A Tentative Analysis of the Distribution Pattern of Tuna Projected on the Long-line Ⅱ※

Correlation of the hooked positions of the individuals of any two species of tuna among the yellow-fin tuna, the big-eye tuna and the albacore, and the analyses on the projected distribution pattern of the yellow-fin tuna through the interval analysis and the arrangement one

by

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Contents

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Introduction

The distribution patterns of the yellow-fin tuna (*Neothunnus albacora*), the big-eye tuna (*Parathunnus obesus*) and the albacore (*Thunnus alalunga*) projected along long-lines were minutely analyzed in the first report of this series of works (MAÉDA, 1960) by applying one of the analysis methods of sequence, most of which were newly constructed being based on the theory of probability for the purpose of fulfilling the peculiar conditions specific to long-line. But only short description and a few example of the correlation among the hooked-positions of individuals of the different species were illustrated; and also concerning the interval analysis and the arrangement one, nothing else than the short description of constructing-method of the formulae was described. Therefore, this report is written for the purpose of supplementing these deficiencies in the first report. And at first the relations of hooked-positions among the individuals of the same species will be shown as the preliminary step to the correlation analysis, next the correlations of hooked-positions observable among the individuals of two species (yellow-fin tuna——big-eye tuna, yellow-fin tuna——albacore and big-eye tuna——albacore) will be represented, which are one of the principal subjects of this report, then the results of the interval analysis and the arrangement one on the hooked-positions of the individuals of the yellow-fin tuna will be illustrated and compared with the results of the spacing analysis. And lastly some tracks of trials for exclusion of the influence of the presence of buoy-lines on the arrangement analysis will be added.

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The Method for Collecting the Data
(Fishing method)

The data used in the present study was offered by the Dai-fuji maru which obtained in the waters central part of the Indian Ocean during the period from April 5 to 16, 1955. A sketch chart of the fishing ground is shown in Fig. 1. The number

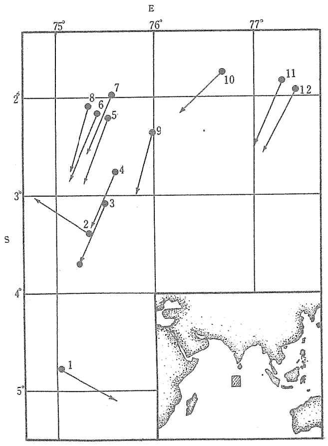


Fig. 1. Chart of the fishing ground.
Notes : Arrows show the length and the hauling direction of gears; solid circles indicate the initial points of hauling. And the numbers represent the station.

Table 1. The date, the number of used gears and the catch-composition at each station.

St.	Date	No. of gear	Catch-composition			
			Yellow-fin tuna	Big-eye tuna	Albacore	Other fishes
1	Apr. 5,'55	372	180	13	2	49
2	6	372	229	9	14	56
3	7	374	214	17	41	59
4	8	375	153	14	24	31
5	9	370	158	21	70	33
6	10	375	254	44	45	27
7	11	377	224	27	37	26
8	12	167	49	6	13	9
9	13	231	70	7	3	18
10	14	376	135	47	18	38
11	15	373	230	14	8	30
12	16	373	160	16	13	32

Notes : Position at each station is shown in Fig. 1. Damaged individuals and juvenile ones are included.

of used gears and the composition of respective catches are given in Table 1. Each set of gears consists of *ca.* 380 main-lines (a main-line is usually represented in the word "a basket", because it is put in a basket when it is not in use) connected in a series and suspended in the water by buoy-lines of 20 m long each attached at every joint. Each main-line is 300 m long and provided with four branch-lines of 25 m long set at regular intervals and each ending in a single hook. The interval between each pair of hook on the same basket is 60 m, while the interval between the distal hook of a certain basket and the adjoining one of the consecutive basket is twice as long as this. As each main-line of respective unit of gears forms catenarian, the average buoy-interval is shorter than the length of the main-line in the actual operation and thus the hooks cannot be suspended at the same level, but their situations are separated into two levels. And the depth level of the adjoining hooks to buoy-lines (the first and the hindmost hooks in respective baskets) is measured by chemical tube to be about 100 m deep while that of the rests of them is to be about 150 m deep. Therefore, hereafter, the hooks belonging to the former group are, for convenience' sake, called the shallower hooks and the rests of them deeper ones. The gears are set from one end and it takes about four hours to empty all the baskets. The setting always begins at midnight, the boat is let drift for about three hours near the final end of the whole gear and then the hauling of gears begins with the final end of the whole gear. This time, it takes about twelve hours or longer to haul up the whole gear. Thus the soaking of the whole gear lasts generally for three hours from 3 *a.m.* to 6 *a.m.*

Part I Correlation Analysis
(Including the spacing analysis as the preliminary step)

Method of Analysis

The most commercially important problem on the distribution of tuna is how to find out the waters where the gears should be set or better catch is expected, and most of the efforts of commercial fishery and of studies on the distribution of tuna are concentrated on this problem; while the distribution pattern treated in this report is never the pattern observable in such a wide range but that observable within a row. And it is a well known fact that the fishes are by no means evenly distributed throughout the bio-geographical zone but showing some sparse and dense. No one perceived clearly the strong school formation or observed schooling adult tuna in the ocean under usual condition, in considering by such a scale as treated in this report; but slight schooling (MURPHY & ELLIOT, 1954) or no evidence supporting school formation (NAKAMURA, 1949, *etc.*) is suggested. The well coincident results with them were obtained in the first report, moreover, Figs. 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24, which represent the catch in each lot of five consecutive baskets of respective examples used in this report, also suggest the presence of no clear school. Accordingly, the following are safely set to be on the basic assumptions of the formulae applied to this report, as in the first report: if the soaking time and depth level of the hooks are the same, the occupied-rates* of all hooks are the same, and whether respective hooks occupied or not are independently of one another.

In the first report of this series of works, schooling tendency of respective species of tuna in respective examples were analyzed, adopting five consecutive baskets, basket and hook-interval (the word "hook-interval" is employed to represent the mean interval between adjoining hooks within the same basket) as the unit-length of consideration. But there are many examples, in which the individuals are rather widely and less densely scattered, consequently even if the unit-length of the consideration is elongated into five consecutive baskets (= 1 km or thereabout), the structure of the highest order expected to be observable within a row can be not so clearly suggested from the analysis interfered by the short-periodic deviation which is considered to be due to the structure of the subordinate orders. Therefore, it is desirable to add another series of analysis in which the section longer than five consecutive baskets is adopted as the unit-length of consideration. On the other hand, the unit-lengths adopted in two series of the first report, five consecutive baskets and a basket, were too apart from each other, which makes it difficult to deduce the pattern connecting the results of these two series of analyses. Therefore, it is also desirable to add

* The word "occupied-rate" used in this report indicates the occupied probability of a hook by individual of a certain species.

another series, the unit-length of which is the intermediate length between a basket and five consecutive ones. Owing to the above-mentioned reasons, two other series of analyses are added to this report, the unit-lengths of which are ten consecutive baskets and two consecutive ones respectively.

Equal number of shallower hooks and deeper ones and a half number of buoy-lines are contained in respective unit-sections of all series of analyses, except for the last one the unit-length of which is hook-interval. Accordingly, there is no need to pay any attention to the peculiar conditions specific to the long-line gears. Moreover, even if we adopt the method proposed in this series of works, it is very difficult, although not impossible, to exclude the influences of the facts that each hook is unable to be occupied by more than one individual and that the number of hooks contained in each section is not so much, consequently maximum number of individuals capable of being hooked in it is limited. Thus, correlogram or analysis method of run seem to be applicable. But I prefer to adopt the methods described in the below, because the influence of the presumable gradient of the occupied-rate due to that of soaking time is excludable adopting these methods, although examining method, applicable to these analysis methods into the question whether the difference in the observed-values from the estimated ones is significant or not, has not yet deviced out. But, for the last series in which all of the peculiar conditions specific to long-line are influential, it is evident that the method adopted in this report has much advantage, because influences of all the peculiar conditions can easily be excluded.

Therefore, at first, the constructing-process of the formulae of spacing analysis applicable to the series, the unit-length under consideration of which is divisible by a basket length, will be shown. Next, those applicable to the analysis, in which the unit-length is as long as hook-interval, and lastly those of correlation analysis will be illustrated.

1. Spacing analysis 1. (Unit-length is divisible by a basket length)

Let us set that the number of the individuals caught in the *ith* section is $N_i = (N_0 + i\varDelta N)$, total number of individuals caught by a row of gears constituted of M consecutive sections is $N=\sum_{i=1}^{M}(N_0 + i\varDelta N)$, and all individuals are distributed showing simple gradient due to that of soaking time. The probability of a certain individual caught in the *ith* section is represented as $P_i = \frac{N_i}{N} = \frac{N_0 + i\varDelta N}{N} = P_0 + i\varDelta P$. Then, the probability of any two individuals caught in the *ith* section is $(P_0 + i\varDelta P)^2$. And the expectant number of the individual-pairs constituted of those hooked within the same unit when no interference among individuals is observable, $X_{(0)}$, is represented as follows, because "i" varies from 1 to M and the number of combinations picking up any two individuals from N hooked-individuals is $\frac{N(N-1)}{2}$:

$$X_{(0)}=\frac{N(N-1)}{2}\sum_{i=1}^{M}(P_0+i\varDelta P)^2$$

$$=\frac{MN(N-1)}{2}P_0^2\left[1+(M+1)\delta+(M+1)(2M+1)\frac{\delta^2}{6}\right] \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

here $\delta=\frac{\varDelta P}{P_0}$.

The probability of occurrence in a certain individual in the *ith* section or the $(i+k)th$ one is $(P_0+i\varDelta P)+(P_0+\overline{i+k}\varDelta P)$; therefore that of any two individuals caught in the *ith* section or the $(i+k)th$ one is $\{(P_0+i\varDelta P)+(P_0+\overline{i+k}\varDelta P)\}^2$. But here, the probabilities of both individuals caught together in the same sections should be included; they are respectively $(P_0+i\varDelta P)^2$ and $(P_0+\overline{i+k}\varDelta P)^2$. Thus, the probability of any two individuals caught separately in the *ith* section and the $(i+k)th$ one is

$$\{(P_0+i\varDelta P)+(P_0+\overline{i+k}\varDelta P)\}^2-(P_0+i\varDelta P)^2-(P_0+\overline{i+k}\varDelta P)^2$$
$$=2(P_0+i\varDelta P)(P_0+\overline{i+k}\varDelta P).$$

"i" varies from 1 to $(M-k)$. Accordingly, for the same reasons as previously mentiond in the construction of Formula (1), the formula representing the expectant number of the individual-pairs of k section-intervals wide ($k\neq 0$) constituted of the individuals of the same species when no interference is observable among the individuals, $X_{(k)}$, is given as follows:

$$X_{(k)}=\frac{N(N-1)}{2}\times 2\sum_{i=1}^{M-k}(P_0+i\varDelta P)(P_0+\overline{i+k}\varDelta P)$$

$$=(M-k)N(N-1)P_0^2\left[1+(M+1)\delta+(M-k+1)(2M+k+1)\frac{\delta^2}{6}\right]\cdots\cdots (2)$$

here $\delta=\frac{\varDelta P}{P_0}$.

Note:

1) Test method, examining into the question whether or not the difference in the observed-value from the estimated one at respective k is significant, has not yet deviced out.

2) The individuals caught within respective sections are methodologically regarded to be caught at the centers of respective sections, despite of the fact that the individuals caught at the parts near an end of respective sections are, actually, more apart from the individuals caught at the parts near the other end within the same section than those caught at the adjoining part in the adjoining section. Thus, the observed-values contain the error added newly by the summing of catch within respective sections.

3) The observed-values may more or less differ according to the situation of the starting point to count the unit of ν consecutive baskets, because there are ν ways to section a row of gears by ν consecutive baskets.

4) If we wish to obtain both the observed-values and the estimated ones free from the influence of these sources of errors, as well as the errors caused by the fact that each hook can not be occupied by more than one individual, we will notice it may seem better to adopt the following method: at first, both the observed-values and the estimated ones are estimated by using the next method, which is applicable to the analysis, the unit-length under consideration of which is as long as hook-interval, then corresponding values may be obtained with summing up every consecutive ν $(H+1)$ values (H is the number of hooks attached to each basket).

5) But, the method described here is adopted in the consideration upon the pattern observable in a wide range, because the magnitude of the error caused by the above-mentioned sources is, actually, not so large, against the difficulty in obtaining the observed-values at longer hook-intervals and presumable computation error being afraid to be introduced in them.

2. Spacing analysis 2. (Unit-length is hook-interval and applicable to the gears attaching to four hooks a basket)

The formulae illustrated in the preceding paragraph are applicable to any long-line gears regardless of the number of hooks attaching to each unit; while those shown in the following paragraph vary according to the number of hooks attached to each basket. Here, only the formulae applicable to the gears with four hooks a basket are represented.

Let us set that N_1 and N_2 individuals are scattered, showing a simple gradient, along shallower and deeper hooks in a row of gears constituted of m consecutive baskets of equal length attached to four hooks a basket, and no interference is expected among the individuals. k is represented as $a(4+1)+R$, when it is separated into the part divisible by the length of a basket and the remainder. Then the hooks spaced by k hook-intervals from respective hooks in the ith basket are repre-

Table 2. Hooks spaced by k hook-intervals from respective hooks in the ith basket ($H=4$).

R	Order of hook in the ith basket			
	1	2	3	4
0	1	2	3	4
1	2	3	4	B
2	3	4	B	**1**
3	4	B	**1**	**2**
4	B	**1**	**2**	**3**

Notes : B indicates buoy-line. Numerals in respective columns, except those printed by gothic, indicate the order of hook in the $(i+a)\,th$ basket, while those by gothic show that in the $(i+a+1)th$ one. k is represented by $a(4+1)+R$, when it is separated into the part divisible by the basket length and remainder.

sented as shown in Table 2. And the occupied-rates of a shallower and a deeper hook in the *ith* basket are expressed respectively $(P_1+i\Delta P_1)$ and $(P_2+i\Delta P_2)$ for the purpose of representing the simple gradient of occupied-rates. Then the occupied probabilities of the hooks corresponding to respective columns in Table 2 are illustrated in Table 3. Accordingly, the probabilities of occurrence in both of the two

Table 3. Occupied-rates corresponding to respective columns of Table 2; the influence of the gradient of the occupied-rate and that of the difference in the occupied-rate due to the difference in the fishing depths of the hooks are taken into consideration.

R \ h	1	2	3	4
	$P_1+i\Delta P_1$	$P_2+i\Delta P_2$	$P_2+i\Delta P_2$	$P_1+i\Delta P_1$
0	$P_1+\overline{i+a}\Delta P_1$	$P_2+\overline{i+a}\Delta P_2$	$P_2+\overline{i+a}\Delta P_2$	$P_1+\overline{i+a}\Delta P_1$
1	$P_2+\overline{i+a}\Delta P_2$	$P_2+\overline{i+a}\Delta P_2$	$P_1+\overline{i+a}\Delta P_1$	0
2	$P_2+\overline{i+a}\Delta P_2$	$P_1+\overline{i+a}\Delta P_1$	0	$P_1+\overline{i+a+1}\Delta P_1$
3	$P_1+\overline{i+a}\Delta P_1$	0	$P_1+\overline{i+a+1}\Delta P_1$	$P_2+\overline{i+a+1}\Delta P_2$
4	0	$P_1+\overline{i+a+1}\Delta P_1$	$P_2+\overline{i+a+1}\Delta P_2$	$P_2+\overline{i+a+1}\Delta P_2$

hooks occupied and one of which is located in the *ith* basket while the other is spaced by k hook-intervals from it are shown in Table 4. But, for the columns in

Table 4. Probability of occurrence in two occupied hooks spaced by k hook-intervals each other.

