(X30)
IP 9

Some Problems in Catch Statistics of Tuna Longliner Fishery[1]

Chien-hsiung WANG[2]

Abstract

In Taiwanese tuna longline fishery, annual catches were raised by four methods; by number of trips, by number of sets, by number of hooks of each ocean and by number of hooks of each 5-degree square subarea. Theoretically, it can be proved that the estimates of annual catch can be checked through the relationship of coverage rate and the hooking rate.

This paper tries to discuss some problems of catch statistics of tuna longliners. The differences of estimates of annual catches raised by ocean coverage rates and subarea coverage rate are compared. Taiwanese tuna longline fisheries are used as an example to check the relationship between the coverage rate and the hooking rate. The relationship of ocean coverage rates and hooking rates of three main South Pacific albacore tuna longline countries are examined too.

The results are concluded as follows.

1. Taiwanese Pacific and Atlantic tuna longliners always tend to provide higher subarea coverage rates when the hooking rates are increased. In the Indian Ocean, they tend to provide lower subarea coverage rates when the hooking rates are increased.
2. Ocean coverage rates of Taiwanese longliners are always decreased when hooking rates are increased. This implies that the annual catches of Taiwanese longliners estimated by subarea coverage rate are always lower than those estimated by ocean coverage rate.
3. Taiwanese and Japanese South Pacific albacore tuna longliners always reveal negative correlation coefficient between ocean coverage rates and hooking rates. But, Korean longliners tend to have a positive correlation coefficient.
4. The distribution of fishing grounds of Korean South Pacific albacore longliners are of the intermediate type of Japanese and Taiwanese South Pacific tuna longliners.

---

1. Contribution No. , Institute of Oceanography, National Taiwan University. Supported by NSC78-0209-B002a-05.

2. Institute of Oceanography, National Taiwan University, Taipei, Taiwan, Republic of China.

INTRODUCTION

Tuna longline fishery is very important in exploitation of tuna-like fishes. In Taiwan, almost all of tuna-like fishes are exploited by tuna longline fisneries. Altnough some other fisheries, like as large purse seiners, large gill netters are developed rapiddly in recent years, longliners are yet the most important fisheries in this area.

Fish stocks are affected by man's activities. The success of the fisneries depends critically on the state of tne fish stock. Hence, we need to know that the condition of tne fish stock and tne effect on these stock of actions being contemplated. We also need to know what the effects of fish stock under different fisnery managements. To assure a successful fishery management can be carried out, the decision-maker need a sufficient scientific advice about the state of the fish stock.

All of the methods used to assess the fish stock are just a tool used to know the state of fish stock under exploitation. The reliability of the result of fish stock assessment depends on both quantity and quality of information collected from the commercial fisheries. Fishery scientists always use the CPUE (Catch Per Unit of fishing Effort) as a well-defined index of abundance.

Update, the most important data source of South Pacific albacore are collected from catch statistics of tuna longliners. Catch statistics collected from the commercial fishery can doubtless provide a large amount of information of population dynamics. In quantity, it is always enough through a complete data collecting system. In quality, some improvements are necessary. For example, the annual catches of Taiwanese tuna longliners published in annual reports are generally said that they are always in under-estimate. It is interesting to know why they are always different from the landing catch data.

In this paper, we try to discuss some problems about the annual estimates of catch statistics of tuna longliners, especially for Taiwanese tuna longliners. All of the analysis based on the coverage rate and the hooking rate of tuna longline fisneries.

MATERIALS AND METHODS

A rather complete data collection system of Taiwanese deep sea tuna longline fishery was built before 1971. From 1971 on, annual report of catch statistics of Taiwanese deep sea tuna longline fishery was published by quarterly and by 5-degree square subarea for each year. Annual catches of Taiwanese tuna longliners were raised by coverage rates which were computed by following four different methods.

Before 1970, only the total number of trips was available, hence annual catches were estimated by the coverage rate of each ocean which was estimated by the number of trips. In 1970-1971, coverage rates were also computed by each ocean, but they were replaced the number of trips by the number of sets. Furthermore, the number of sets was replaced by the number of hooks in 1972-1976. Before 1976, the coverage rate was yet computed by each ocean too. Before 1976, catches of each 5-degree square subarea had not been raised to 100%.

From 1977 on, the coverage rates computed according to the number of hooks used in each 5-degree square subarea were also published in the annual report. But annual catches were yet raised by coverage rates which were estimated by each ocean. From 1980 on, the annual catches were accumulated from the catch of each 5-degree square subarea which had been raised to 100%.

As stated above, catch statistics of Taiwanese tuna longliners were raised by coverage rates which were computed according to four different methods; by number of trips of each ocean (before 1970), by number of sets of each ocean (1971-1972), by number of hooks of each ocean (1972-1979) and by number of hooks of each 5-degree square subarea (1980-). Before 1980, the effects of the annual estimates depend on the data sources; by trips, by sets or by hooks. After 1972, the estimate of annual catches also depend on the methods which were used; raised by ocean coverage rate or by subarea coverage rate.

In this paper, two assumptions are necessary. One is that the reliability of the data sources is disregarded, that is that all of the original data are assumed to be collect. The other one is that coverage rates of Japanese and Korean tuna longliners can be converted to those estimated by number of hooks. Then the annual catches estimated by different methods and by different tuna longline countries can be discussed as follows.

Assumed that the annual catches were estimated by two different methods; one (method A) was raised by coverage rate of each ocean. and the other one (method B) was summarized from the catches of each 5-degree square subarea which had been raised to 100%. The results estimated by these two methods can be represented as follows.

In the case of two subareas, it can be written as follows.

$$\text{method A :} \quad TC = (C1 + C2)\ (H1 + H2)/(h1 + h2) \qquad \text{..... 1}$$

and

$$\text{method B :} \quad TC' = C1\ H1/h1 + C2\ H2/h2 \qquad \text{..... 2}$$

where,

H1 = total number of hooks used in subarea 1,
H2 = total number of hooks used in subarea 2,
h1 = sample number of hooks used in subarea 1,
h2 = sample number of hooks used in subarea 2,
C1 = catch in number of individual in subarea 1,
C2 = catch in number of individual in subarea 2,
TC = annual estimate by method-A,
TC' = annual estimate by method-B.

