211	2	23,710	68	23,778		68	
81	209	3	10,794	582	11,376	8,456	582	9,038
82	121	10	9,517	2,042	11,559	8,410	2,042	10,452
83	102	11	8,807	799	9,606	7,053	799	7,852
84	96	12	7,005	416	7,421	6,046	416	6,464
1985	94	11	10,244	1,624	11,868	7,887	1,624	9,511
86	134	13	10,780	2,427	13,207	5,648	2,427	8,075
87	138	20	11,824	17,383	29,207	7,558	17,383	24,941
88	124	23	11,422	14,560	25,982	9,769	14,560	24,329
89	152	30	8,284	34,532	42,816	7,291	34,532	41,823
1990	182	39	13,891	34,765	48,656	8,674	34,765	43,439
91	220	36	10,664	55,416	66,080	4,636	55,416	60,052
92	166	36	12,519	66,982	79,501	9,881	66,982	76,863
93	148	34	10,000	52,659	62,659	6,728	52,659	59,387

LL : Longline fishery
PS : Purse seine fishery
* : Estimated using log-book data
- : No fishing vessel and catch

logsheet coverage PS 1993 = 62%

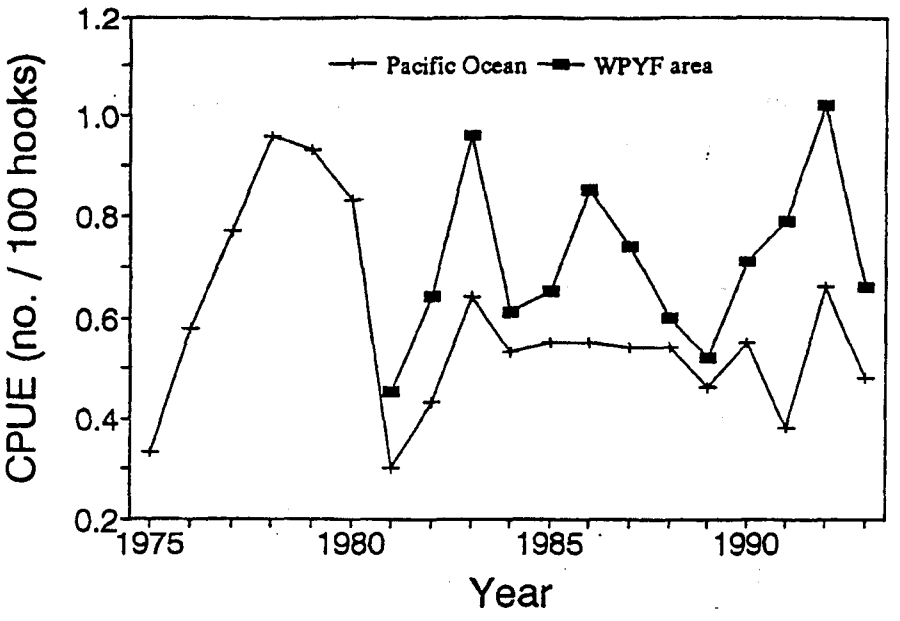

Fig. 1. Long-term trends in catch per effort (CPUE) of yellowfin tuna observed from Korean longline fishery in the Pacific Ocean and western Pacific yellowfin tuna research (WPYF) area during 1975~1993.