R	Order of hook in the *ith* basket starting to count k: 1		2	
0	$(P_1+i\Delta P_1)$	$(P_1+\overline{i+a}\Delta P_1)$	$(P_2+i\Delta P_2)$	$(P_2+\overline{i+a}\Delta P_2)$
1	$(P_1+i\Delta P_1)$	$(P_2+\overline{i+a}\Delta P_2)$	$(P_2+i\Delta P_2)$	$(P_2+\overline{i+a}\Delta P_2)$
2	$(P_1+i\Delta P_1)$	$(P_2+\overline{i+a}\Delta P_2)$	$(P_2+i\Delta P_2)$	$(P_1+\overline{i+a}\Delta P_1)$
3	$(P_1+i\Delta P_1)$	$(P_1+\overline{i+a}\Delta P_1)$	0	
4	0		$\mathbf{(P_2+i\Delta P_2)}$	$\mathbf{(P_1+\overline{i+a+1}\Delta P_1)}$

R	Order of hook in the *ith* basket starting to count k: 3		4	
0	$(P_2+i\Delta P_2)$	$(P_2+\overline{i+a}\Delta P_2)$	$(P_1+i\Delta P_1)$	$(P_1+\overline{i+a}\Delta P_1)$
1	$(P_2+i\Delta P_2)$	$(P_1+\overline{i+a}\Delta P_1)$	0	
2	0		$\mathbf{(P_1+i\Delta P_1)}$	$\mathbf{(P_1+\overline{i+a+1}\Delta P_1)}$
3	$\mathbf{(P_2+i\Delta P_2)}$	$\mathbf{(P_1+\overline{i+a+1}\Delta P_1)}$	$\mathbf{(P_1+i\Delta P_1)}$	$\mathbf{(P_2+\overline{i+a+1}\Delta P_2)}$
4	$\mathbf{(P_2+i\Delta P_2)}$	$\mathbf{(P_2+\overline{i+a+1}\Delta P_2)}$	$\mathbf{(P_1+i\Delta P_1)}$	$\mathbf{(P_2+\overline{i+a+1}\Delta P_2)}$

Notes are the same as in Table 2.

each of which one hook is picked up from the *ith* basket, and the other hook is from the $(i+a)th$ basket, "i" can vary from 1 to $(m-a)$; while for those in each of which one is picked up from the *ith* basket, and the other is from the $(i+a+1)th$ one, "i" varies from 1 to $(m-a-1)$. Accordingly, the expectant number of the individual-pairs of *k* hook-intervals wide and constituted of the same species is estimative from the following formulae:

at $R=0$

$$X_{(k)}=2\sum_{i=1}^{m-a}(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)+2\sum_{i=1}^{m-a}(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)$$

$$=2\left[P_1^2(m-a)\left\{1+(m+1)\delta_1+(m-a+1)(2m+a+1)\frac{\delta_1^2}{6}\right\}\right.$$

$$\left.+P_2^2(m-a)\left\{1+(m+1)\delta_2+(m-a+1)(2m+a+1)\frac{\delta_2^2}{6}\right\}\right] \quad \cdots\cdots(3)$$

$R=1$

$$X_{(k)}=\sum_{i=1}^{m-a}(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)+\sum_{i=1}^{m-a}(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)$$

$$+\sum_{i=1}^{m-a}(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)$$

$$=P_1P_2(m-a)\left[2+(m+1)(\delta_1+\delta_2)+(m-a+1)(2m+a+1)\frac{\delta_1\delta_2}{3}\right]$$

$$+P_2^2(m-a)\left[1+(m+1)\delta_2+(m-a+1)(2m+a+1)\frac{\delta_2^2}{6}\right] \quad \cdots\cdots(4)$$

$R=2$

$$X_{(k)}=\sum_{i=1}^{m-a}(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)+\sum_{i=1}^{m-a}(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)$$

$$+\sum_{i=1}^{m-a-1}(P_1+i\Delta P_1)(P_1+\overline{i+a+1}\Delta P_1)$$

$$=P_1P_2(m-a)\left[2+(m+1)(\delta_1+\delta_2)+(m-a+1)(2m+a+1)\frac{\delta_1\delta_2}{3}\right]$$

$$+P_1^2(m-a-1)\left[1+(m+1)\delta_1+(m-a)(2m+a+2)\frac{\delta_1^2}{6}\right] \quad \cdots\cdots(5)$$

$R=3$

$$X_{(k)}=\sum_{i=1}^{m-a}(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)+\sum_{i=1}^{m-a-1}(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\Delta P_1)$$

$$+\sum_{i=1}^{m-a-1}(P_1+i\Delta P_1)(P_2+\overline{i+a+1}\Delta P_2)$$

$$=P_1^2(m-a)\left[1+(m+1)\delta_1+(m-a+1)(2m+a+1)\frac{\delta_1^2}{6}\right]$$

$$+P_1P_2(m-a-1)\left[2+(m+1)(\delta_1+\delta_2)+(m-a)(2m+a+2)\frac{\delta_1\delta_2}{3}\right] \quad \cdots\cdots(6)$$

and at R=4

$$X_{(k)}=\sum_{i=1}^{m-a-1}(P_2+i\varDelta P_2)(P_1+\overline{i+a+1}\varDelta P_1)+\sum_{i=1}^{m-a-1}(P_2+i\varDelta P_2)(P_2+\overline{i+a+1}\varDelta P_2)$$

$$+\sum_{i=1}^{m-a-1}(P_1+i\varDelta P_1)(P_2+\overline{i+a+1}\varDelta P_2)$$

$$=P_1P_2(m-a-1)\left[2+(m+1)(\delta_1+\delta_2)+(m-a)(2m+a+2)\frac{\delta_1\delta_2}{3}\right]$$

$$+P_2{}^2(m-a-1)\left[1+(m+1)\delta_2+(m-a)(2m+a+2)\frac{\delta_2{}^2}{6}\right]\cdots\cdots(7)$$

here $\delta_1=\frac{\varDelta P_1}{P_1}$ and $\delta_2=\frac{\varDelta P_2}{P_2}$.

3. Correlation analysis 1. (Unit-length is divisible by a basket length)

Let us set that N_A individuals of species A and N_B of species B are distributed, showing simple gradient along a row of gears constituted of M consecutive sections and no interference is observable among the individuals of both species. And in order to express the gradient of distribution, the number of individuals caught in the *ith* section is set as $(A_0+i\varDelta A)$ for species A and $(B_0+i\varDelta B)$ for species B.

Here $N_A=\sum_{i=1}^{M}(A_0+i\varDelta A)$ and $N_B=\sum_{i=1}^{M}(B_0+i\varDelta B)$.

Number of the combinations to take one individual from species A and the other from species B observable in the *ith* section is $(A_0+i\varDelta A)(B_0+i\varDelta B)$. And "$i$" can vary from 1 to M. Accordingly the number of such combinations, individual-pairs constituted of the individuals of the different species while caught within the same section, $C_{(0)}$, observable in a whole row of gears is represented as follows:

$$C_{(0)}=\sum_{i=1}^{M}(A_0+i\varDelta A)(B_0+i\varDelta B)$$

$$=A_0B_0M\left[1+(M+1)\frac{\delta_A+\delta_B}{2}+(M+1)(2M+1)\frac{\delta_A\delta_B}{6}\right]\cdots\cdots(8)$$

here $\delta_A=\frac{\varDelta A}{A_0}$ and $\delta_B=\frac{\varDelta B}{B_0}$.

But the number of the combinations to take one individual from species A hooked in the *ith* section and the other from species B hooked in the $(i+k)th$ section is $(A_0+i\varDelta A)(B_0+\overline{i+k}\varDelta B)$. And *vice versa* is $(B_0+i\varDelta B)(A_0+\overline{i+k}\varDelta A)$. Accordingly the expectant number of the individual-pairs of k section-intervals wide and constituted of the individuals belonging to the different species hooked one in the *ith* section while the other in the $(i+k)th$ one is the sum of them. And the number of them observable in a whole row of gears is represented as follows, because "i" varies from 1 to $(M-k)$.

$$C_{(k)}=\sum_{i=1}^{M-k}\left\{(A_0+i\Delta A)(B_0+\overline{i+k}\Delta B)+(B_0+i\Delta B)(A_0+\overline{i+k}\Delta A)\right\}$$

$$=A_0 B_0(M-k)\left[2+(M+1)(\delta_A+\delta_B)+(M-k+1)(2M+k+1)\frac{\delta_A\delta_B}{3}\right]\cdots\cdots\cdots(9)$$

here $\delta_A=\frac{\Delta A}{A_0}$ and $\delta_B=\frac{\Delta B}{B_0}$.

4. Correlation analysis 2. (Unit-length is hook-interval and applicable to the gears attaching to four hooks a basket)

Like the same as the spacing analysis, the formulae applicable to the analysis, unit-length of which is hook-interval, also take the different forms according to the number of hooks attaching to each basket. And, the formulae only applicable to the the gears attaching to four hooks a basket will be shown.

For the purpose of representing the simple gradient of distribution due to that of the soaking time and the difference in the occupied-rates due to that of settled depth levels of hooks, let us set that the occupied-rates of respective hooks by respective species take the values represented in Table 5 (c). When k is represented as

Table 5. Probability of occurrence in two hooks, one of which is located in the ith basket and occupied by the individual of species A while the other is spaced by k hook-intervals from it and occupied by the individual of species B (a), and that in which the occupying species are mutually replaced (b).

(a)

R	Order of hook in the ith basket starting to count k			
	1		2	
0	$(Aso+i\Delta As)$	$(Bso+\overline{i+a}\Delta Bs)$	$(Ado+i\Delta Ad)$	$(Bdo+\overline{i+a}\Delta Bd)$
1	$(Aso+i\Delta As)$	$(Bdo+\overline{i+a}\Delta Bd)$	$(Ado+i\Delta Ad)$	$(Bdo+\overline{i+a}\Delta Bd)$
2	$(Aso+i\Delta As)$	$(Bdo+\overline{i+a}\Delta Bd)$	$(Ado+i\Delta Ad)$	$(Bso+\overline{i+a}\Delta Bs)$
3	$(Aso+i\Delta As)$	$(Bso+\overline{i+a}\Delta Bs)$	0	
4	0		$(Ado+i\Delta Ad)$	$(Bso+\overline{i+a+1}\Delta Bs)$

R	Order of hook in the ith basket starting to count k			
	3		4	
0	$(Ado+i\Delta Ad)$	$(Bdo+\overline{i+a}\Delta Bd)$	$(Aso+i\Delta As)$	$(Bso+\overline{i+a}\Delta Bs)$
1	$(Ado+i\Delta Ad)$	$(Bso+\overline{i+a}\Delta Bs)$	0	
2	0		$(Aso+i\Delta As)$	$(Bso+\overline{i+a+1}\Delta Bs)$
3	$(Ado+i\Delta Ad)$	$(Bso+\overline{i+a+1}\Delta Bs)$	$(Aso+i\Delta As)$	$(Bdo+\overline{i+a+1}\Delta Bd)$
4	$(Ado+i\Delta Ad)$	$(Bdo+\overline{i+a+1}\Delta Bd)$	$(Aso+i\Delta As)$	$(Bdo+\overline{i+a+1}\Delta Bd)$

(b)

R	Order of hook in the *ith* basket starting to count *k*			
	1		2	
0	$(Bso+i\Delta Bs)$	$(Aso+\overline{i+a}\Delta As)$	$(Bdo+i\Delta Bd)$	$(Ado+\overline{i+a}\Delta Ad)$
1	$(Bso+i\Delta Bs)$	$(Ado+\overline{i+a}\Delta Ad)$	$(Bdo+i\Delta Bd)$	$(Ado+\overline{i+a}\Delta Ad)$
2	$(Bso+i\Delta Bs)$	$(Ado+\overline{i+a}\Delta Ad)$	$(Bdo+i\Delta Bd)$	$(Aso+\overline{i+a}\Delta As)$
3	$(Bso+i\Delta Bs)$	$(Aso+\overline{i+a}\Delta As)$	0	
4	0		$(Bdo+i\Delta Bd)$	$(Aso+\overline{i+a+1}\Delta As)$

R	Order of hook in the *ith* basket starting to count *k*			
	3		4	
0	$(Bdo+i\Delta Bd)$	$(Ado+\overline{i+a}\Delta Ad)$	$(Bso+i\Delta Bs)$	$(Aso+\overline{i+a}\Delta As)$
1	$(Bdo+i\Delta Bd)$	$(Aso+\overline{i+a}\Delta As)$	0	
2	0		$(Bso+i\Delta Bs)$	$(Aso+\overline{i+a+1}\Delta As)$
3	$(Bdo+i\Delta Bd)$	$(Aso+\overline{i+a+1}\Delta As)$	$(Bso+i\Delta Bs)$	$(Ado+\overline{i+a+1}\Delta Ad)$
4	$(Bdo+i\Delta Bd)$	$(Ado+\overline{i+a+1}\Delta Ad)$	$(Bso+i\Delta Bs)$	$(Ado+\overline{i+a+1}\Delta Ad)$

Note: Probability of occurrence in the individual of respective species to respective hooks are represented as follows:

(c)

	Order of basket					
	i		i+a		i+a+1	
	Shallower	Deeper	Shallower	Deeper	Shallower	Deeper
A	$(Aso+i\Delta As)$	$(Ado+i\Delta Ad)$	$(Aso+\overline{i+a}\Delta As)$	$(Ado+\overline{i+a}\Delta Ad)$	$(Aso+\overline{i+a+1}\Delta As)$	$(Ado+\overline{i+a+1}\Delta Ad)$
B	$(Bso+i\Delta Bs)$	$(Bdo+i\Delta Bd)$	$(Bso+\overline{i+a}\Delta Bs)$	$(Bdo+\overline{i+a}\Delta Bd)$	$(Bso+\overline{i+a+1}\Delta Bs)$	$(Bdo+\overline{i+a+1}\Delta Bd)$