Generally, they can be rewritten as follows if fishing ground is divided into n subareas.

method-A : $TC = (\sum_{i=1}^{n} Ci)(\sum_{i=1}^{n} Hi)/(\sum_{i=1}^{n} hi)$ 3

method-B : $TC' = \sum_{i=1}^{n} (Ci\ Hi/hi)$ 4

Then, the difference of estimates of annual catch between these two methods can be computed as

$$D = TC - TC'$$

$$= \frac{H1\ H2}{h1 + h2}\left(\frac{C1}{h1} - \frac{C2}{h2}\right)\left(\frac{h1}{H1} - \frac{h2}{H2}\right)$$ 5

for two subareas. For n subareas; i, j = 1, 2, 3 ..... n, it can be proved by induction that

$$D = TC - TC' = \left(\sum_{\substack{i=1\\ j>i}}^{n} Hi\ Hj\left(\frac{Ci}{hi} - \frac{Cj}{hj}\right)\left(\frac{hi}{Hi} - \frac{hj}{Hj}\right)\right) \Big/ \sum_{i=1}^{n} hi$$

$$= \left(\sum_{\substack{i=1\\ j>i}}^{n} HiHj\ (Ui - Uj)\ (Vi - Vj)\right) \Big/ \sum_{i=1}^{n} hi$$ 6

Here, $U=C/h$ and $V=h/H$ can be considered as the hooking rate and the coverage rate, respectively.

Generally, the variation of coverage rates may be effected by the goodness of the hooking rates. Higher hooking rates could be considered as a helpful factor to promote the fishermen to provide more catch information. And, they have a lower willingness to provide any catch informatioen when they met a very bad fishing condition. On the other hand, they may be tend to cover a factor of good fishing condition too, because they don't like to let other fishermen to share their lucky or better experiments. Here, assumed that the coverage rate depends on the hooking rate, that is $V = a + b\,U$. Then, formula-6 can be rewritten as follows.

$$D = TC - TC' = \left(\sum_{\substack{i=1 \\ j>i}}^{n} Hi\ Hj\ b\ (Ui - Uj)^2\right) \Big/ \sum_{i=1}^{n} hi \qquad \ldots\ldots 7$$

Since Hi, Hj, hi, Uj, and Ui are always positive, the sign of D=TC-TC' depends on the value of regression coefficient (b) and relative values of the coverage rate (V = h/H) or the hooking rate (U = C/h) of each subarea. That is

1. If each subarea has the same hooking rate, then D = 0, that is TC = TC'. These two methods have the same estimate.

2. If each subarea has the same coverage rate, then D = 0 and the same result is obtained too.

3. If each subarea with higher hooking rate has higher coverage rate and/or lower hooking rate has lower coverage rate, then D is positive, that is TC > TC'. In this case, the annual catch estimated by method A with Ocean coverage rate is greater than that estimated by method B with subarea coverage rate.

4. Conversely, if each subarea with higher hooking rate always has lower coverage rate, or lower hooking rate always has higher coverage rate, then D is minus, that is TC < TC'. In this case, the annual catch estimated by method A is smaller than that estimated by method B.

5. For other case, that is if among higher hooking rate subareas, some one povides higher coverage rate and some one provides lower coverage rate, then the sign of D is determined by the relative values of hooking rate and/or coverage rate of each subarea. If higher hooking rate tends to have higher coverage rate then the sign of D tends to be positive. Conversely, if higner hooking rate area tends to have lower coverage rate then the sign of D tends to be minus.

As stated above, to check the relationship between the coverage rate and the hooking rate becomes an important technique to examine the estimate of annual catches. In this paper, Japanese (Fisheries Agency of Japan 1971-1985), Korean (Fisheries Research and Development Agency of Korea 1980, 1981, 1985, 1986) and Taiwanese (NTUIO 1971-1985) annual reports of catch statistic of tuna longliners are used to discuss the relationship between the coverage rate and the hooking rate.

Symbols used in this paper are listed as follows.

n = the number of subareas,
a = intercept of regression line,
b = regression coefficient,
r = correlation coefficient,

U = CPUE by catch in number of individuals per 100 hooks or catch in weight of kilogram per 100 hooks,
V = ocean coverage rate or subarea coverage rate,
c.v. = coefficient of variation.

RESULTS AND DISCUSSIONS

Table 1 shows the results of regression analysis of coverage rate (Y) as a linear function of each subarea hooking rate (X) of Taiwanese Pacific albacore tuna longline fishery. It reveals that positive correlation coefficient of 1981, 1983 and 1984 imply that higher hooking rate subarea tends to have a higher coverage rate. On the other hand, negative correlation coefficient of 1982 and 1985 imply that higher hooking rate subarea tends to have lower coverage rate in Taiwanese Pacific albacore tuna longline fishery. However, no one of the correlation coefficient reaches the significant level. Average coverage rates are varied in 67%-82% and average hooking rates in 1.5-3.0 individuals per 100 hooks.

Table 2 is the result of regression analysis of Taiwanese Indian albacore tuna longline fishery. According to this Table, only the correlation coefficient of 1983 is positive. This means that only in 1983, higher hooking rate subarea tends to have higher coverage rate. For the other 4 years, higher hooking rate subarea always tends to have lower coverage rate for the negative correlation coefficient. In 1982, the negative correlation coefficient reaches 5% significant level. And, in 1981 and 1985, they also reach 10% significant level. It strongly implies that Taiwanese Indian albacore tuna longliners always provide a little information when hooking rate is increased. Average coverage rates and average hooking rates are varied in 61%-79% and 1.0-1.6 individuals per 100 hooks, respectively.

The results of regression analysis of Taiwanese Atlantic albacore tuna longliners are shown in Table 3. The results are very different from those of Indian Ocean. From this Table, only two negative correlation coefficients of 1983 and 1984 can be found. For the other 3 years, positive correlation coefficients imply that higher hooking rate subarea tends to have higher coverage rate. Generally, the value of correlation coefficient is very small and no one reaches the significant Level. Average coverage rates and average hooking rates are varied in 54%-80% and 2.2-2.5 individuals per 100 hooks, respectively.

As stated above, the results of regression analysis of coverage rate and hooking rate by each subarea reveal that Taiwanese Pacific and Atlantic albacore tuna longliners always tend to provide higher coverage rate when the hooking rate is increased and conversely, they provide lower coverage rate when the hooking rate is decreased, though the tendence is not so clear. On the other hand, they clearly have the converse tendence in the Indian Ocean. They always provide a lower coverage rate when the hooking rate is increased.

Next, the relationship between the annual hooking rate and the coverage rate by each ocean is compared too. As shown in Table 4, all of these three oceans show a significant negative correlation coefficients, especially in Indian albacore longliners. The negative correlation coefficient of Indian Ocean is -0.506** reaching 5% of significant level. The next is the Atlantic Ocean. It is -0.501* over 10% of significant level. In the Pacific Ocean, though it is lower than 10% of significant level, it also shows a clearly negative regression relation between the coverage rate by ocean and the annual hooking rate.

For overall fishing grounds of Taiwanese tuna longline fishery, the negative correlation coefficient is -0.694*** over 1% of significant level. This implies strongly that Taiwanese albacore tuna longliners always tend to provide lower coverage rate when the hooking rate is increased. The reasons may be considered as follows.

1. When they find a good fishing ground, they always tend to conceal it and they don't like to provide the detail fishing information.

2. They are busy in catch when they arrived a good fishing ground. They haven't so much time to fill the logbbok which is asked.