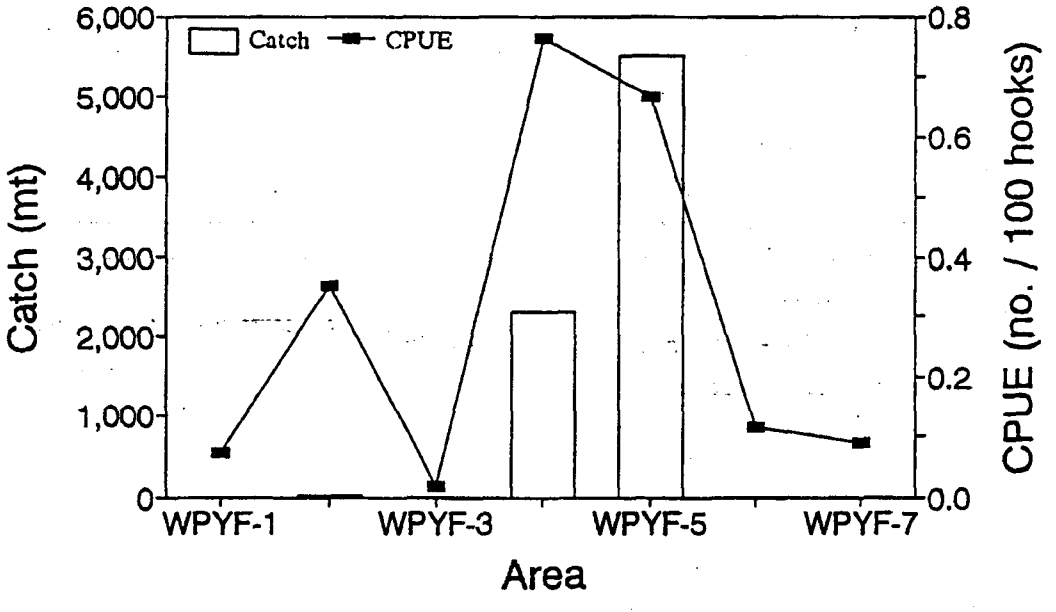

Fig. 2. Averaged yellowfin tuna catch and CPUE of Korean longline fishery in the WPYF area during 1988~1993.

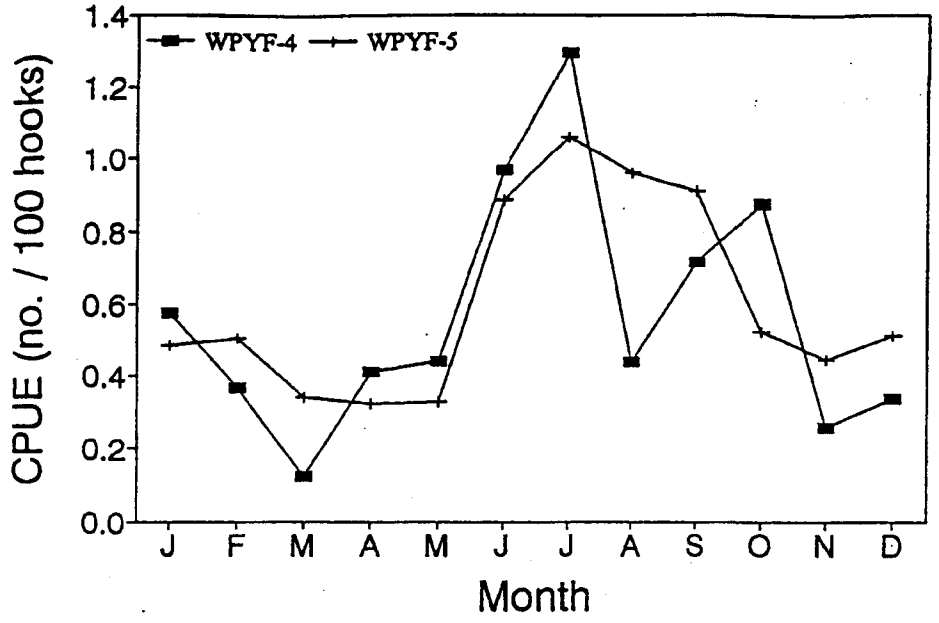

Fig. 3. Monthly CPUE trend of yellowfin tuna in the areas of WPYF-4 and WPYF-5 from Korean longline fishery in 1993.