$a(4+1)+R$ by the same way as that shown in the spacing analysis, the hooks spaced by k hook-intervals from respective hooks in the *ith* basket are shown in Table 2. Accordingly, when no interference is observable among the individuals of both species, number of the combinations picking up one individual from species A hooked in the *ith* basket and the other from species B spaced by k hook-intervals from it is horizontal sum of columns in Table 5 (a); while *vice versa* is that in Table 5 (b). Here, for the columns in which one hook is picked up from the *ith* basket while the other is in the $(i+a)th$ one, "i" can vary from 1 to $(m-a)$. But about the rests of them, "i" varies from 1 to $(m-a-1)$. Therefore, the expectant number of the individual-pairs of k hook-intervals wide and constituted of the different species can be represented as follows:

at R=0

$$C_{(k)}=2\sum_{i=1}^{m-a}(As_0+i\Delta As)(Bs_0+\overline{i+a}\Delta Bs)+2\sum_{i=1}^{m-a}(Ad_0+i\Delta Ad)(Bd_0+\overline{i+a}\Delta Bd)$$

$$+2\sum_{i=1}^{m-a}(Bs_0+i\varDelta Bs)(As_0+\overline{i+a}\varDelta As)+2\sum_{i=1}^{m-a}(Bd_0+i\varDelta Bd)(Ad_0+\overline{i+a}\varDelta Ad)$$

$$=2As_0\,Bs_0\,(m-a)\left[2+(m+1)(\delta A_s+\delta B_s)+(m-a+1)(2m+a+1)\frac{\delta A_s\,\delta B_s}{3}\right]$$

$$+2Ad_0\,Bd_0\,(m-a)\left[2+(m+1)(\delta A_d+\delta B_d)+(m-a+1)(2m+a+1)\frac{\delta A_d\,\delta B_d}{3}\right]\cdots(10)$$

R=1

$$C_{(k)}=\sum_{i=1}^{m-a}(As_0+i\varDelta As)(Bd_0+\overline{i+a}\varDelta Bd)+\sum_{i=1}^{m-a}(Bs_0+i\varDelta Bs)(Ad_0+\overline{i+a}\varDelta Ad)$$

$$+\sum_{i=1}^{m-a}(Ad_0+i\varDelta Ad)(Bd_0+\overline{i+a}\varDelta Bd)+\sum_{i=1}^{m-a}(Bd_0+i\varDelta Bd)(Ad_0+\overline{i+a}\varDelta Ad)$$

$$+\sum_{i=1}^{m-a}(Ad_0+i\varDelta Ad)(Bs_0+\overline{i+a}\varDelta Bs)+\sum_{i=1}^{m-a}(Bd_0+i\varDelta Bd)(As_0+\overline{i+a}\varDelta As)$$

$$=As_0\,Bd_0\,(m-a)\left[2+(m+1)(\delta A_s+\delta B_d)+(m-a+1)(2m+a+1)\frac{\delta A_s\,\delta B_d}{3}\right]$$

$$+Ad_0\,Bs_0\,(m-a)\left[2+(m+1)(\delta A_d+\delta B_s)+(m-a+1)(2m+a+1)\frac{\delta A_d\,\delta B_s}{3}\right]$$

$$+Ad_0\,Bd_0\,(m-a)\left[2+(m+1)(\delta A_d+\delta B_d)+(m-a+1)(2m+a+1)\frac{\delta A_d\,\delta B_d}{3}\right]\cdots(11)$$

R=2

$$C_{(k)}=\sum_{i=1}^{m-a}(As_0+i\varDelta As)(Bd_0+\overline{i+a}\varDelta Bd)+\sum_{i=1}^{m-a}(Bs_0+i\varDelta Bs)(Ad_0+\overline{i+a}\varDelta Ad)$$

$$+\sum_{i=1}^{m-a}(Ad_0+i\varDelta Ad)(Bs_0+\overline{i+a}\varDelta Bs)+\sum_{i=1}^{m-a}(Bd_0+i\varDelta Bd)(As_0+\overline{i+a}\varDelta As)$$

$$+\sum_{i=1}^{m-a-1}(As_0+i\varDelta As)(Bs_0+\overline{i+a+1}\varDelta Bs)$$

$$+\sum_{i=1}^{m-a-1}(Bs_0+i\varDelta Bs)(As_0+\overline{i+a+1}\varDelta As)$$

$$=As_0\,Bd_0\,(m-a)\left[2+(m+1)(\delta A_s+\delta B_d)+(m-a+1)(2m+a+1)\frac{\delta A_s\,\delta B_d}{3}\right]$$

$$+Ad_0\,Bs_0\,(m-a)\left[2+(m+1)(\delta A_d+\delta B_s)+(m-a+1)(2m+a+1)\frac{\delta A_d\,\delta B_s}{3}\right]$$

$$+As_0\,Bs_0\,(m-a-1)\left[2+(m+1)(\delta A_s+\delta B_s)+(m-a)(2m+a+2)\frac{\delta A_s\,\delta B_s}{3}\right]\cdots(12)$$

R=3

$$C_{(k)}=\sum_{i=1}^{m-a}(As_0+i\Delta As)(Bs_0+\overline{i+a}\Delta Bs)+\sum_{i=1}^{m-a}(Bs_0+i\Delta Bs)(As_0+\overline{i+a}\Delta As)$$

$$+\sum_{i=1}^{m-a-1}(Ad_0+i\Delta Ad)(Bs_0+\overline{i+a+1}\Delta Bs)$$

$$+\sum_{i=1}^{m-a-1}(Bd_0+i\Delta Bd)(As_0+\overline{i+a+1}\Delta As)$$

$$+\sum_{i=1}^{m-a-1}(As_0+i\Delta As)(Bd_0+\overline{i+a+1}\Delta Bd)$$

$$+\sum_{i=1}^{m-a-1}(Bs_0+i\Delta Bs)(Ad_0+\overline{i+a+1}\Delta Ad)$$

$$=As_0\,Bs_0\,(m-a)\left[2+(m+1)(\delta_{A_s}+\delta_{B_s})+(m-a+1)(2m+a+1)\frac{\delta_{A_s}\delta_{B_s}}{3}\right]$$

$$+Ad_0\,Bs_0\,(m-a-1)\left[2+(m+1)(\delta_{A_d}+\delta_{B_s})+(m-a)(2m+a+2)\frac{\delta_{A_d}\delta_{B_s}}{3}\right]$$

$$+As_0\,Bd_0\,(m-a-1)\left[2+(m+1)(\delta_{A_s}+\delta_{B_d})+(m-a)(2m+a+2)\frac{\delta_{A_s}\delta_{B_d}}{3}\right]\cdots(13)$$

R=4

$$C_{(k)}=\sum_{i=1}^{m-a-1}(Ad_0+i\Delta Ad)(Bs_0+\overline{i+a+1}\Delta Bs)$$

$$+\sum_{i=1}^{m-a-1}(Bd_0+i\Delta Bd)(As_0+\overline{i+a+1}\Delta As)$$

$$+\sum_{i=1}^{m-a-1}(Ad_0+i\Delta Ad)(Bd_0+\overline{i+a+1}\Delta Bd)$$

$$+\sum_{i=1}^{m-a-1}(Bd_0+i\Delta Bd)(Ad_0+\overline{i+a+1}\Delta Ad)$$

$$+\sum_{i=1}^{m-a-1}(As_0+i\Delta As)(Bd_0+\overline{i+a+1}\Delta Bd)$$

$$+\sum_{i=1}^{m-a-1}(Bs_0+i\Delta Bs)(Ad_0+\overline{i+a+1}\Delta Ad)$$

$$=Ad_0\,Bs_0\,(m-a-1)\left[2+(m+1)(\delta_{A_d}+\delta_{B_s})+(m-a)(2m+a+2)\frac{\delta_{A_d}\delta_{B_s}}{3}\right]$$

$$+As_0\,Bd_0\,(m-a-1)\left[2+(m+1)(\delta_{A_s}+\delta_{B_d})+(m-a)(2m+a+2)\frac{\delta_{A_s}\delta_{B_d}}{3}\right]$$

$$+\mathrm{Ad_0\,Bd_0\,(m-a-1)}\left[2+(\mathrm{m}+1)(\delta\mathrm{A_d}+\delta\mathrm{B_d})+(\mathrm{m-a})(2\mathrm{m}+\mathrm{a}+2)\frac{\delta\mathrm{A_d}\,\delta\mathrm{B_d}}{3}\right]\cdots(14)$$

Here $\delta\mathrm{A_s}=\dfrac{\Delta\mathrm{As}}{\mathrm{As_0}}$, $\delta\mathrm{A_d}=\dfrac{\Delta\mathrm{Ad}}{\mathrm{Ad_0}}$, $\delta\mathrm{B_s}=\dfrac{\Delta\mathrm{Bs}}{\mathrm{Bs_0}}$ and $\delta\mathrm{B_d}=\dfrac{\Delta\mathrm{Bd}}{\mathrm{Bd_0}}$.

5. Estimation of constants of the formulae used in this report

The constants used in the first report of this series of works were estimated from the regression lines of the catch in respective lots of 50 consecutive baskets wide on lot number; while for the purpose of computing the constants introducing lesser computation error into the estimated-values in these analyses, at first, as mentioned in the chapter "consideration upon the error" in the first report, only ΔP or ΔP_1 and ΔP_2 are computed from the regression lines of the catch in respective lots on lot number, in which each lot is shortened into a width of 20 consecutive baskets for the purpose of not only increasing the number of lots but also lessening the hindmost residual part which can not reach a lot and is neglected from the estimation of regression line, because the largest error is introduced by neglect of it; next P_0 or P_1 and P_2 are computed from the equation $N=\sum_{i=1}^{M}(P_0+i\Delta P)$ or $N_1=2\sum_{i=1}^{M}(P_1+i\Delta P_1)$ and $N_2=2\sum_{i=1}^{M}(P_2+i\Delta P_2)$, because the next large error is caused by the fact that $N\neq\sum_{i=1}^{M}(P_0+i\Delta P)$, here $M=\dfrac{m}{20}$. And lastly, P and ΔP *etc.* per lot of 20 consecutive baskets are converted into corresponding values per respective unit-lengths under consideration. And a series of the estimated constants per basket is shown in Table 6 as an example and the methods for conversion are added to this table.

Table 6. Estimated constants of respective species in respective examples.

Species	Example No.	m	N_1	N_2	P_1	ΔP_1	P_2	ΔP_2
Yellow fin tuna	1	372	68	112	0.056,513	0.000,187	0.117,337	0.000,178
	2	372	110	119	0.050,894	0.000,520	0.067,321	0.000,497
	3	374	89	125	0.033,360	0.000,457	0.057,059	0.000,587
	4	375	65	88	0.048,106	0.000,205	0.081,198	0.000,192
	5	370	54	104	−0.020,591	0.000,504	−0.014,521	0.000,836
	6	375	103	151	0.126,662	0.000,057	0.130,032	0.000,379
	7	377	101	123	0.040,085	0.000,497	0.062,193	0.000,534
	8	167	14	35	0.048,167	−0.000,074	0.053,540	0.000,610
	9	231	32	38	0.089,037	−0.000,170	0.025,569	0.000,489
	10	376	56	79	0.037,993	0.000,194	0.054,475	0.000,268
	11	373	106	124	0.040,292	0.000,544	0.019,795	0.000,783
	12	373	61	99	0.113,371	−0.000,169	0.163,826	−0.000,166

	1	372	6	7	−0.007,333	0.000,083	0.004,356	0.000,027
	2	372	5	4	−0.005,068	0.000,063	−0.005,209	0.000,057
	3	374	6	11	−0.002,137	0.000,054	0.015,915	−0.000,006
	4	375	9	5	−0.000,854	0.000,068	−0.007,642	0.000,076
	5	370	6	15	−0.001,464	0.000,052	0.021,945	−0.000,009
Big eye tuna	6	375	19	25	0.004,719	0.000,110	0.019,025	0.000,076
	7	377	4	23	−0.000,546	0.000,031	−0.004,117	0.000,183
	8	167	1	5	−0.000,756	0.000,045	0.008,720	0.000,074
	9	231	0	7	0	0	0.037,560	−0.000,193
	10	376	14	33	0.020,319	−0.000,009	0.040,479	0.000,018
	11	373	3	11	0.005,710	−0.000,009	−0.004,312	0.000,102
	12	373	5	11	0.003,808	0.000,015	0.005,579	0.000,049
	1	372	1	1	−0.002,265	0.000,019	0.002,066	−0.000,004
	2	372	6	8	0.000,366	0.000,041	0.004,016	0.000,036
	3	374	21	20	0.022,028	0.000,032	0.024,319	0.000,013
	4	375	14	10	0.015,029	0.000,019	0.022,064	−0.000,046
	5	370	25	45	0.051,731	−0.000,097	0.058,179	0.000,014
Alba-core	6	375	14	31	0.023,517	−0.000,026	0.063,403	−0.000,117
	7	377	16	21	0.032,435	−0.000,059	0.030,046	−0.000,116
	8	167	7	6	0.012,208	0.000,104	0.000,464	0.000,208
	9	231	1	2	−0.000,472	0.000,023	−0.003,580	0.000,068
	10	376	6	12	0.010,410	−0.000,013	0.002,827	0.000,070
	11	373	2	6	0.001,716	0.000,005	0.009,490	−0.000,008
	12	373	2	11	0.003,646	−0.000,005	0.022,223	−0.000,040

Note : Constants, in which the gradient is put out of consideration, can be easily estimative from m and N_1+N_2 or N_1 and N_2.

Constants per lot of different length, in which the gradient is taken into consideration, can be computed by the following methods :

1) Constants per hook, in which the difference in occupied-rate of hooks located at the different depth levels is put out of consideration

$$P_0 = \frac{P_1+P_2}{2} \qquad \Delta P = \frac{\Delta P_1+\Delta P_2}{2}$$

2) Constants per basket.

$$P = 2\,(P_1+P_2) \qquad \Delta P = 2\,(\Delta P_1+\Delta P_2)$$

3) Constants per lot of other length: At first, ΔP is computed from the following relation :
(ΔP per 10 baskets)= 4 (ΔP per 5 baskets)= 25 (ΔP per 2 baskets) =100(ΔP per basket).
Then P_0 is computed adopting the below mentioned relation : $N=\Sigma(P_0+i\Delta P)$.

6. Supplement for decoding

The maximum length treated in the first report of this series was limited to the width of 250 consecutive baskets which did not reach the whole length of a row of gears. But another series in which a width of 10 consecutive baskets is adopted as the unit-length added, it gets possibility of covering the whole length of a row of gears. And this also makes it easier to deduce the number of schools distributed in a row, because the small deviations are averaged to disappear together with the following reasons: let us set that S schools are distributed in a whole row of gears. And when all intervals between any two schools do not take the same width, the peaks of the observed-values, except the first one which begins from $k=0$, have to be observable as frequently as the number of combinations picking up 2 from S, which is $\frac{S(S-1)}{2}$; while when all schools are arranged spaced at regular intervals, $(S-1)$ peaks may be observable. Accordingly, if Θ peaks are observable, maximum number of schools contained is expected to be $(\Theta+1)$, while minimum, s, is $\frac{1+\sqrt{1+8\Theta}}{2}$. But if k of respective peaks of the observed-values are set to be $k_1, k_2, \cdots k_i \cdots k_j \cdots k_l \cdots$ and k_n, and $k_l=k_i+k_j$, moreover number of k frequently showing such relation is set to be θ, it is also highly probable that $(\Theta+1-\theta)$ must be one of the key numbers of some significance upon the estimation of number of schools hooked in a row, perhaps indicating the most probable number.