3. Fishing information are always provide by those fishmen who are interesting in collecting fishing information.

4. Provided information are quite different from the virtual information, that is that they don't like to offer true fishing information, but experimently they always fill a series of meanless numerals.

However, according to the aforementioned theoretical proof and the computations, the significantly negative correlation coefficiens of Taiwanese tuna longliners strongly imply that fishmen always tend to provide lower coverage rate when the hooking rate is increased. This is one of the important reasons why the annual catches listed in annual reports are always said to be under-estimates. Of course the precision of the annual estimate may be effected by other factors too. In the future, if we want to improve the precision of the annual report, it is absolutely necessary to increase the willingness of filling the catch data.

Table 4 reveals that Taiwanese Indian Ocean longliners provide the highest 46.991% coverage rate. The next one of coverage rate is 45.247% which is offered by Pacific Ocean longliners. The lowest one is 42.840% which is provided by the Atlantic Ocean longliners. For the overall fishing grounds of Taiwanese commercial longliners, they offered an average coverage rate of 44.085% and the average hooking rate of 2.954 individuals per 100 hooks.

Japan, Korea and Taiwan are three main tuna longline countries. Generally, assessment of tuna-like fish stock is mainly based on catch statistics of commercial fisheries of these three tuna longline countries. The relationship of the annual hooking rate and the annual coverage rate of these three countries are also compared as follows. Furthermore, because that surplus production model was always employed to assess the fish stock, the relationships between hooking rate represented by catch in weight (kilogram per 100 hooks) and the coverage rate are also checked in this paper.

Table 5 shows the catch in number of individuals per 100 hooks, catch in weight of kilogram per 100 hooks, percentage of albacore in total number of catch and the annual coverage rate of overall Taiwanese, Japanese and korean South Pacific albacore fishing grounds in 1971-1985. The definition of the South Pacific Ocean is the same as that given in the Taiwanese tuna longline annual report.

In Table 5, annual coverage rates of Taiwanese tuna longliners are estimated by hooks used in overall South Pacific fishing grounds. Japanese coverage rates are based on the number of trips of overall fishing grounds listed in annual reports. Korean coverage rates are adopted from the annual reports which was estimated by the ratio of sampling catch and total landing catch of overall Pacific longline fishing grounds.

As shown in Table 5, Taiwanese hooking rates represented in both weight and number are maintained at a rather stable level. The coefficient of variance (c.v.) is 0.200 and 0.217, respectively. Percentages of albacore in total number of catch are still keeping at a very high level with an average value 82.00%. Comparatively, coverage rates are varied heavily with a larger coefficient of variance 0.598.

Table 5 also reveals that the coefficients of variance of hooking rate in number and coverage rate of Japanese tuna longliners are keeping at a rather low level. Attention is paid to the very low percentages of albacore in total catch of Japanese tuna longliners. The target species are changed heavily with a 0.375 coefficient of variance during this period. Albacore is the target species of Taiwanese tuna longliners, but only 11.41% of average catch of Japanese longliners is albacore.

On the other hand, Korean longliners have a larger values of coefficient of variance during these eight years. The average percentage of albacore in total number of catch is 39.79% which is lower than Taiwanese longliners, but greater than Japanese longliners. The average values of CPUE in both weight and number are also lower than Taiwanese tuna longliners, and greater than Japanese tuna longliners. The results imply that Korean tuna longliners are of intermediate type of Taiwanese and Japanese tuna longliners.

Table 6 shows the results of regression analysis of annual coverage rate as a linear function of annual CPUE of these three tuna longline countries of South Pacific albacore. In the case of CPUE in catch of number, no one of the correlation coefficient reaches the 10% of significant level. It is interesting in the difference of the sign of correlation coefficients. Only Korean tuna longliners have a positive correlation coefficient. Does this imply that only Korean tuna longliners tend to offer more information when the hooking rate is increased? Although the tendence is not so clear.

In the case of catch in weight, it reveals a very different tendence as shown in correlation coefficient. For Taiwanese tuna longliners, it shows a very high negative correlation coefficient. For Japanese longliners, though it is yet a negative value, it is very small. For Korean tuna longliners, rather large positive correlation coefficient can be found, though it doesn't yet reach the significant level. Because that catches in weight of Taiwanese tuna longliners listed in annual reports are estimated on the vessels, it needs more detail information to explain the significance of the negative correlation coefficient.

Table 7 shows the results of regression analysis of CPUE of catch in number between different tuna longline countries. No signifcant relationship of CPUE in catch of number of these three tuna longline countries can be found. But, the values of correlation coefficient seem to reflect the difference of target species and the distribution of fishing grounds of these three tuna longline countries.

The smallest correlation coefficient of Japanese to Taiwanese tuna longliners seems to imply the clear separation of main fishing grouns of these two countries (Wang 1988; FAO 1980). Taiwanese South Pacific tuna longliners are targeting on South Pacific albacore, and main fishing grounds are distributed on the south of 40°S, especially on the south of 30°S. Japanese tuna longliners are targeting on southern bluefin tuna, and seasonally change to targeting on bigeye or yellowfin tuna. As shown in Figure 1, main fishing grounds are concented on the western part and north-eastern part of the South Pacific Ocean.

On the other hand, rather large of correlation coefficients can be found in the relations of Taiwan-Korea and Japan-Korea. Korean South Pacific tuna longliners are widely interesting in exploitation of all tuna like-fishes. As stated in Table 5, Korean South Pacific tuna longliners are of the intermediate type of Japanese and Taiwanese longliners. As shown in Figure 2, Korean South Pacific longline fishing grounds mainly distribut on lower latitude areas, especially between 160°E to 140°W. They can be found that distributions of main fishing grounds of Korean South Pacific tuna longliners havs a certain degree of overlap in seasonally with that of Japanese or Taiwanese longliners. The percentages of yellowfin and bigeye tuna in total number of catch of Korean longliners are far greater than those of Taiwanese South Pacific tuna longliners, but they near to those of Japanese South Pacific tuna longliners.

SUMMARY

1. Annual catches of Taiwanese tuna longliners are estimated by four different methods; by trip, by set, by hook of ocean and by hook of subarea.

2. Theoretically, it can be proved that the relationship of coverage rate and hooking rate by each subarea can be used to check the estimates of annual catch.

3. If all of coverage rates or hooking rates are equal in each subarea, then the annual catch estimated by ocean coverage rate are equal to that estimated by subarea coverage rate.

4. If each subarea which has higher hooking rate tends to have higher coverage rate, then the annual catch estimated by ocean coverage rate is higher than that estimated by subarea

coverage rate.

5. If each subarea which has higher hooking rate tends to have lower coverage or conversely, lower hooking rate tends to have higher coverage rate, then the annual catch estimated by ocean coverage rate is lower than that estimated by subarea coverage rate.

6. During 1981-1985, Taiwanese Pacific and Atlantic tuna longliners tend to provide higner subarea coverage rate when the hooking rate is increased. However, the tendence is not so clear.