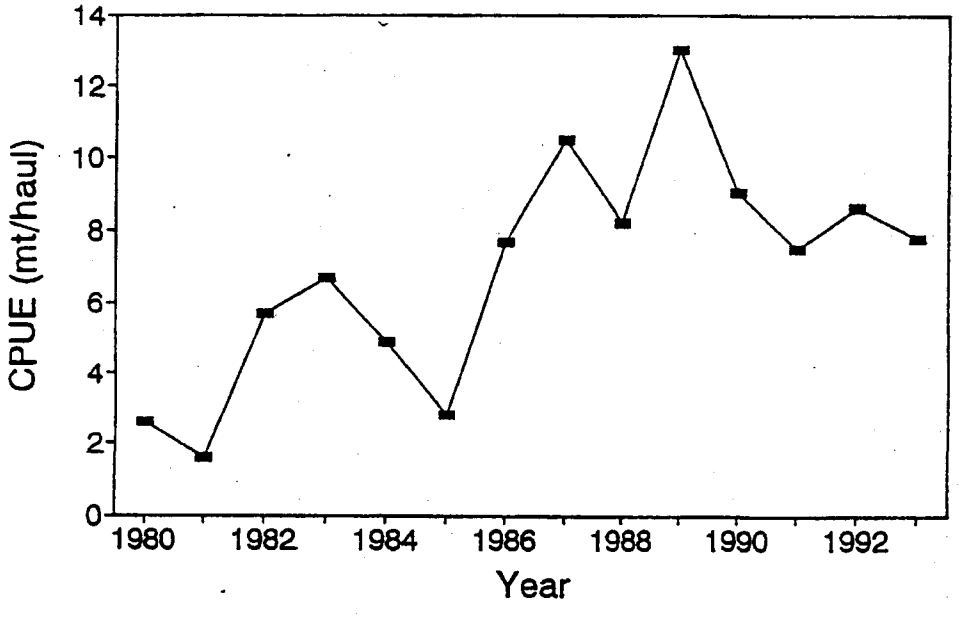

Fig. 4. Long-term trends in CPUE of yellowfin tuna from Korean purse seine fishery in the western Pacific Ocean from 1980 to 1993.