Results of the Spacing Analysis

It is one of the principal subjects of this report to show the results of the correlation analysis. But it is presupposable that the relation of the hooked-positions between the individuals of the different species to consider with large scale can easily be found out from the distribution patterns of respective species, although the relation of the hooked-positions within a short range is hardly assumable from them. Therefore, the tendencies of the deviations of the observed-values of respective species represented in the results of spacing analysis, which is constructed on the same basic idea as in the correlation analysis, should be examined as a preliminary step and suitable attention has to be paid to the tendencies of the deviation of the observed-values, for the purpose of analyzing the correlation easily and clearly. Also, it is one of the principal subjects of this report to show the actually analyzed examples adopting the more advanced methods——the interval analysis and the arrangement one. Therefore, I must examine what kind of superficial and fundamental differences in the decoded patterns are caused by the difference in the basic assumptions between the spacing method and the newly added ones. Owing to the above-mentioned reasons, I can not help describing, even if not so in detail, about the results of the spacing analysis.

On the other hand, if the results of the spacing analysis were described for the purpose of finding out the general tendencies of the distribution pattern of respective species, the descriptions should be arranged species by species; while when they are shown as one of the auxiary materials for the analysis of the correlation, it seems to be far more convenient and reasonable to be arranged operation by operation. And the descriptions are arranged following this reason.

For convenience' sake of representation, the series of analyses, in which 10 consecutive basket width is adopted as the unit-length, is called Series I; that of five consecutive basket width is Series II; that of two consecutive basket width is Series III; that of one basket width is Series IV; while that of one hook-interval width is Series V, respectively. And the scarcity of catch makes it impossible to get the figure with less risk introducing severe influence of accidental error into decoding; therefore, when catch by a row is poorer than five individuals, all series of analyses are omitted; when that is neither poorer than six nor richer than 10, all the series except Series I are omitted; when that is neither poorer than 11 nor richer than 15, other series than Series I and II are omitted; when that is neither poorer than 16 nor richer than 20, Series IV and V are omitted; while when that is neither poorer than 21 nor richer than 25, Series V is omitted.

In all diagrams showing the results of the spacing analysis, solid circles represent the observed-values; while the open ones show the theoretical values computed from Formulae (1) and (2) (for Series I ~ IV) or Formulae (3) and (4) (for Series V).

1. Exposition of particular example

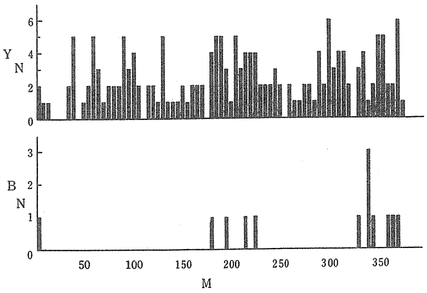


Fig. 2. Distribution of each species in each of five consecutive baskets in Example 1.
Abbreviations (common to Figs. 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24)
Y : Yellow-fin tuna
B : Big-eye tuna
A : Albacore
M : Basket number counted from the initial point of hauling
N : Number of the individuals caught by respective consecutive five baskets; therefore, pay special attention to the fact that, when the section is fully occupied, this value should be 20.

Example 1

Yellow-fin tuna : From the diagram of Series I, we may be unable to deduce out any fact except that the hooked-individuals are, generally speaking, distributed almost by chance. But high occupied-rate due to good total catch and less number of lots resulted to show high observed-values. Accordingly, the confidence zone of the esti-

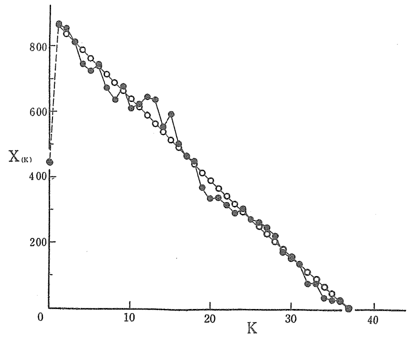


Fig. 3—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 1, Series I : unit is 10 consecutive basket width =*ca.* 2 km).

Notes (common to Figs. 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23 and 25) : Solid circles show the observed-values ; while open ones indicate the estimated ones.

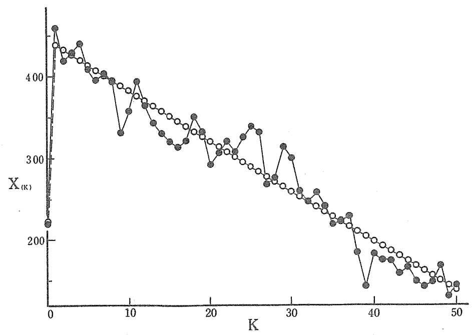
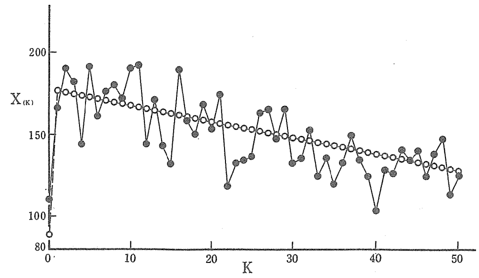


Fig. 3—Y—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 1, Series II : unit is 5 consecutive basket width =*ca.* 1 km)



.Fig. 3—Y—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 1, Series III : unit is 2 consecutive basket width=*ca.* 0.4 km).

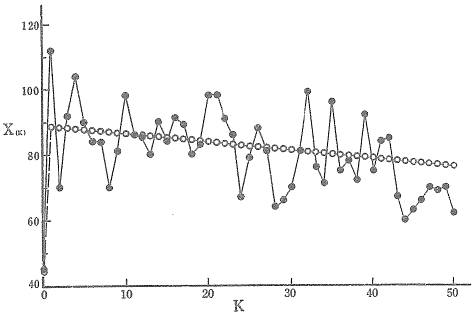


Fig. 3—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 1, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

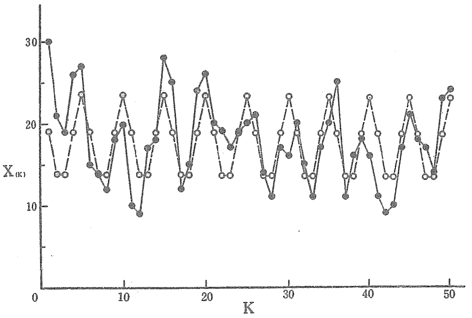


Fig. 3—Y—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 1, Series Ⅴ : unit is one hook-interval width= *ca.* 40 m).

mated-values is thought to be narrow. Therefore, some significance and consideration can be given to most of or at least some of the above-mentioned small deviations, although, at the present stage of this study, I can not yet find out any examination method determining how largely biased values are safely said to be different significantly. And if so, the following facts come to be deducible. The pattern most clearly suspected from the diagram of Series Ⅰ is that there are three groups of schools, adjoining centers of which are spaced by a width as long as from 110 (= 20 km) to 180 baskets (= 35 km) one another while the centers of the distal pair of schools are spaced by a width as long as 250 baskets (= 50 km) each other. And they may seem to indicate the groups of the heavily-occupied lots found at the positions around the 80th, the 200th and the 350th baskets, respectively (the *xth* basket indicates the position where the *xth* basket counting from the beginning of hauling is located, in which the basket number is counted as one function of more than 2.5

while less than 5.0 and more than 7.5 while less than 10.0 as a unit and cut away the rest). Besides, a peak of the observed-value at $k = 6$ lots (lot = 10 consecutive baskets) in the diagram of Series Ⅰ, which is more clearly represented in the diagram of Series Ⅱ at $k = 11$ and in Series Ⅲ at k = a little shorter than 30, suggests the presence of other obscure schools, the centers of which are spaced by a width as long as 60 baskets (= 12 km) from some of the above-mentioned schools. The schools pointed out here seem to indicate the groups of heavily-occupied lots found at the positions around the 140th and the 300th baskets. But the significance of the presence of the former is somewhat doubtful. The deviations of the short periodicity found in the observed-values of the diagrams of Series Ⅱ, Ⅲ and Ⅳ seem to show the presence of some structures of the subordinate orders. The analysis of Series Ⅴ shows that maximum width of the elemental cluster is estimated as long as a basket width (= *ca.* 200 m)——*i.e.*, the hooks spaced by a length shorter than a basket from any occupied one are occupied more frequently than expected from the chance distribution.

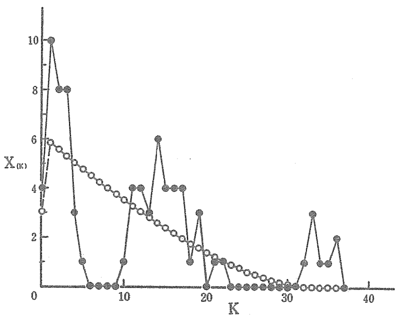


Fig. 3—B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 1, Series Ⅰ : unit is 10 consecutive basket width = *ca.* 2 km).

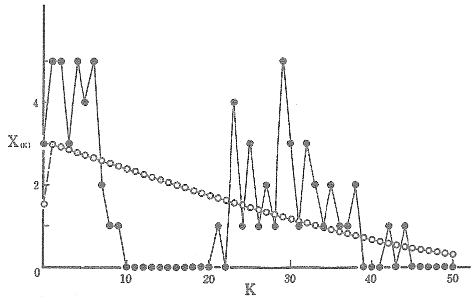


Fig. 3—B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 1, Series Ⅱ : unit is 5 consecutive basket width = *ca.* 1 km).

Big-eye tuna : The diagram of Series I indicates clearly that, as easily noticeable from Fig. 2, there are three distinct schools, among which the centers of the adjoining pairs are spaced by a width as long as *ca.* 15 lots (= 30 km) (lot = 10 consecutive baskets) one another while the distal pair is by *ca.* 35 lots (70 km). And the diagram of Series II may show that they are constituted of many clusters of subordinate orders, but any significance and description can hardly be given to it, because the number of the individuals constituting each subordinate cluster is supposed to be not so many. And I must record here, for the purpose of calling attention, that the words "school or cluster" conveniently used indicate frequently even a single hooked-individual, especially in such a case of extremely low occupied-rate as this, although whether they are swimming solitary or a single individual unfortunately hooked from many individuals swimming together as a school is the other problem.

Albacore : Omitted from the analysis, because no more than two individuals are hooked by a whole row of gears.

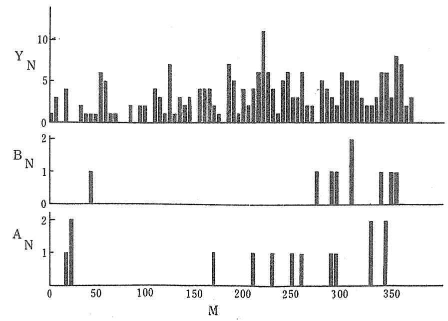


Fig. 4. Distribution of each species in each of five consecutive baskets in Example 2.

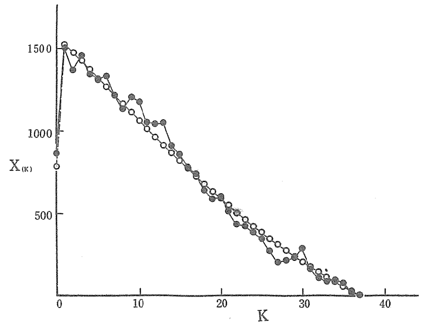


Fig. 5 — Y — I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 2, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

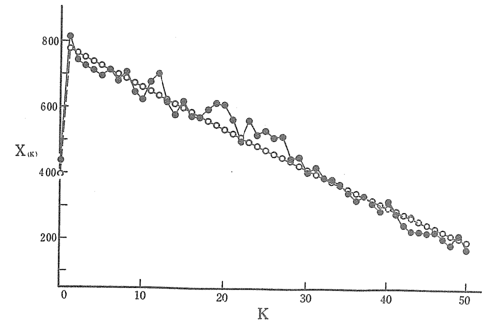


Fig. 5—Y—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 2, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

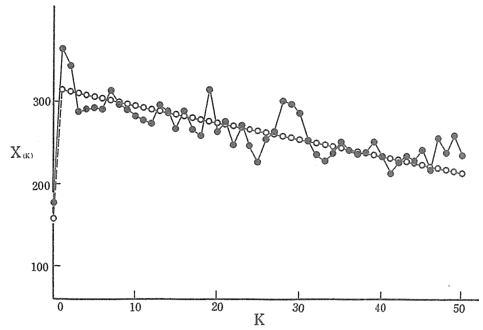


Fig. 5—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 2, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

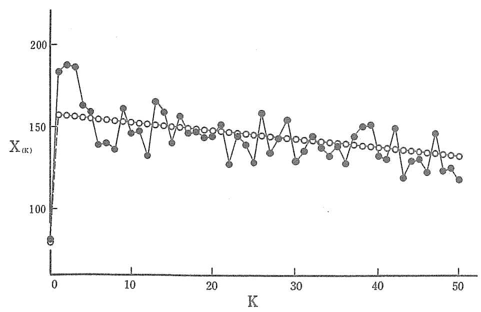


Fig. 5—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 2, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

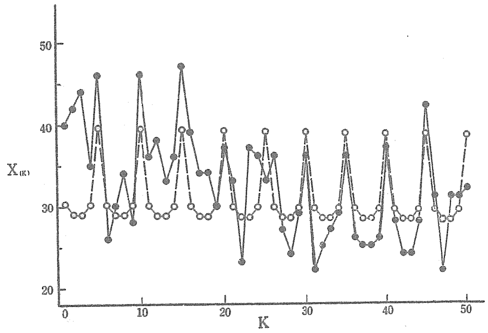


Fig. 5—Y—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 2, Series V : unit is one hook-interval width = *ca.* 40 m).

Example 2

Yellow-fin tuna : Rather strong gradient of distribution is suspected from Fig. 4. And the influence of it is excluded in all series of estimated-values. The analysis of Series I shows that less than five schools are arranged closely. Besides, the presence of two other schools, the centers of which are spaced by a width as long as about 200 (= 40 km) or 300 baskets (= 60 km) from the center of the above-mentioned group of schools, is suggested, of which the significance of the former is low. Therefore, from Fig. 4 together with Table 12, the position of schools detected lastly is assumed to be around the 50th basket. But the positional relation between schools, the centers of which are spaced by a width shorter than 250 baskets (= 50 km) one another, is represented more clearly in the diagram of Series II, in which the peaks of the observed-values are located at k = 12,19 and 25 lots (lot = 5 consecutive baskets). Therefore, the group of schools detected from the first series seems to be constituted of less than four schools, the centers of which, including that located at the position around the 50th basket, are spaced by the width as long as about 60 (= 12 km), 95 (= 19 km) or 125 baskets (=25 km) one another. And one of these schools is set to be hooked at the position around the 220th basket, because a most heavily-occupied lot is observable at the 220th basket. Therefore, the expectant positions of schools, where are spaced by the width of respective key-lengths mentioned above from the 220th basket, are estimated to be the 95th, the 125th, the 160th, the 280th, the 315th and the 345th baskets. And in examining Fig. 4 and Table 12, I found that individuals were heavily occupying all of the expectant positions except the first one. Therefore, the above-mentioned positions are thought to indicate the positions of schools. On the analyses of Series III and IV, besides the above-mentioned pattern, nothing can be drawn out other than the fact that heavily-occupied baskets are a little frequently observable at the positions spaced by a width shorter than five baskets from any occupied basket especially from heavily-occupied one, ——*i.e.*, contagiousness reaches a width as long as five baskets (= 1 km). The analysis of Series Ⅴ shows that contagiousness reaches a width as long as one basket (= 0.2 km) and that the pairs of individuals caught by the hooks spaced by the width neither shorter than two baskets (= 0.4 km) nor longer than five baskets (= 1 km) are more frequently observable than expected from chance distribution. For the meanings of the latter fact, whether it shows the relation within the same elemental clusters or between them is uncertain, but the analyses of Series Ⅲ and Ⅳ suggest that it seems to be more natural to consider that this fact also indicates the relation within the same elemental clusters —— *i.e.*, the presence of heavily-occupied part covering a width as long as five baskets (= 1 km) is suggested as one of the most clearly represented characteristics of the distribution pattern of this example, or in other words, strong school-formation covering not so wide range is suggested. And this result is strongly supported by the fact that there are more than seven lots constituted of more than five individuals and covering a width as long as or shorter than five baskets.