7. On the other hand, the significant negative correlation coefficient of Taiwanese Indian tuna longliners implies that higher subarea hooking rate tends to provide lower coverage rate in the same period.

8. Higher negative correlation coefficient between ocean coverage rate and the hooking rate of Taiwanese tuna longliners imply that they always tend to provide lower coverage rate when the hooking rate is increased.

9. The relationships of hooking rate and ocean coverage rate of Japanese, Taiwanese and Korean South Pacific tuna longliners are also examined, respectively. Taiwanese and Japanese longliners show a negative correlation coefficient, but Korean longliner has a rather large value of positive correlation coefficient.

10. The relationships of CPUE of catch in number per 100 hooks of South Pacific tuna longliners are also used to examine the distribution of fishing grounds of longline countries. Korean longliners are of the intermediate type of Taiwanese and Japanese longliners. Main fishing grounds of Korean longliners have certain degree of overlap with Taiwanese and Japanese tuna longliners. Comparatively, distributions of Japanese longline fishing gounds are separated from those of Taiwanese longliners.

ACKNOWLEDGEMENT

The write wish to thank Mr. M. C. Lin and Miss M. S. Chang for their assistance in preparing this manuscript. This research was supported by the National Scientific Committee under the contract Nos. NSC78-0209-8002a-05.

REFERRENCES CITES

FAO (1980) State of selected stocks of tuna and billfish in the Pacific and Indian Oceans. FAO Fish. Tech. Paper, No. 200, 89 pp.

Fisheries Agency of Japan (1971-1985) Annual report of effort and catch statistics by area on Japanese tuna longline fishery.

Fisheries Research and Development Agency of Korea (1980, 1981, 1985, 1986) Annual report of catch and effort statistics and fishing grounds on Korean tuna longline fishery.

NTUIO (1971-1985) Annual catch statistics of Taiwan's tuna longline fishery. Institute of Oceanography, National Taiwan University, Taipei, Taiwan, Republic of China.

Wang, C. H. (1988) Seasonal changes of the distribution of South Pacific albacore based on Taiwan's tuna longline fishery, 1971-1985. Acta Oceanographica Taiwanica 20: 13-40.

Table 1. Regression analysis of the subarea coverage rate (V) as a linear function of the hooking rate (U) of Taiwanese Pacific albacore tuna longliners in 1981-1985.

year	n	a	b	r	U-mean	V-mean
1981	173	78.494	0.824	0.047	1.584	79.709
1982	125	82.620	-1.830	-0.093	2.010	78.820
1983	89	78.412	1.158	0.105	2.954	81.656
1984	89	70.910	2.050	0.096	2.173	75.210
1985	69	72.032	-1.529	-0.078	2.567	67.897

note : ns = no significance, * = 10% significant level,
** = 5% significant level, *** = 1% significant level.

Table 2. Regression analysis of the subarea coverage rate (V) as a linear function of the hooking rate (U) of Taiwanese Indian albacore tuna longliners in 1981-1985.

year	n	a	b	r	U-mean	V-mean
1981	124	82.156	-2.605	-0.165*	1.508	78.095
1982	135	80.791	-2.943	-0.192**	1.502	76.250
1983	129	65.254	1.582	0.070	1.222	67.086
1984	123	62.976	-1.422	-0.063	1.090	61.324
1985	105	19.160	-4.250	-0.188*	1.008	64.517

refer to footnote of Table 1.

Table 3. Regression analysis of the subarea coverage rate (V) as a linear function of the hooking rate (U) of Taiwanese Atlantic albacore tuna longliners in 1981-1985.

year	n	a	b	r	U-mean	V-mean
1981	154	75.499	2.051	0.124	2.220	79.954
1982	154	73.533	1.829	0.099	2.408	77.837
1983	139	76.784	-0.250	-0.012	2.417	76.613
1984	133	71.461	-1.450	-0.078	2.430	67.830
1985	144	48.971	0.258	0.123	2.333	54.913

Table 4. Regression analysis of the ocean coverage rate (V) as a linear function of the hooking rate (U) of Taiwanese albacore tuna longliners in 1971-1985.

Ocean	n	a	b	r	U-mean	V-mean
Pacific Ocean	15	104.18	-16.51	-0.432ns	3.487	45.247
Indian Ocean	15	103.14	-24.72	-0.516**	2.217	46.991
Atlantic Ocean	15	166.56	-37.17	-0.501*	3.270	42.840
Total area	15	141.02	-32.19	-0.694***	2.954	44.085

refer to footnote of Table 1.

Table 6. Regression analysis of the coverage rate (V) as a linear function of CPUE (U by number or by weight) of Taiwanese, Japanese and Korean South Pacific albacore tuna longliners.

		n	a	b	r	U-mean	V-mean
Taiwan	U = n/100H	15	100.80	-18.684	-0.3997ns	2.941	45.85
	U = kg/100H	15	112.93	- 1.524	-0.5294**	44.025	45.85
Japan	U = n/100H	15	85.64	-51.241	-0.3288ns	0.197	75.54
	U = kg/100H	15	80.04	- 1.660	-0.1371ns	2.708	75.54
Korea	U = n/100H	8	20.24	15.948	+0.4571ns	1.087	37.58
	U = kg/100H	8	21.79	0.941	+0.3763ns	16.780	37.58

refer to footnote of Table 1.

Table 7. Regression analysis of CPUE (in n/100H) between different tuna longline countries.

X	Y	n	a	b	r	X-mean	Y-mean
Taiwan	Japan	15	0.1634	0.0115	0.0721ns	2.9407	0.1971
Taiwan	Korea	8	0.0863	0.3513	0.4838ns	2.8495	1.0873
Japan	Korea	8	0.3400	5.2671	0.4214ns	0.1419	1.0873

refer to footnote of Table 1.

Table 5. Annual hooking rate and coverage rate of Taiwanese, Japanese and Korean South Pacific albacore tuna longliners in 1971-1985