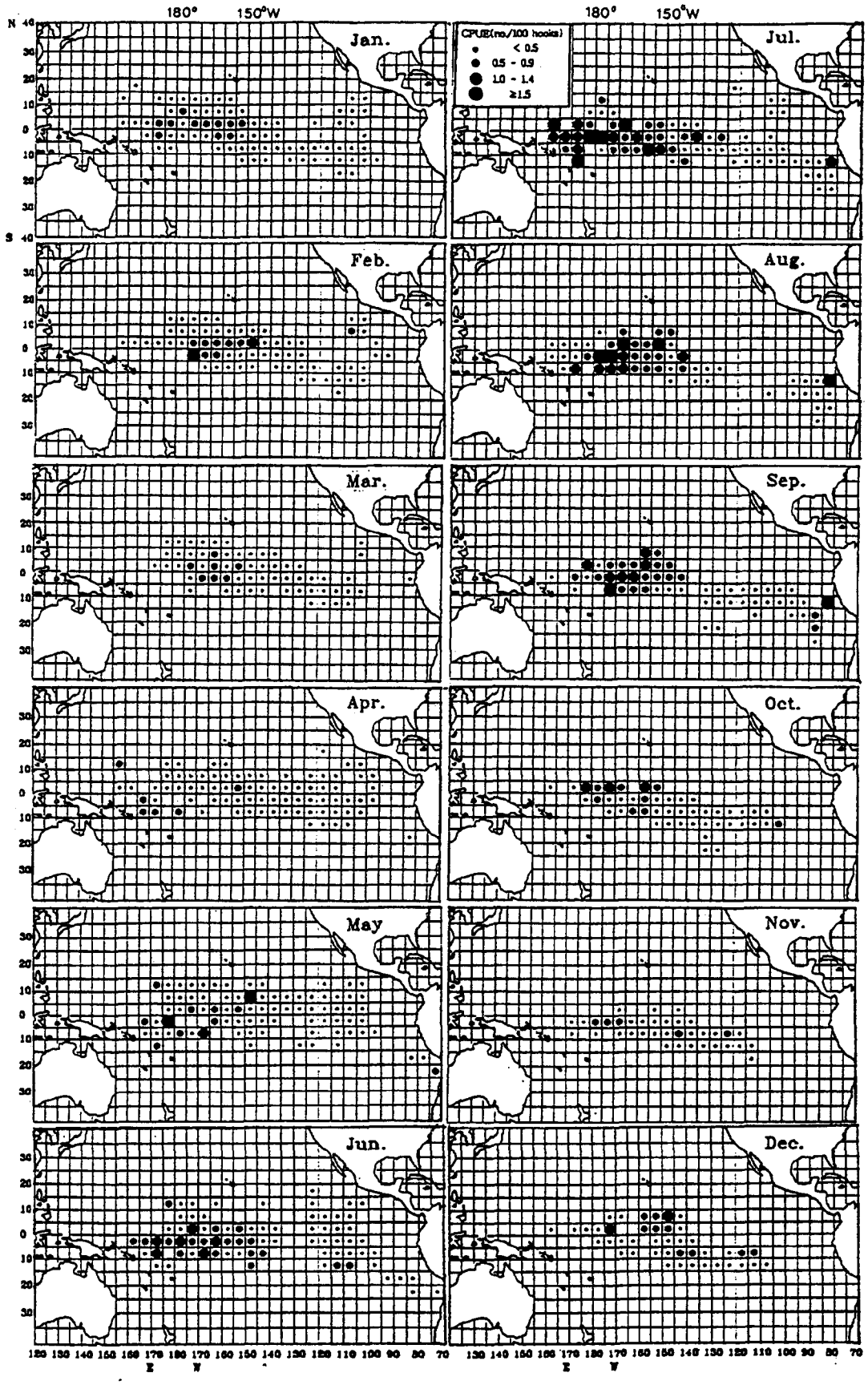

Fig. 5. Monthly distribution of CPUE (5° lat., 5° long.) of yellowfin tuna from Korean longline fishery in the Pacific Ocean in 1993.