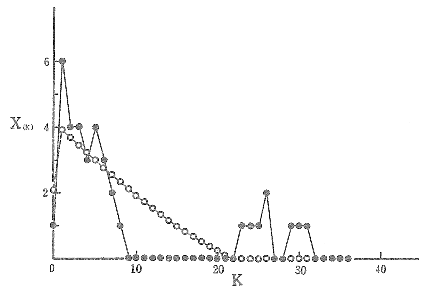


Fig. 5—B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 2, Series Ⅰ : unit is 10 consecutive basket width = *ca.* 2 km).

Big-eye tuna : The diagram of Series Ⅰ reveals that there are some schools, the centers of which are spaced by the width as long as 5, 25 and 30 lots (lot = 10 consecutive baskets = 2 km) one another. Accordingly, the number of schools is estimated to be three at minimum while four at maximum. But it is highly probable that the peaks observable at $k = 5$ and 25 mean the same fact, because $5+25 = 30$. Therefore, the most probable number of schools is thought to be three. From Fig. 4, it becomes clear that the above-mentioned schools indicate a single or group of the individuals hooked at the 50th, around the 300th and the 350th baskets, respectively.

Albacore : The severe deviation due to poor catch and to scattered structure makes it impossible to deduce from the diagram of Series Ⅰ nothing else than that the hooked-individuals are scattered self-spacingly all over a whole row of gears, against the fact that hooked population is clearly constituted of three individuals aggregated rather strongly and hooked at the 20th basket and of a widely dispersed school covering

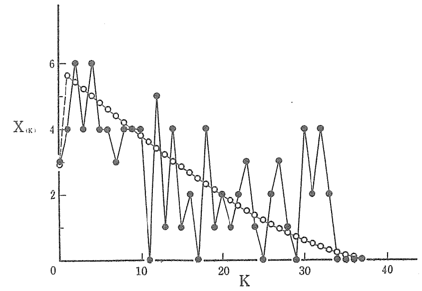


Fig. 5—A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 2, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

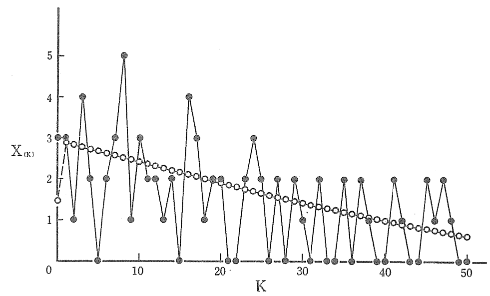


Fig. 5—A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 2, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

a space from the 170th to the 350th basket; while the deviation of short periodicity disappears when the unit-length under consideration is elongated into from three to five times as long as the unit-length adopted in the analysis of Series I, and the diagram showing the pattern coinciding well with that expected from Fig. 4 comes to be obtainable.

Example 3

Yellow-fin tuna : The distribution of the individuals shows strong gradient. But the presence of a single school of very weak contagiousness covering a space as wide as from 130 to 180 baskets (= 25~35 km) is discernible, which seems to be located in the range from the 190th to the 315th basket or including the part from the 140th to the 190th basket. And the structure of subordinate order is deducible from the short-periodic deviation of the observed-values in Fig. 7—Y—II, which indicates that the peaks of the observed-values are located at the positions around k = 3, 7, 12, 16, 18

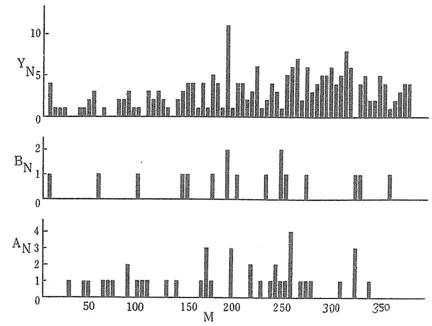


Fig. 6. Distribution of each species in each of five consecutive baskets in Example 3.

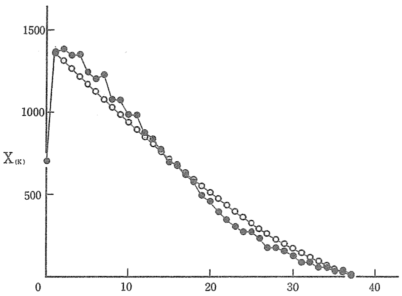


Fig. 7—Y—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 3, Series Ⅰ : unit is 10 consecutive basket width=*ca.* 2 km).

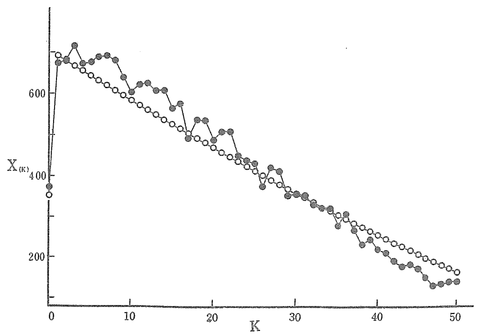


Fig. 7—Y—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 3, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

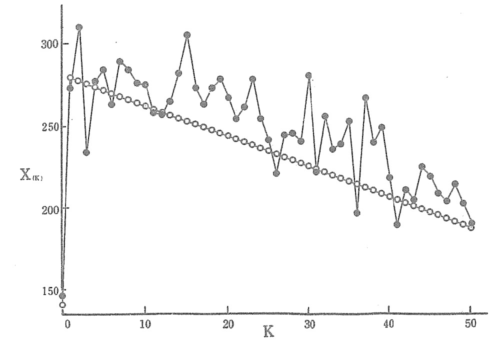


Fig. 7—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 3, Series Ⅲ : unit is 2 consecutive basket width = *ca.* 0.4 km).

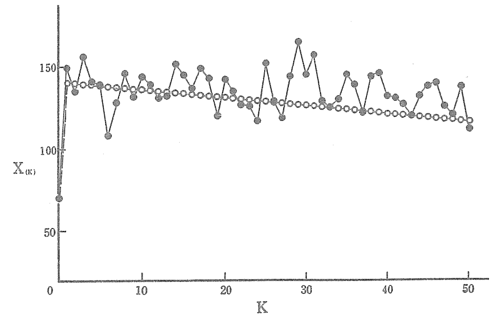


Fig. 7—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 3, Series Ⅳ : unit is 1 basket width = *ca.* 0.2 km).

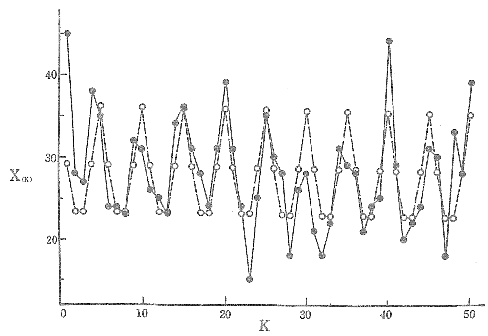


Fig. 7—Y—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 3, Series Ⅴ : unit is one hook-interval width = *ca.* 40 m).

and 21 lots (lot = five consecutive baskets) among which the significance of the third one is somewhat doubtful (if supposed to cover longer, one or two more peaks are observable in which the first one, $k = 27$, is the most distinct). Therefore, the number of schools of the subordinate order is estimated to be from three at minimum to seven at maximum. And a most distant pair of the subordinate schools is estimated to be spaced by the width as long as 105 baskets (= *ca.* 20 km) each other. But the position of the center of the subordinate school hooked in the hindmost part of a school is set to be the 310th basket, consequently the subordinate school hooked in the foremost part of a school is set to be located at the 205th basket. Next, for the purpose of finding out the positions of the other schools of the subordinate order located between them, the expectant positions of their centers are estimated as follows: the 220th, the 230th, the 240th, the 250th, the 265th, the 275th, the 285th and the 295th baskets, where are spaced by respective k mentioned above from each of the terminal schools of the subordinate order. But there is no definite method to distinguish the actual sub-schools from the imaginal ones. The diagram of Series II shows not so clearly the feature of the school-formation of the above-mentioned subordinate order, because it is influenced by the structure of the more subordinate orders. The deviation of the short periodicity shows that clusters of this order are frequently observable spaced by the width of $5A$ lots ($= 2A$ km) (lot = two consecutive baskets and A is a positive integer) one another. The analysis of Series V adds such information that the elemental clusters seem to cover a space as wide as or narrower than a basket width, especially a hook-interval.

Big-eye tuna : The diagram of Series I suggests that as many individuals as expected from chance distribution are caught by any occupied-lot, while these occupied-lots are so self-spacingly distributed that less individuals than or at most as many individuals as expected are hooked in the lots spaced by a width as long as or shorter than three lots from any occupied one, but the occupied-lots are frequently located spaced by the widths about 2, 5, 9, 13, 17, 21, 24, 26, 31 and 35 lots (lot = 2 km)

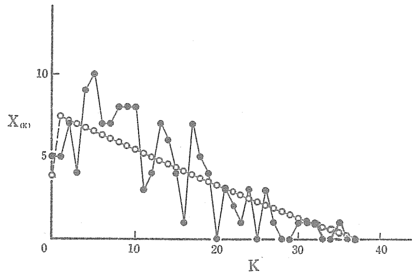


Fig. 7—B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 3, Series I : unit is 10 consecutive basket width $= ca.$ 2 km).

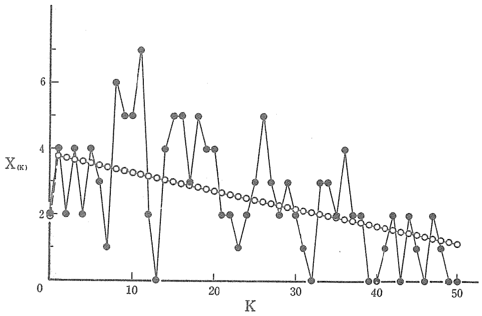


Fig. 7—B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 3, Series Ⅱ : unit is 5 consecutive basket width =*ca.* 1 km).

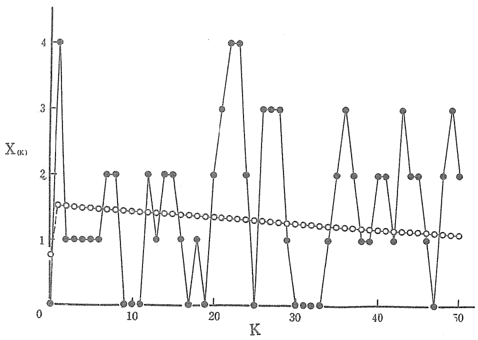


Fig. 7—B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 3, Series Ⅲ : unit is 2 consecutive basket width =*ca.* 0.4 km).

one another. Therefore, the number of schools distributed in a row is guessed out to be from 5 to at most 11. But among them, a most probable number of schools is 10, because sums of two other k frequently take 26. And the same but more detailed pattern is suggested from the diagram of Series Ⅱ. And the diagram of Series Ⅲ may seem to allude to the subordinate or more detailed pattern, but no significance can be given to it because of being afraid of the influence of accidental error introduced by low observed-values.

Albacore : General tendency of the deviations of the observed-values of Series Ⅰ shows that the population seems to be constituted of single school covering a wide range. But, the small deviations cause the peaks of the observed-values located at k = 2, 4, 6, 12, 15, 17, 19, 21, 23, 25, 27, and 29 lots (lot = 10 consecutive baskets). Therefore, the basic pattern of the subordinate order of this school is thought to be

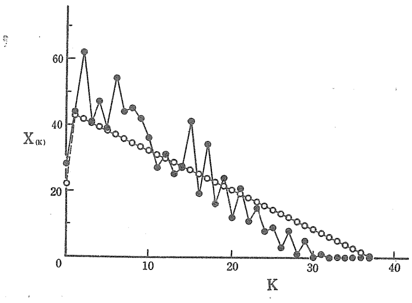


Fig. 7—A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 3, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

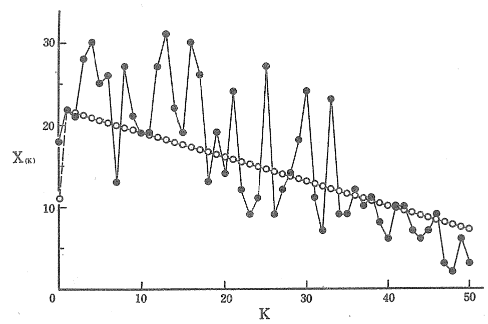


Fig. 7—A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 3, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

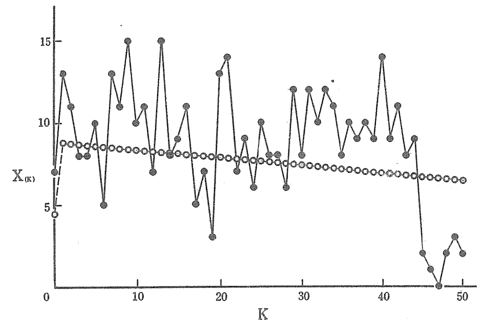


Fig. 7—A—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 3, Series III : unit is 2 consecutive basket width=*ca.* 0.4 km).

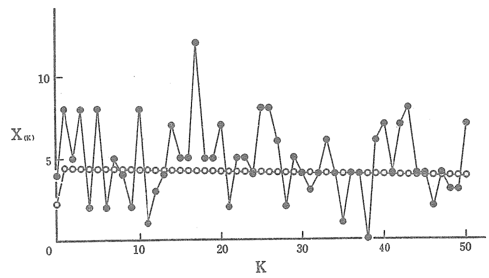


Fig. 7—A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 3, Series Ⅳ : unit is 1 basket width$=ca.$ 0.2 km).

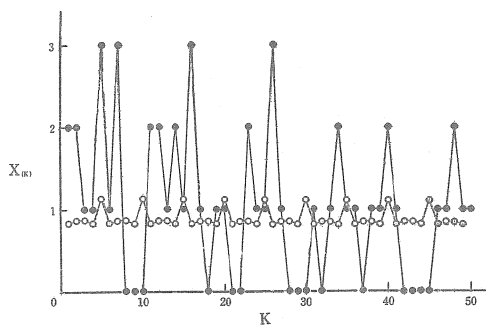


Fig. 7—A—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 3, Series Ⅴ : unit is one hook-interval width$=ca.$ 40 m).