Year	TAIWAN				JAPAN				KOREA			
	n/100H	Kg/100H	%	V	n/100H	Kg/100H	%	V	n/100H	Kg/100H	%	V
1971	2.864	45.736	66.64	32.77	0.461	5.895	20.99	56.61	-	-	-	-
1972	3.279	53.084	69.65	24.74	0.280	3.502	13.67	53.32	-	-	-	-
1973	3.097	50.956	73.06	16.80	0.234	2.763	5.81	55.08	-	-	-	-
1974	2.712	39.001	79.49	10.92	0.166	1.853	13.35	58.40	-	-	-	-
1975	2.735	41.223	78.76	16.27	0.105	1.244	6.83	62.15	0.527	10.528	15.75	9.6
1976	3.743	60.462	80.40	10.41	0.102	1.744	6.64	81.64	0.992	18.459	38.66	17.8
1977	3.717	54.030	86.91	26.04	0.140	1.862	8.80	85.12	1.127	16.113	38.43	44.9
1978	3.652	50.727	86.52	47.54	0.163	2.649	9.82	75.12	2.169	32.748	50.67	64.7
1979	2.516	37.572	76.79	68.71	0.137	1.909	8.82	75.46	1.252	18.156	41.38	35.7
1980	2.132	30.477	82.25	53.33	0.093	1.342	6.80	79.53	0.435	7.532	17.08	59.9
1981	1.962	27.701	86.04	83.02	0.221	3.322	13.22	89.46	0.875	13.128	59.46	33.1
1982	2.339	34.343	89.57	78.17	0.174	2.533	15.07	89.87	1.321	17.574	56.88	34.9
1983	3.631	51.518	91.86	81.53	0.270	4.008	15.70	87.09	-	-	-	-
1984	2.559	37.372	90.62	69.58	0.187	2.722	14.32	93.48	-	-	-	-
1985	3.173	46.171	90.90	67.93	0.224	3.291	11.25	90.79	-	-	-	-
Mean	2.941	44.025	82.00	45.85	0.197	2.708	11.41	75.54	1.087	16.780	39.79	37.6
c.v.	0.200	0.217	0.096	0.598	0.197	0.445	0.375	0.193	0.497	0.450	0.414	0.502

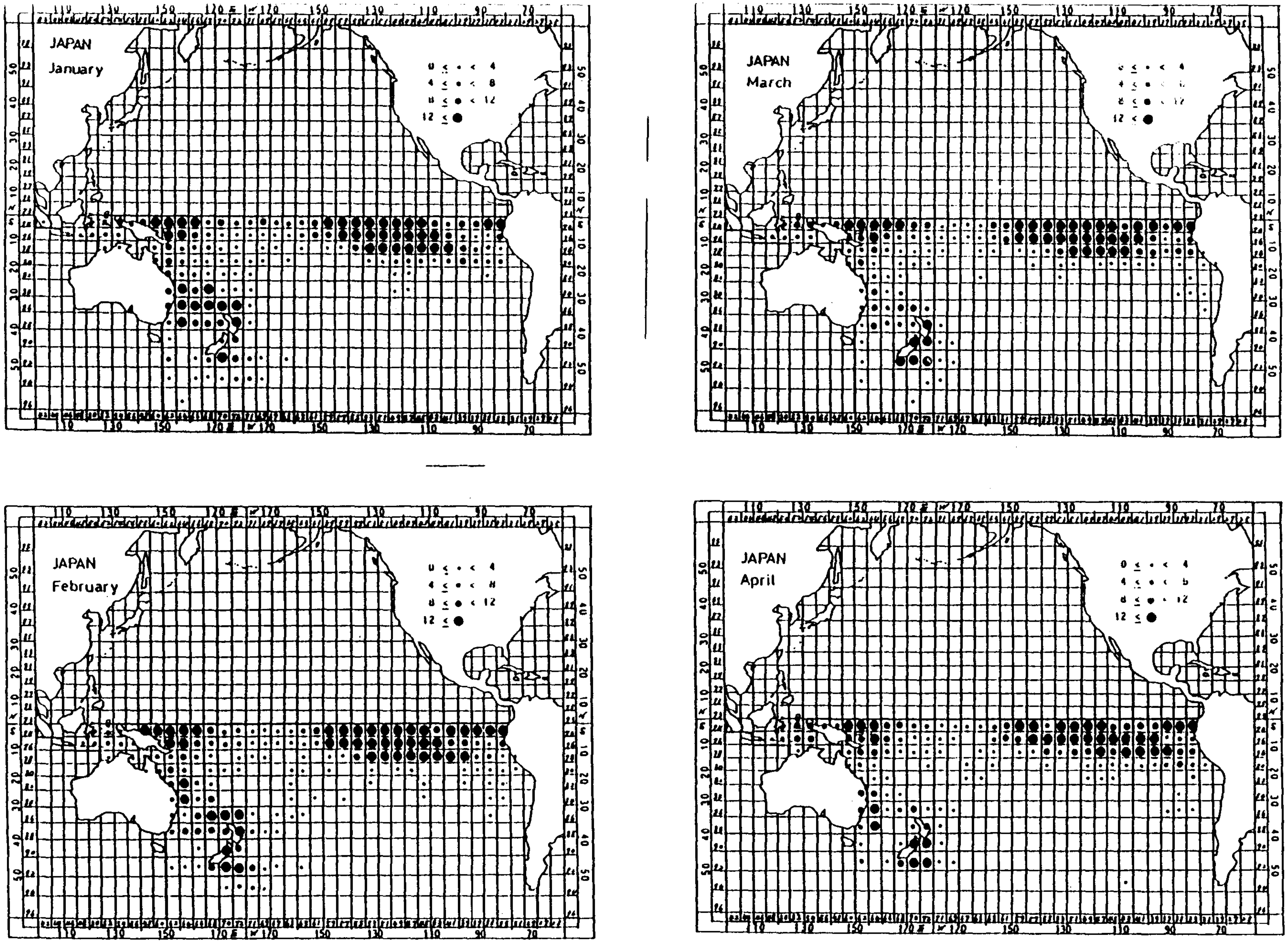


Figure 1. Monthly distributions of Japanese South Pacific albacore tuna longline fishing grounds. Numeral means the number of years of Japanese longliners occured in that subarea during 1971-1985.