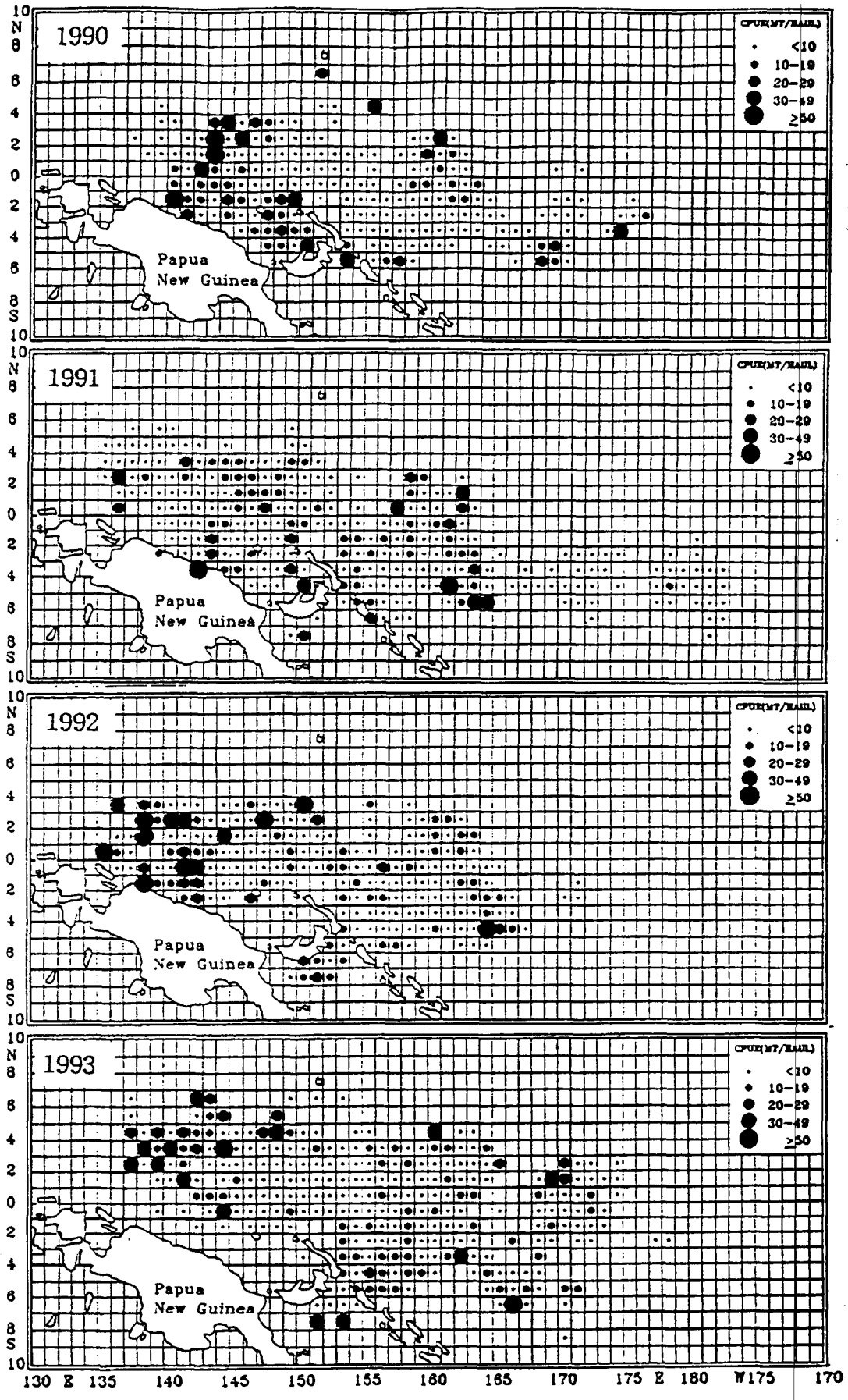

Fig. 6. Yearly distribution of CPUE(1° lat., 1° long.) of yellowfin tuna from Korean purse seine fishery, 1990–1993.

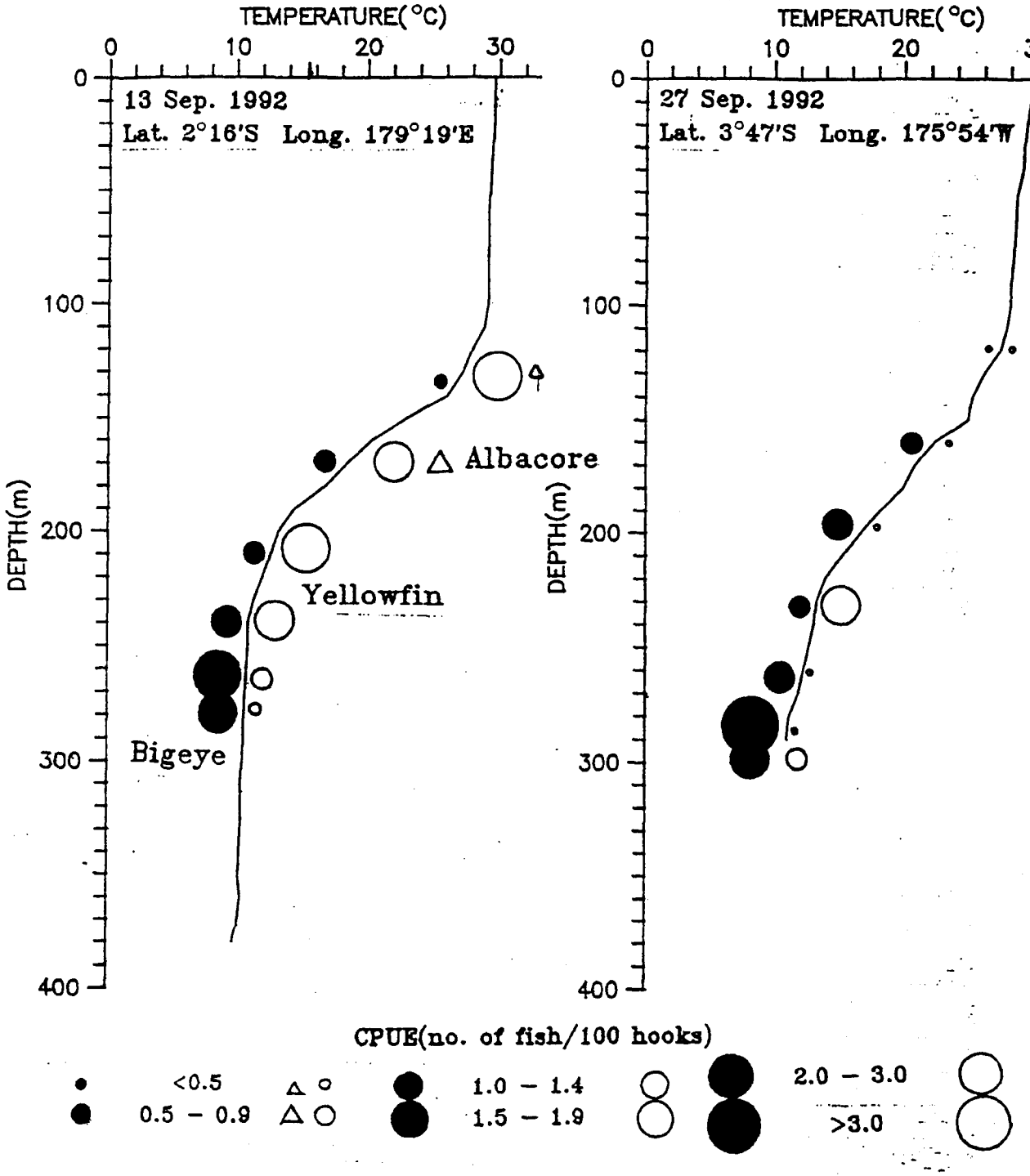

Fig. 7. CPUE distribution of yellowfin, albacore and bigeye tunas by fishing depth and water temperature observed from Korean tuna longliners during the scientific monitoring in the central Pacific Ocean from 13 September to 1 October 1992.