13 or less occupied-lots, especially heavily-occupied ones, distributed showing two-lot periodicity, to which some less heavily-occupied lots are added.

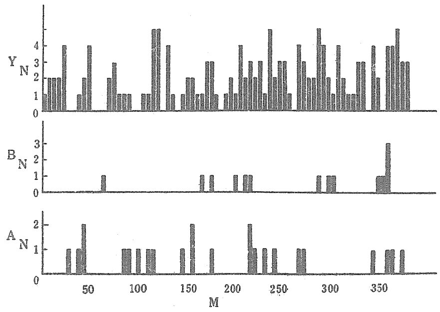


Fig. 8. Distribution of each species in each of five consecutive baskets in Example 4.

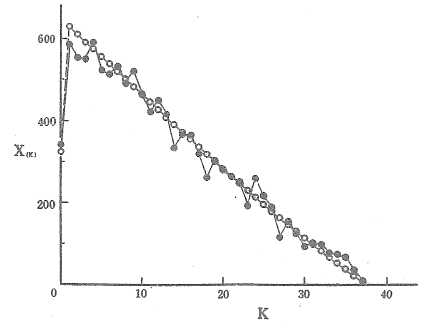


Fig. 9—Y—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 4, Series Ⅰ : unit is 10 consecutive basket width=*ca.* 2 km).

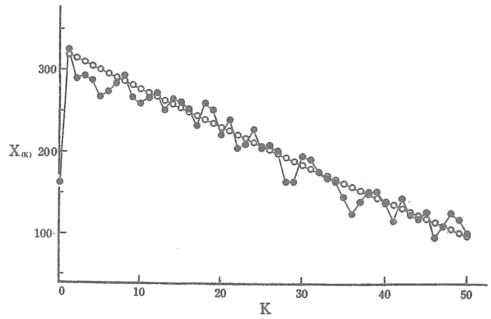


Fig. 9—Y—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 4, Series Ⅱ : unit is 5 consecutive basket width =*ca.* 1 km).

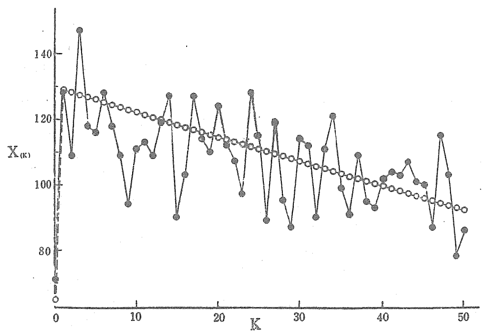


Fig. 9—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 4, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

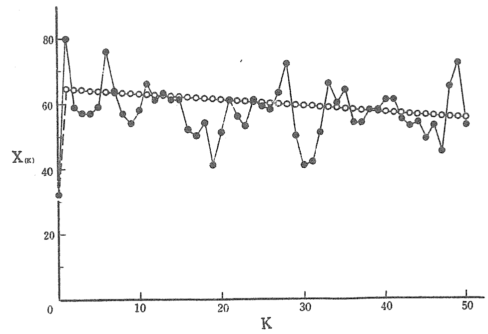


Fig. 9—Y—IV. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 4, Series IV : unit is 1 basket width=*ca.* 0.2 km).

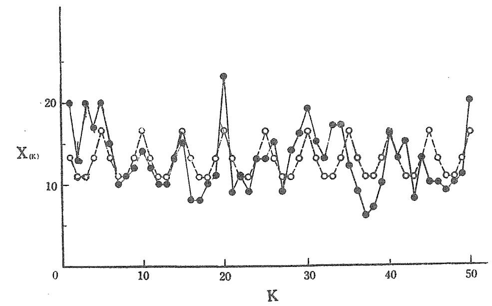


Fig. 9—Y—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 4, Series V : unit is one hook-interval width =*ca.* 40 m).

Example 4

Yellow-fin tuna : The deviations of the observed-values in the diagrams of Series I and II show essentially the same fact that the number of individuals hooked in respective lots (lot = 10 consecutive baskets) is not so different from the number expected from chance distribution but heavily-occupied lots are scattered throughout a whole row spaced by a width of $4A$ lots (A is a positive integer but not so large) one another, while the number of individuals hooked by the lots spaced by the width shorter than four lots from any occupied one especially from heavily-occupied one does not reach the value expected when respective occupied-lots are arranged by chance. Therefore, the distribution pattern is decoded to be as follows: many schools of narrow width are evenly scattered throughout a whole row. A little irregular periodicity of three-lot width observable in the results of analysis of Series III and six-lot periodicity in the analysis of Series IV show the same fact that the occupied baskets, especially heavily-occupied ones, are frequently observable spaced by a width of $6A$ baskets or thereabout one another. The analysis of Series Ⅴ also supports this six-basket periodicity, besides the fact that the widths of the elemental clusters do not exceed a length little longer than a basket.

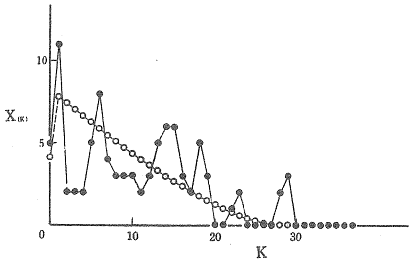


Fig. 9—B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 4, Series Ⅰ : unit is 10 consecutive basket width $= ca.$ 2 km).

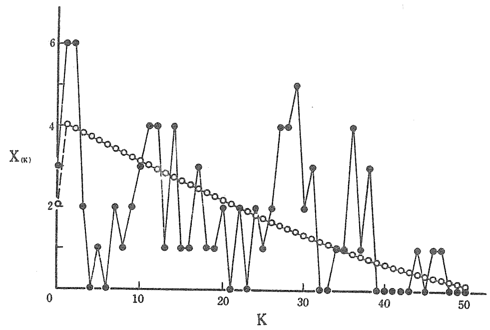


Fig. 9—B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 4, Series Ⅱ : unit is 5 consecutive basket width $=$ *ca.* 1 km).

Big-eye tuna : The diagram of Series Ⅰ shows that there are some schools, the centers of which are spaced by 6, 14, 18, 23 and 29 lots (lot = 10 consecutive baskets and as long as 2 km) one another. Consequently, population seems to contain from four schools at minimum to six schools at maximum. But a most probable number of schools contained is five, because $6 + 23 = 29$. And this result coincides well with such a pattern easily deducible from Fig. 8 that individuals are distributed forming five schools constituted of from one to five hooked-individuals and located at the positions respectively around the 65th, the 170th, the 210th, the 290th and the 350th baskets. The same pattern is deducible from the diagram of Series Ⅱ, although it is not so clear to be influenced by irregular deviations of the short periodicities. Nothing can be deducible from the diagrams of the succeeding series, because of the low observed-values and the estimated ones.

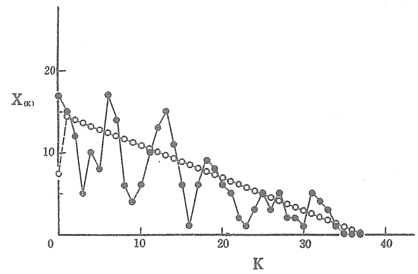


Fig. 9—A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 4, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

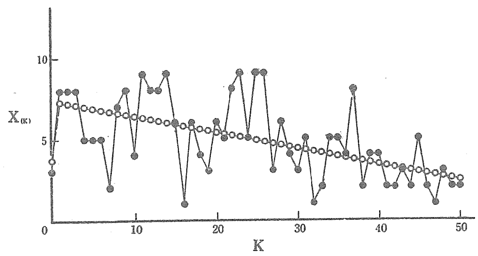


Fig. 9—A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 4, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

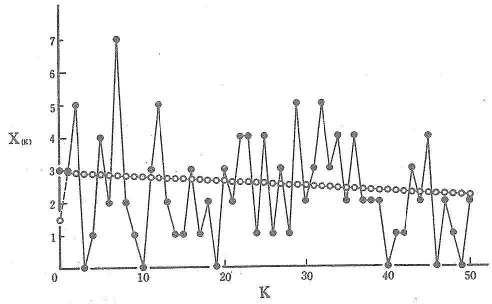


Fig. 9—A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 4, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

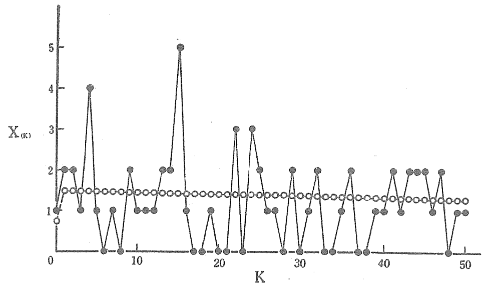


Fig. 9—A—IV. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 4, Series IV : unit is 1 basket width = *ca.* 0.2 km).

Albacore : Five peaks of the observed-values, except the first one beginning from $k = 0$, are clearly observable in the diagram of Series I, which are located at k = 6, 13, 18, 26 and 31, respectively. Accordingly, the number of schools contained is estimated to be from four at minimum to six at maximum. But the peaks located at k = 18 and 26, especially the latter, deviate not so severely. Accordingly, it is more probable to assume that four or five schools are scattered throughout a row of gears spaced rather regularly by a width as long as $60A$ baskets one another. It becomes clear that the above-mentioned results decoded from the diagram of Series I are well coincident with the pattern suggested from Fig. 8 : —— the population is constituted of five schools, each of which is constituted of not so many hooked-individuals and located at the positions around the 40th, the 100th, the 155th, the 230th and the 350th baskets, respectively. And the long-periodic deviations of the observed-values in the following series of analyses allude to the same pattern not so clearly to be influenced by the short-periodic deviations. But I do not wish to describe any fact, although the short-periodic one seems to suggest some detailed or subordinate structures, because the population size constituting each of them is not so large, which makes it impossible to give any significance upon them.

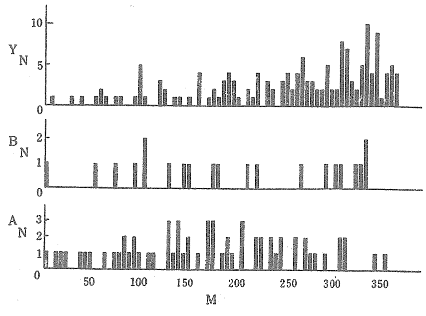


Fig. 10. Distribution of each species in each of five consecutive baskets in Example 5.

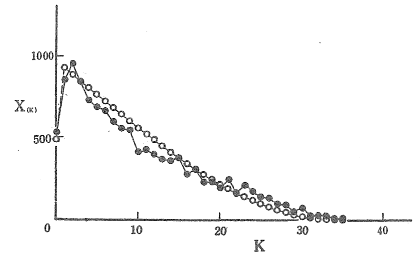


Fig. 11—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 5, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

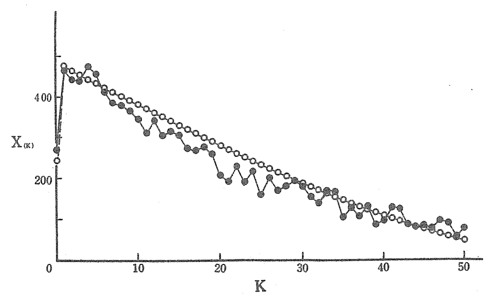


Fig. 11—Y—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 5, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

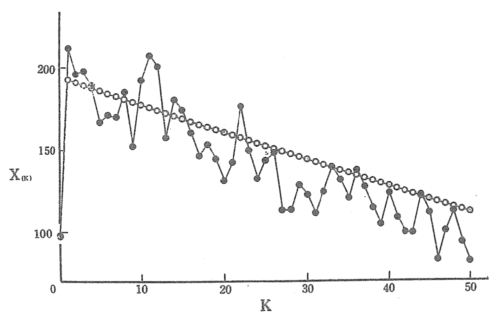


Fig. 11—Y—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 5, Series III : unit is 2 consecutive basket width=*ca.* 0.4 km).

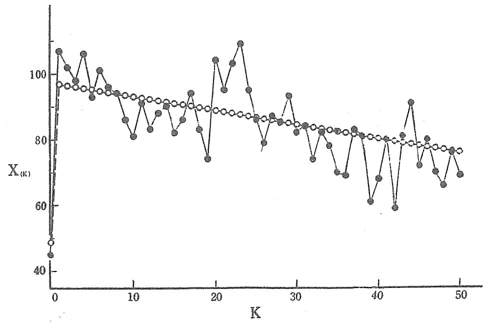


Fig. 11—Y—IV. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 5, Series IV : unit is 1 basket width = *ca.* 0.2 km).

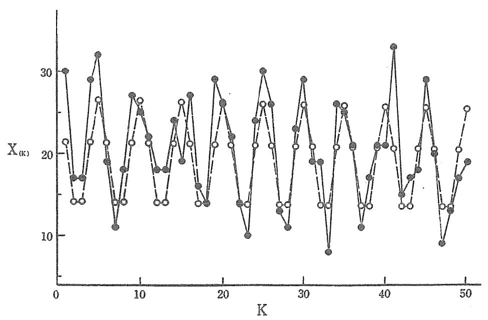


Fig. 11—Y—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 5, Series V : unit is one hook-interval width = *ca.* 40 m).

Example 5

Yellow-fin tuna : A strong gradient of the occupied-rate is suggested from Fig. 10. But comparing the observed-values with the estimated ones in which the influence of the gradient is taken into consideration, I found that there were two schools, the centers of which were spaced by a width about as long as 250 baskets (= 50 km) each other. And examining Fig. 10, I found, taking the influence of the gradient into consideration, that the above-mentioned fact indicated the relation between the parts of heavily-occupied lots around the 100th and those around the 350th baskets. The analysis of Series V shows that each elemental cluster covers a space as long as or shorter than a basket length, especially one hook-interval.