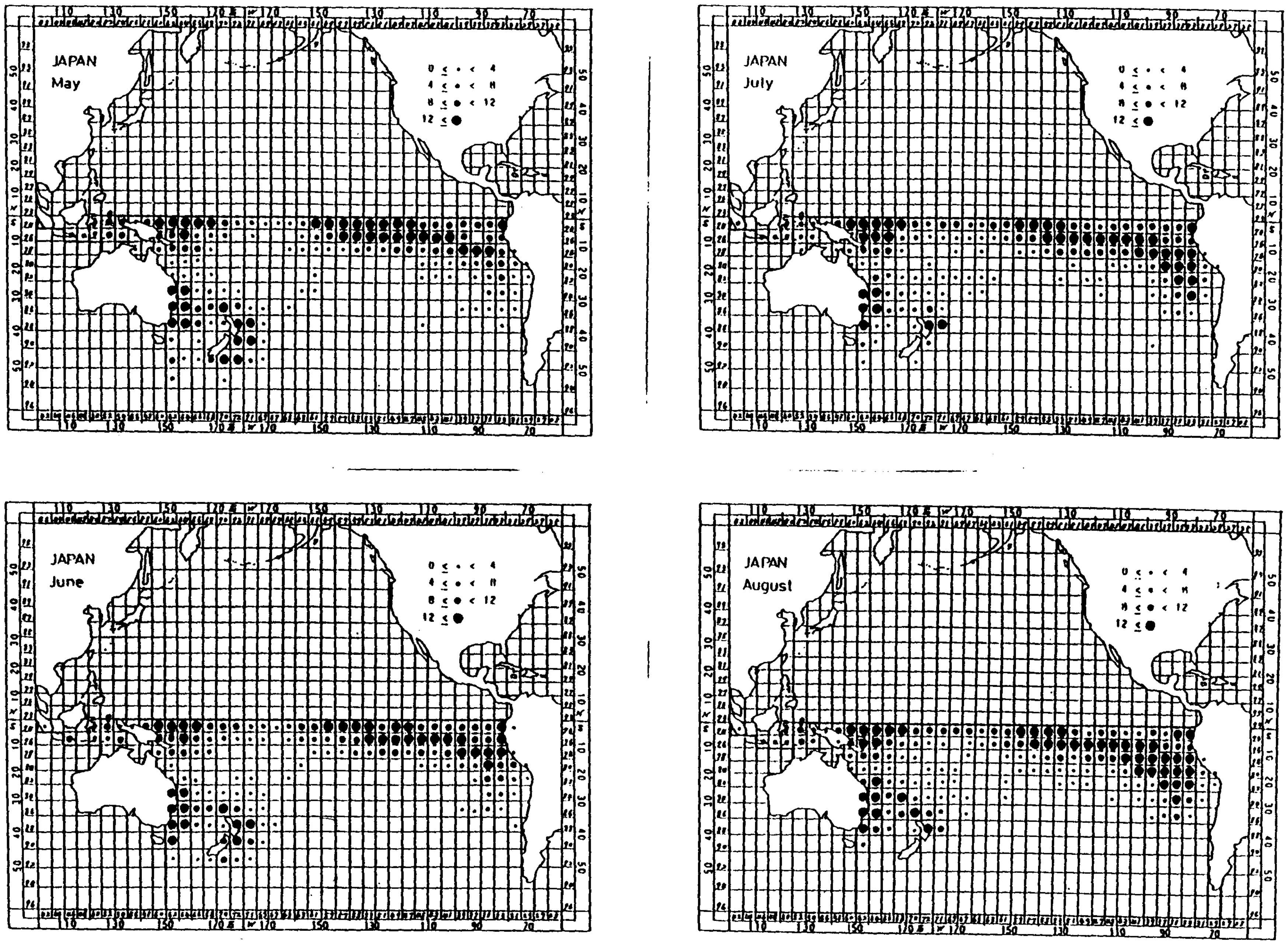


Figure 1. ..... continued.

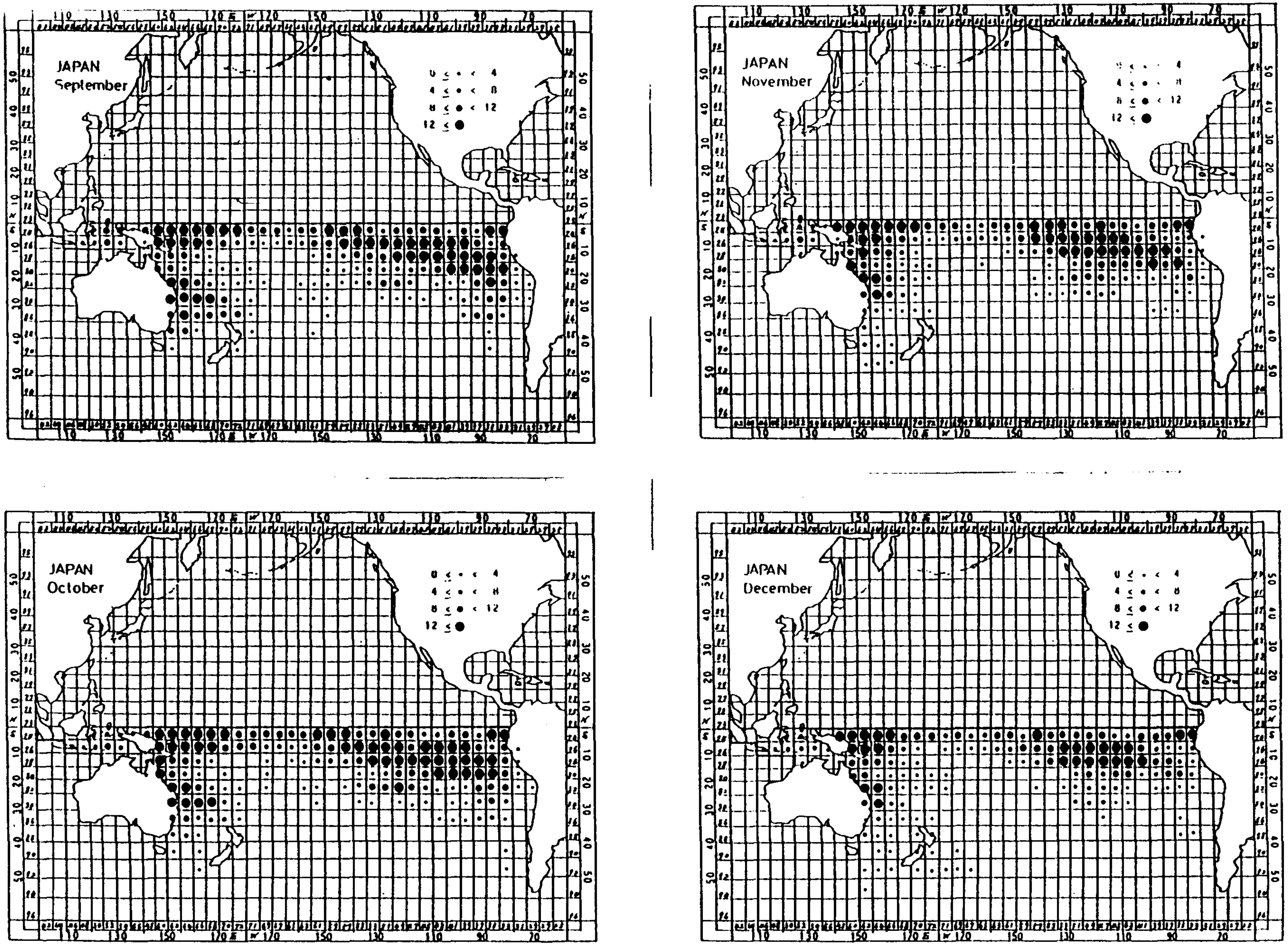


Figure 1. ..... continued.