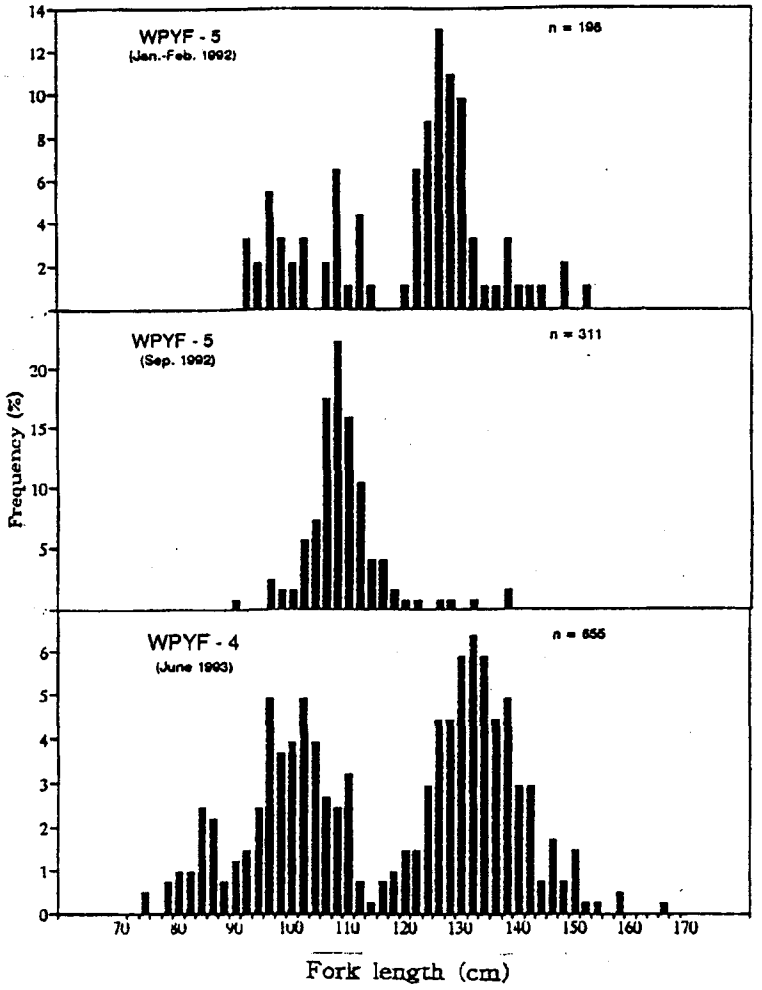

Fig. 8a. Length distribution of yellowfin tuna sampled from Korean longliners during scientific monitoring activity in the central Pacific Ocean in Jan.~Feb. and Sep. 1992, and June 1993.

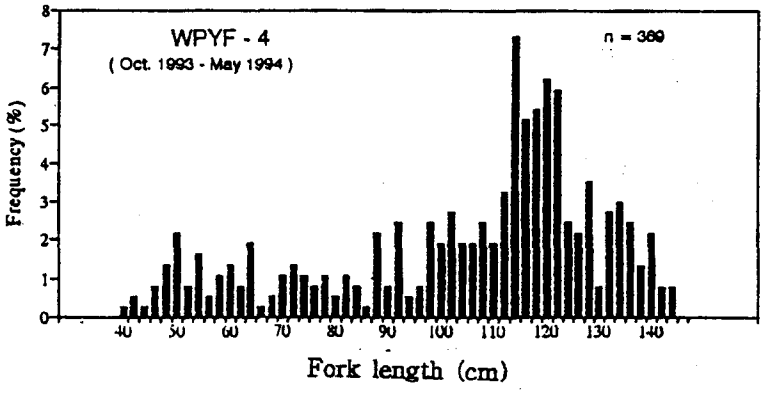

Fig. 8b. Length composition of yellowfin tuna sampled from Korean purse seine fishery during October 1993~May 1994.