Big-eye tuna : General tendency of the deviations of the observed-values in the diagram of Series I suggests that the hooked-individuals are scattered throughout a whole

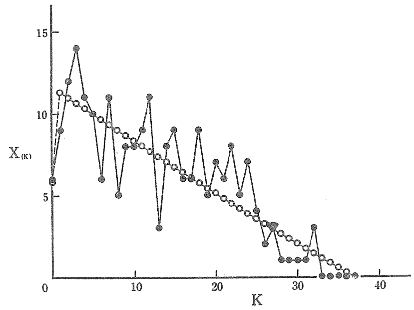


Fig. 11—B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 5, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

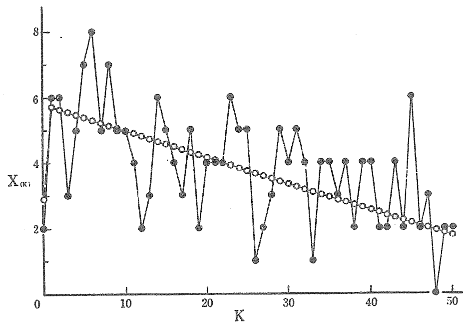


Fig. 11—B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 5, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

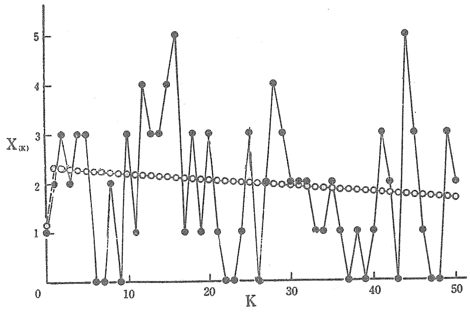


Fig. 11—B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 5, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

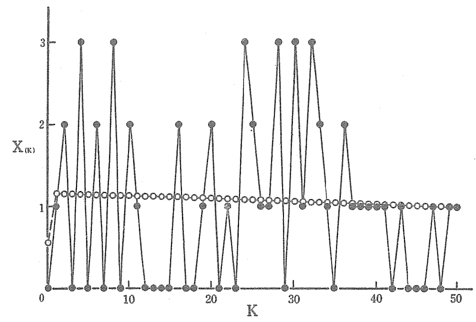


Fig. 11—B—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 5, Series Ⅳ : unit is 1 basket width = *ca.* 0.2 km).

row slightly self-spacingly, in other words forming a single widely dispersed school covering the width of 250 baskets (= 50 km). But examining the more in detail, I found that as many individuals as expected from chance distribution were hooked by the lots preceding to or succeeding to any occupied one, and that the occupied-lots were more frequently observable spaced by 3, 7, 12, 15, 18, 20, 22, 24, 27 and 32 lots (lot = 10 consecutive baskets and as long as 2 km) one another. Accordingly, the number of schools contained is estimated to be from 5 at minimum to 11 at maximum. But the sums of two other k frequently take 27, against the facts that the observed-value at $k = 27$ is not so high comparing with not only the estimated-value at $k = 27$ but also the observed ones at adjoining k. Accordingly, the more probable number of schools is 10. And this result also coincides well with the pattern easily deducible from Fig. 10. I do not wish to give any significance upon any fact deduced from the diagrams of Series Ⅱ and Ⅲ, although some subordinate structures may be shown in them, not only because of the low observed-values and the estimated ones but also because each school of subordinate order deducible from these diagrams is constituted of from a single to at most four hooked-individuals.

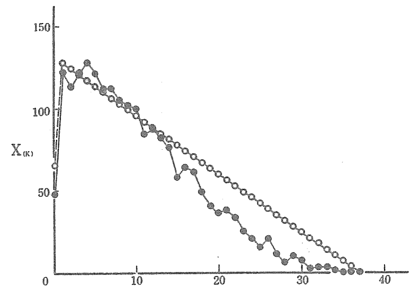


Fig. 11—A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 5, Series Ⅰ : unit is 10 consecutive basket width = *ca.* 2 km).

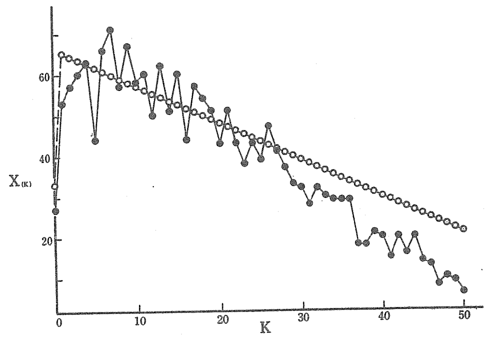


Fig. 11—A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 5, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

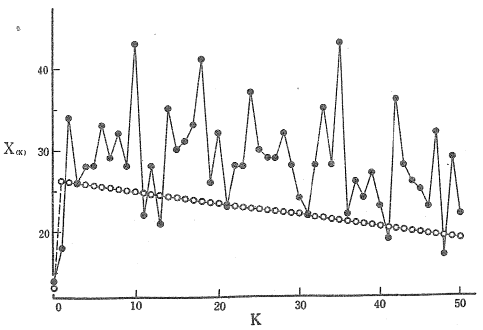


Fig. 11—A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 5, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

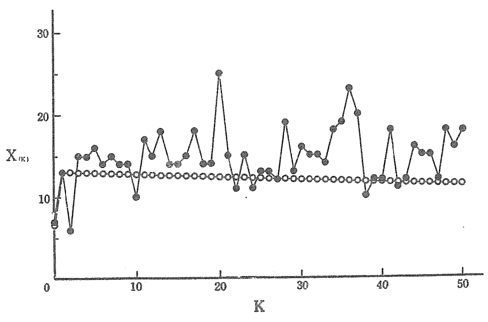


Fig. 11—A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 5, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

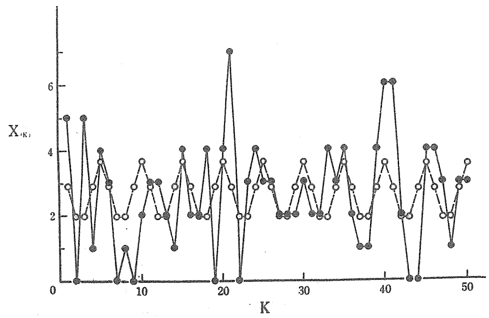


Fig. 11—A—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 5, Series V : unit is one hook-interval width = *ca.* 40 m)

Albacore : The deviation of the observed-values in Series I shows that there is a large school, in which heavily-occupied lots are arranged self-spacingly. And the severe deviation of the observed-values and high observed-values in the following series of analyses suggest the presence of distinct structures of subordinate order of some significance.

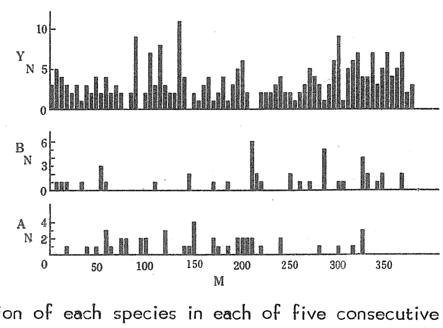


Fig. 12. Distribution of each species in each of five consecutive baskets in Example 6.

Example 6

Yellow-fin tuna : The population, in which heavily-occupied lots are arranged so as to show the periodicity of two lot width as basic structure, contains, to see generally, two groups of schools; their centers are spaced by a width longer than 200 baskets (= 40 km) each other, and these schools seem to be hooked respectively at the positions around the 100th basket and the part latter than the 300th basket. The analysis of Series II reveals the relation of the positions of schools within the same group more clearly than the analysis of Series I. This diagram also suggests that the smaller group covering the width of 50 baskets is constituted of three schools or thereabout, while the larger one covering the width longer than 75 baskets is consti-

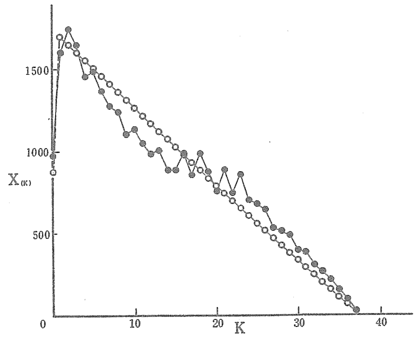


Fig. 13—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 6, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

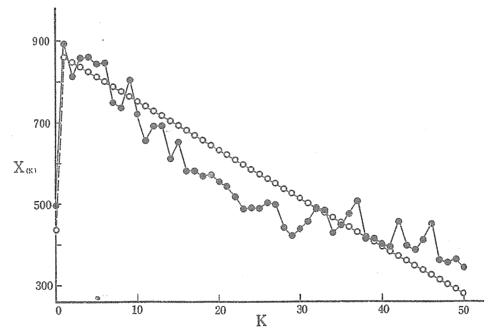


Fig. 13—Y—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 6, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

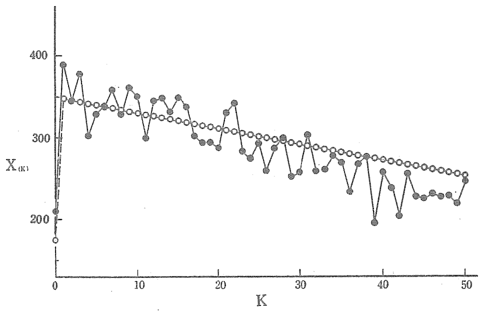


Fig. 13—Y—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 6, Series III : unit is 2 consecutive basket width=*ca.* 0.4 km).

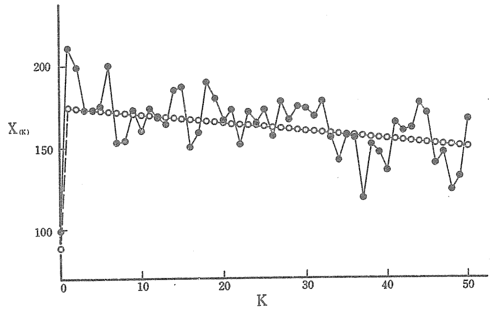


Fig. 13—Y—IV. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 6, Series IV : unit is 1 basket width=*ca.* 0.2 km).

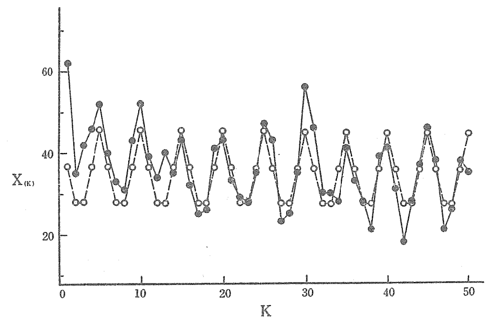


Fig. 13—Y—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 6, Series V : unit is one hook-interval width= *ca.* 40 m).

tuted of six schools or thereabout. And examining Fig. 12 and Table 16, I found that the schools constituting the smaller group were estimated to be located at the positions around the 85th, around the 110th and the 135th baskets respectively, while those constituting the larger one were located at the positions around the 275th, the 295th, the 310th, the 320th, the 335th and the 360th baskets respectively. Against the fact that the presence of two other aggregations, each of which is constituted of the population of the same order as those treated in the above, is suggested from Table 16 and the original records, no clear symptom suggesting the presence of them can be found out from the results of the spacing analysis. The analyses of Series III and IV do not add any new information about the distribution pattern. The analysis of Series V reveals that the elemental cluster occasionally covers a space as long as two-basket width or thereabout, although the symptoms suggesting such pattern can also be alluded to from the analyses of Series III and IV especially from the latter.

Strictly speaking, this fact means simply that the pairs of individuals spaced by the width shorter than two baskets each other are more frequently observable than expected from chance distribution. But it is not unreasonable to consider that, this fact evolved, there may be many lots covering the range as wide as two baskets or thereabout in which many individuals are hooked. Furthermore, it is highly probable that each school seems to be chiefly constituted of such a lot to which some solitary individuals are added. And many proofs supporting such a structure can easily be found out from Table 16 and the original records.

Big-eye tuna : The severe deviations of the observed-values in the diagram of Series I suggest the presence of some clear structures. Rather good catch enables the decoded structures to give high significance. That is to say, the general tendency of the deviations of the observed-values shows clearly that there are two groups of schools and that their centers are spaced by the width about as long as 250 baskets or longer each other, and these groups of schools may indicate the groups of individuals hooked in the ranges from the first to the 60th and from the 200th to the

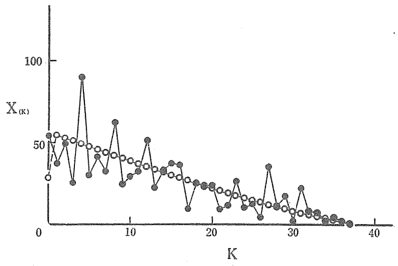


Fig. 13—B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 6, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

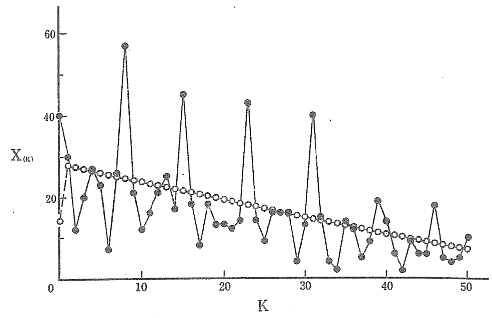


Fig. 13—B—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 6, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

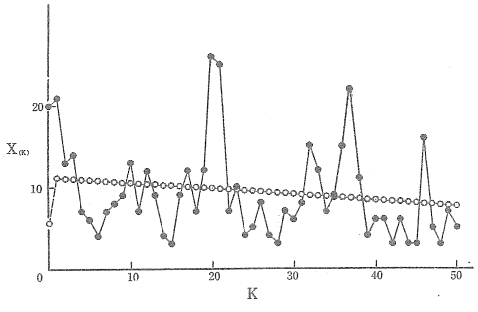


Fig. 13—B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 6, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

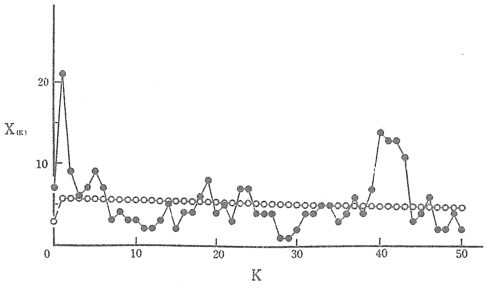


Fig. 13—B—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 6, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

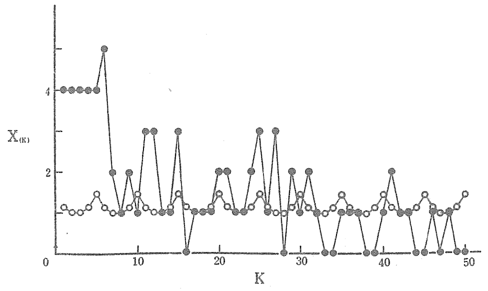


Fig. 13—B—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 6, Series Ⅴ : unit is one hook-interval width= *ca.* 40 m).

hindmost basket respectively. Besides them, the distinct and short-periodic deviation shows that rather strongly aggregated schools are observable spaced by 4, 8, 12, 15, 19, 23, 27, 31, and 35 lots (lot = 10 consecutive baskets and as long as 2 km) one another, among which the significance of the hindmost one is somewhat doubtful —— *i. e.*, showing nearly perfect periodicity of four-lot width. Besides them, not so clear peaks of the observed-values are found at k = 2,6 and 29, among which the hindmost one is as clear as those treated in the above —— at the middle of the above-mentioned ones. Accordingly, the pattern represented most clearly is deduced to be as follows: most of the occupied-lots are arranged spaced by the width as long as 40A baskets each other (A is a positive integer but not so large) and some not so heavily-occupied lots are located at some of the positions spaced by 20-basket width from some of the above-mentioned lots. But the diagrams of the following three series of analyses add no explanation to the pattern other than that the periodicities of 40- and 20-basket widths pointed out in the above are far more strict and stronger ones than that impressed from the diagrams representing the results of the preceding series of analyses.