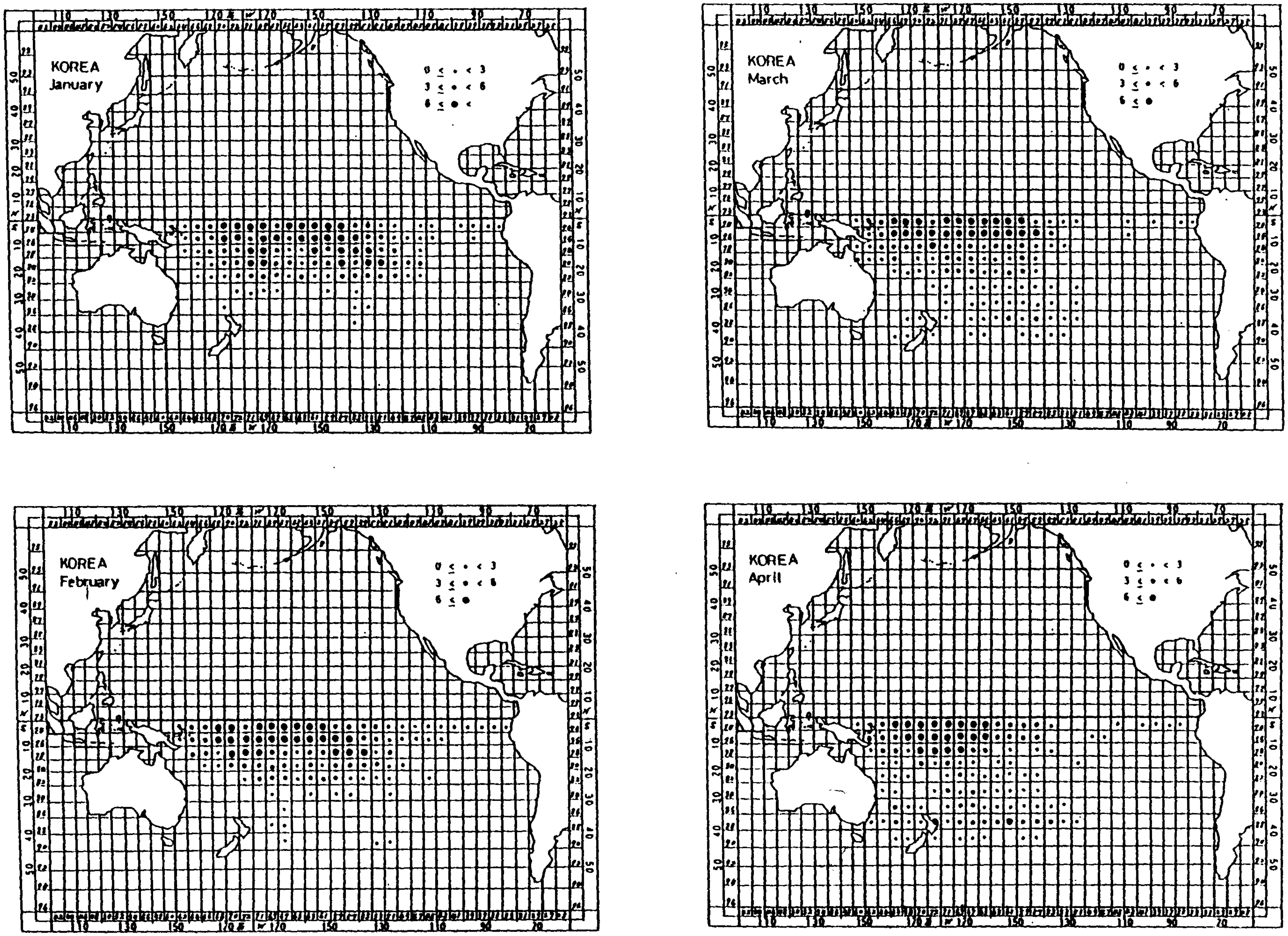


Figure 2. Monthly distributions of Korean South Pacific albacore tuna longline fishing grounds. Numeral means the