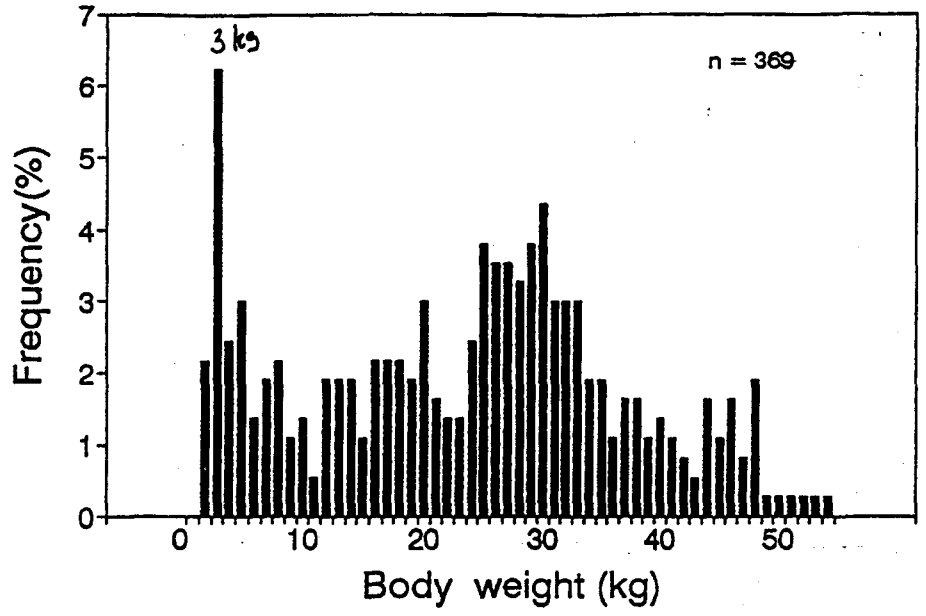

Fig. 9. Body weight composition of yellowfin tuna sampled from Korean purse seine fishery during October 1993~May 1994.

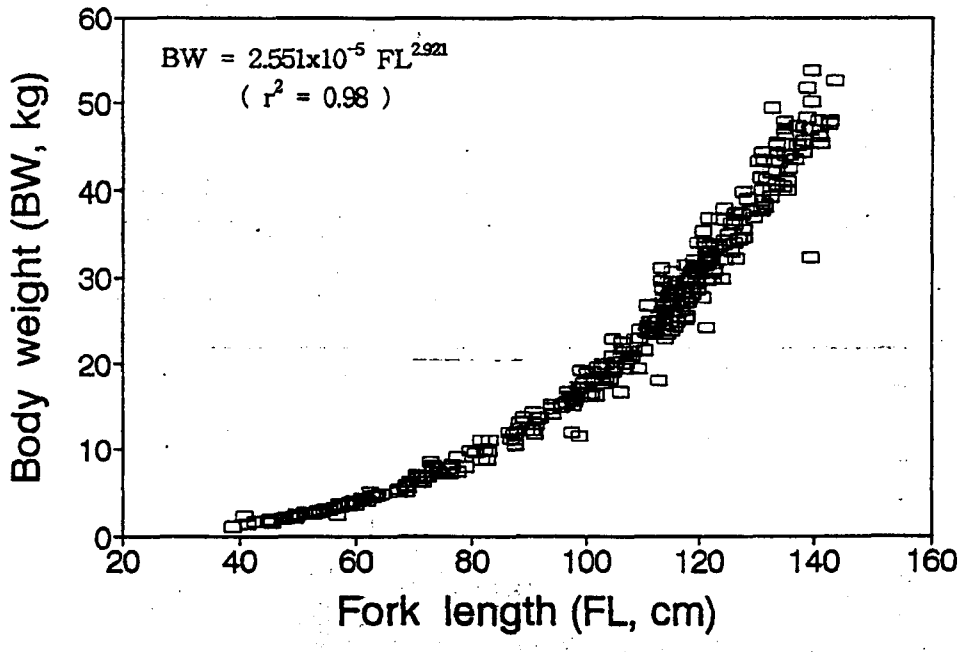

Fig. 10. Length-weight relationship of Yellowfin tuna sampled from Korean purse seine fishery in the WPYF area during October 1993~May 1994.