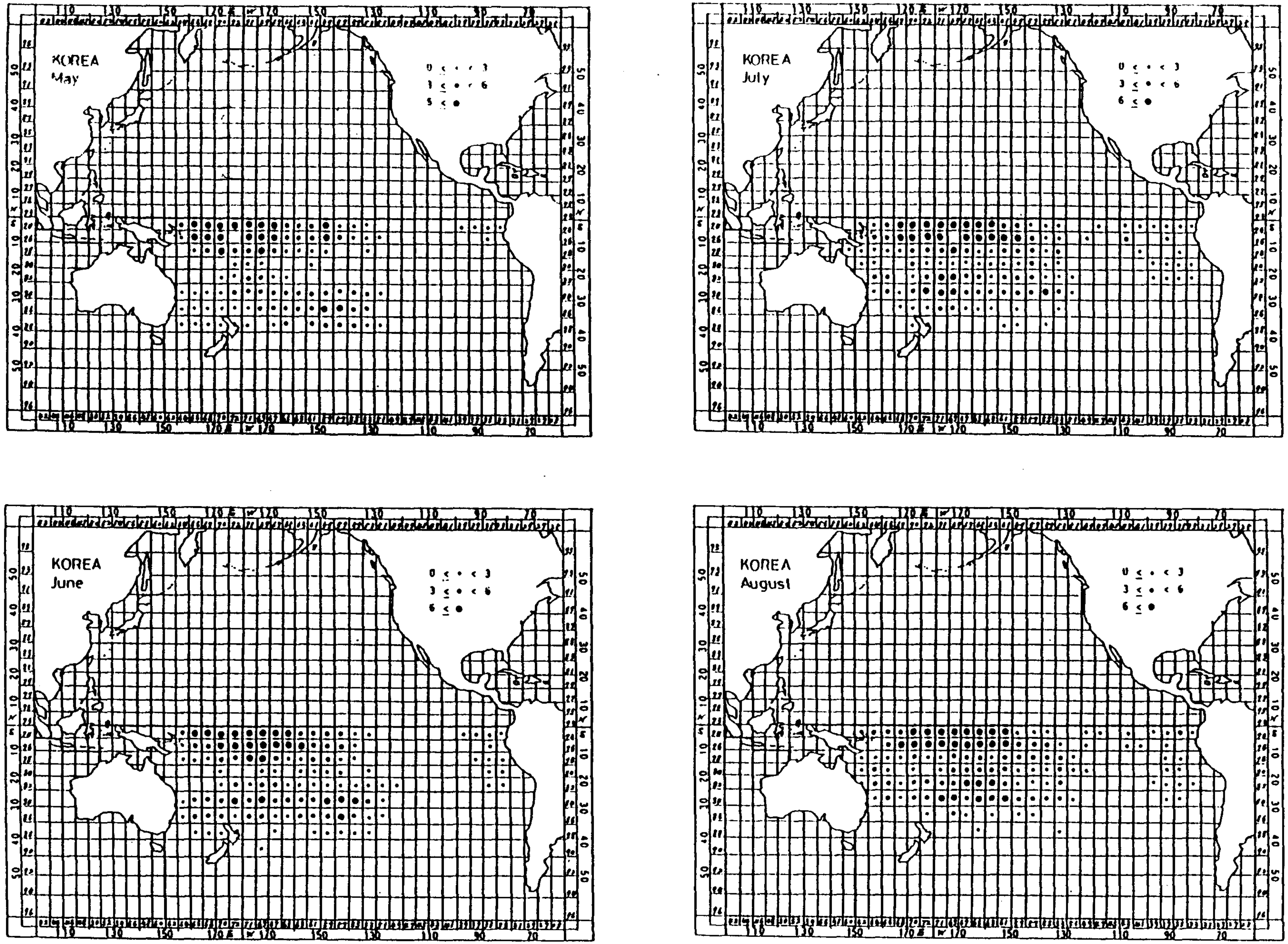
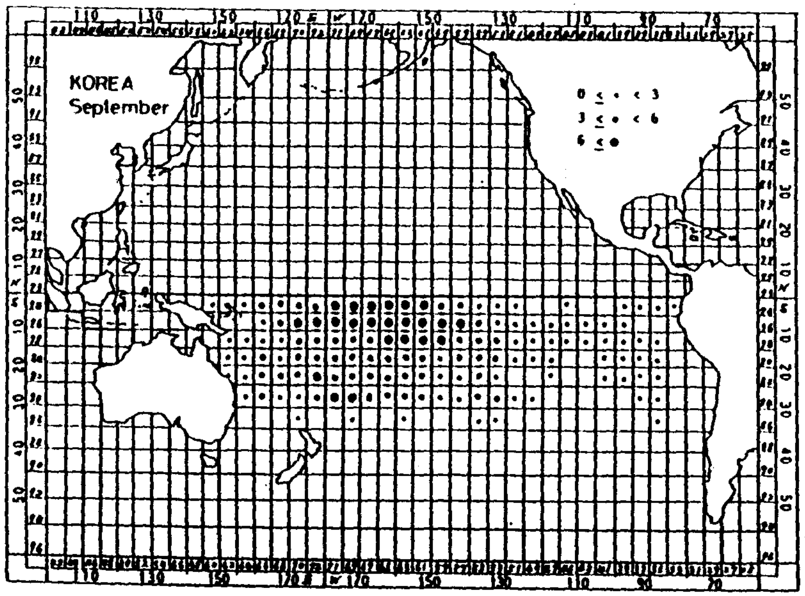
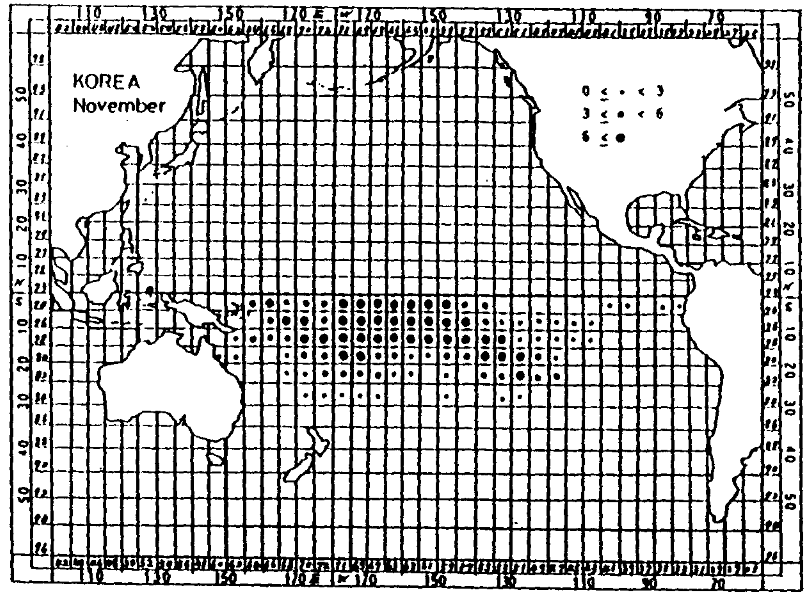
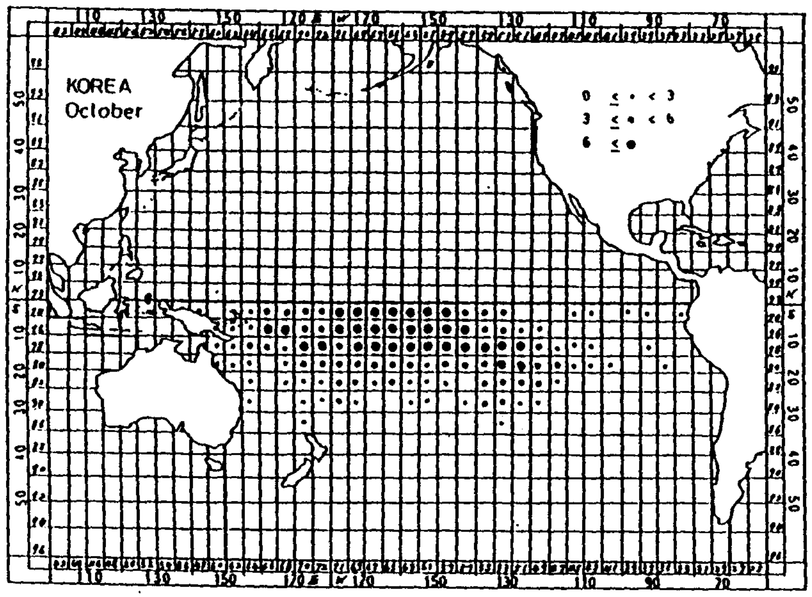


Figure 2. ..... continued.







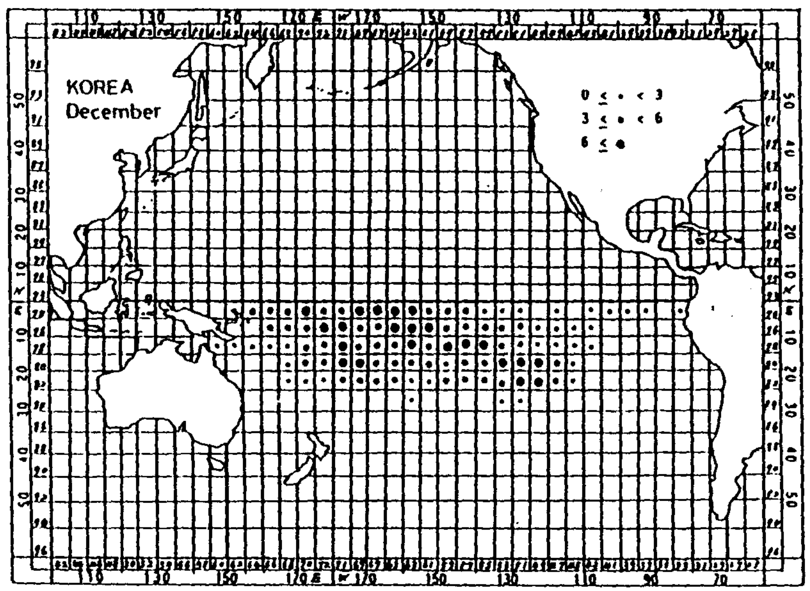


Figure 2. ..... continued.