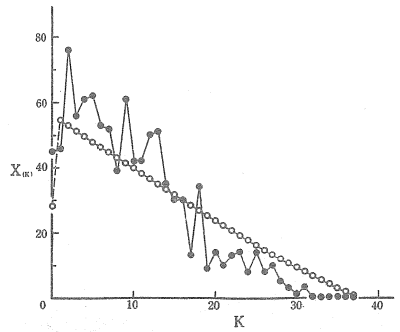


Fig. 13—A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 6, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

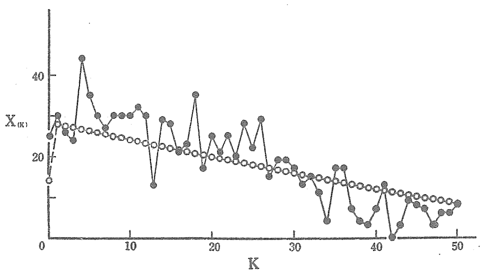


Fig. 13—A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 6, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

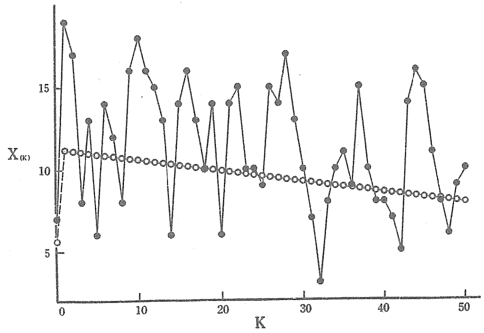


Fig. 13—A—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 6, Series III : unit is 2 consecutive basket width = *ca.* 0.4 km).

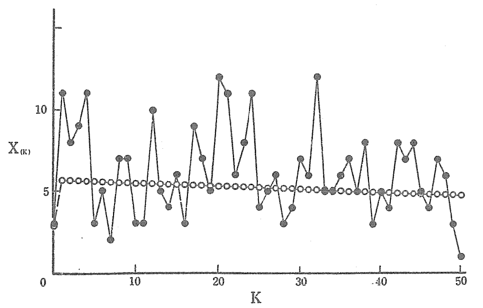


Fig. 13—A—IV. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 6, Series IV : unit is 1 basket width = *ca.* 0.2 km).

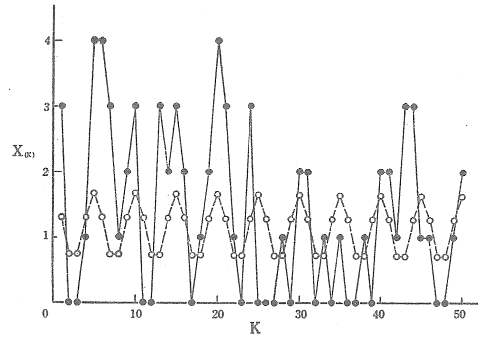


Fig. 13—A—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 6, Series V : unit is one hook-interval width = *ca.* 40 m).

Albacore : The presence of a large school covering the width as long as 200 baskets or thereabout and bearing the below-mentioned structure of the subordinate order is suggested from the general tendency of the deviations of the observed-values in Series I; this school is thought to be located in the range from the 40th to the 240th basket or thereabout. And the short-periodic deviation of the observed-values causes the peaks observable at $k = 2, 5, 9, 13$ and 18 lots; this means that the above-mentioned school contains from four schools of the subordinate order at minimum to at most six schools. And the presence of some individuals hooked out of the school is also suspected. The diagram of the following series may seem to allude to some facts, but I wish to give not so high significance upon them because each of the school of subordinate order mentioned above is estimated to be constituted of not so many hooked-individuals.

Example 7

Yellow-fin tuna : The diagram of Series I reveals that the population contains three schools, the centers of which are spaced by the width as long as 150 or 300 baskets one another (= *ca.* 30 km or 60 km), and Fig. 14 suggests that they are thought to

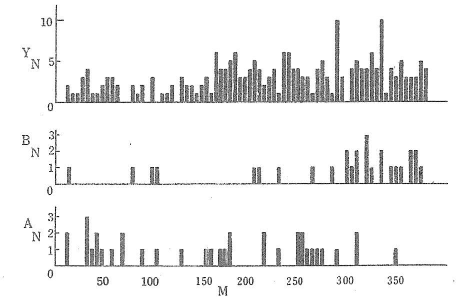


Fig. 14. Distribution of each species in each of five consecutive baskets in Example 7.

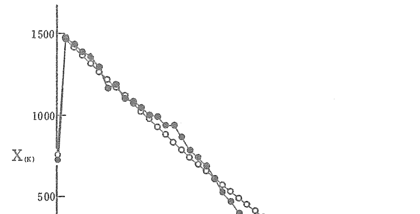


Fig. 15—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 7, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

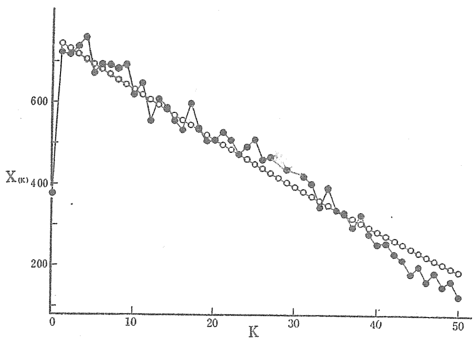


Fig. 15—Y—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 7, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

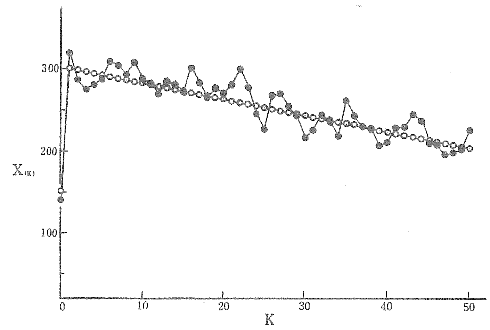


Fig. 15—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 7, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

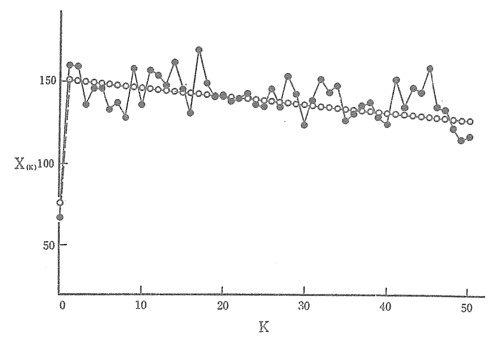


Fig. 15—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 7, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

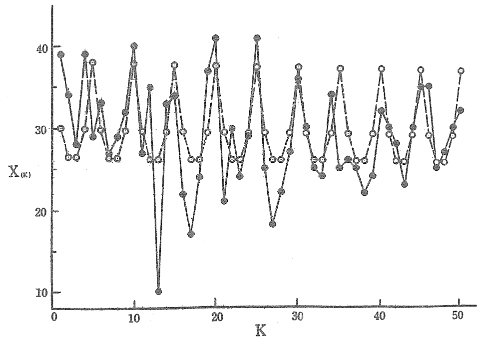


Fig. 15—Y—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 7, Series V : unit is one hook-interval width $= ca.$ 40 m).

be located respectively at the positions around the 50th, the 200th and the 350th baskets; among these schools, the population size of the middle one is the largest of all. The structure of the subordinate order most clearly represented in the results of the following three series of analyses is that the heavily-occupied lots are observable spaced by the width as long as 15 baskets (= 3 km) or thereabout one another. And the width of the elemental cluster is estimated to be as long as or shorter than four hook-intervals, in which those each covering a space of one or four hook-intervals are more predominant than the others.

Big-eye tuna : The general tendency of the deviations of the observed-values in Series I shows the presence of two schools aggregated densely and each covering a wide range; the centers of these schools are spaced by the width about as long as 250 baskets (= 50 km) each other. From Fig. 14, it becomes clear that the schools illustrated in the above are located at the range from the first to the 100th basket and the range from the 200th to the hindmost basket, especially dense population is observable at the hindmost part of each school. And the diagram of Series I also

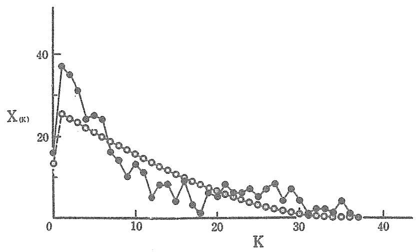


Fig. 15—B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 7, Series I : unit is 10 consecutive basket width $= ca.$ 2 km).

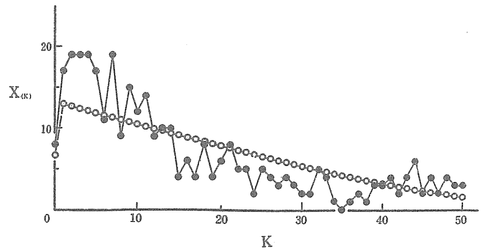


Fig. 15—B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 7, Series Ⅱ : unit is 5 consecutive basket width $=ca.$ 1 km).

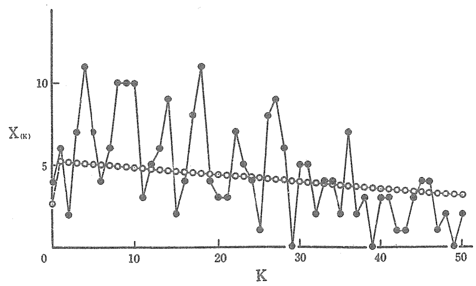


Fig. 15—B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 7, Series Ⅲ : unit is 2 consecutive basket width$=$ *ca.* 0.4 km).

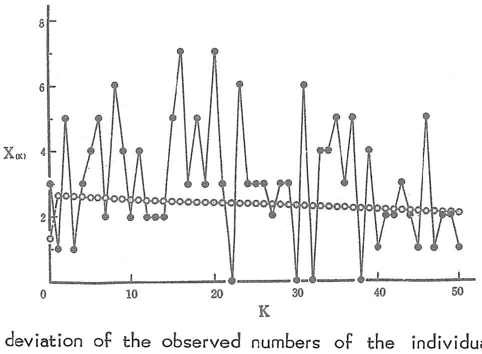


Fig. 15—B—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 7, Series Ⅳ : unit is 1 basket width$=ca.$ 0.2 km).

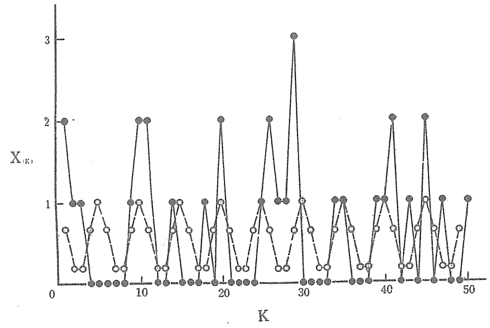


Fig. 15—B—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 7, Series V : unit is one hook-interval width = *ca.* 40 m).

suggests that these schools are constituted of each two schools of subordinate order, details of which are also easily assumable from Fig. 14. Then, some patterns may be deducible from the small deviations of the observed-values of this series and from the diagrams of the following series. But I wish to add no description, because each school of subordinate order mentioned above except that located at the range from the 260th to the hindmost basket is constituted of three hooked-individuals at maximum, consequently the deducible pattern is only that of the hindmost school of subordinate order, moreover not so high significance can be given to it.

Albacore : The deviation of the observed-values in the diagram of Series I shows rather clearly that there are two schools, the centers of which are spaced by the width as long as 200 baskets (= 40 km) each other, and at the middle of them, the presence of another not so distinct school is suspected. (Here, "not so distinct" indicates the school of not so strongly aggregated or constituted of fewer individuals). On Fig. 14, it is easily found out that two schools are located at the positions around the 50th and around the 250th baskets respectively and each of them is constituted of

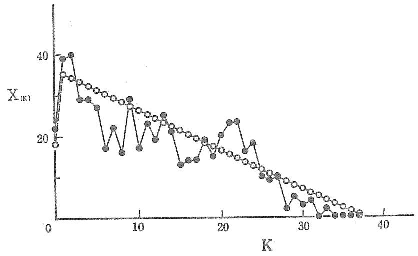


Fig. 15—A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 7, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

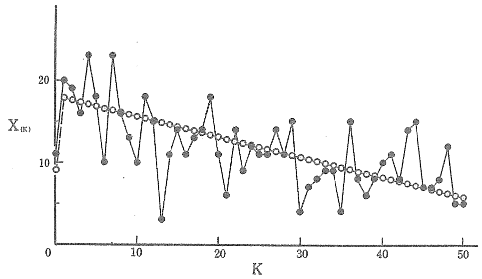


Fig. 15—A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 7, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

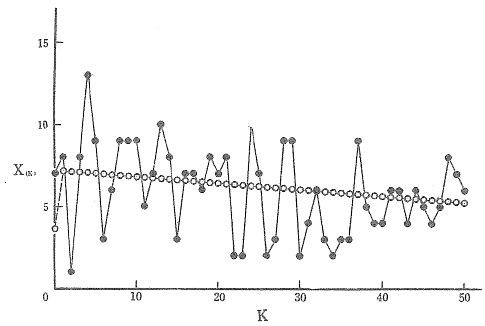


Fig. 15—A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 7, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

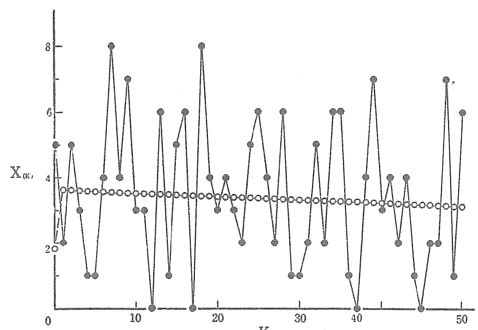


Fig. 15—A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 7, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

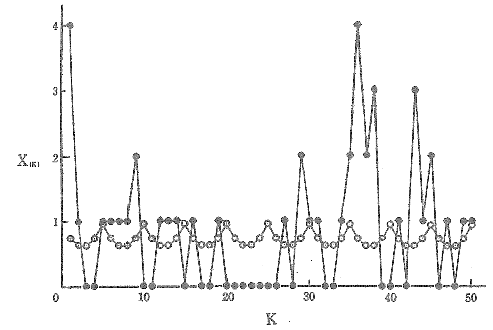


Fig. 15—A—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 7, Series V : unit is one hook-interval width = *ca.* 40 m).

10 or more hooked-individuals, while not so distinct one is at the position around the 150th basket and this is constituted of six hooked-individuals or thereabout. The diagram of Series II reveals that each school seems to be constituted of five subordinate clusters or thereabout, but significance of the pattern of this order is somewhat doubtful because, if so, each cluster results in being constituted of a single or two to at most five hooked-individuals. And for the same reason, no further structure is drawn out from the following series of analyses other than the fact that the pairs of individuals hooked adjoiningly or spaced by seven or nine baskets are frequently observable, although they are not so many as impressed from the word "frequently" but are only as many as four or a little more.

Example 8

Yellow-fin tuna : On the diagram of Series I, the presence of three schools, the centers of which are spaced by 6 or 13 lots (lot = 10 consecutive baskets and as long as 2 km) one another, is represented. And they may be located at the positions around the 20th, the 80th and the 150th baskets, respectively. The analysis of Series II shows the same fact not so clearer than that of Series I. The severe deviations

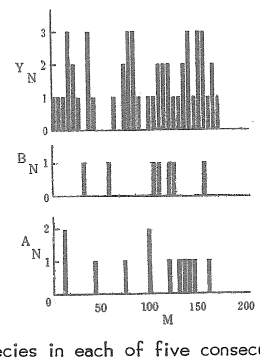


Fig. 16. Distribution of each species in each of five consecutive baskets in Example 8.

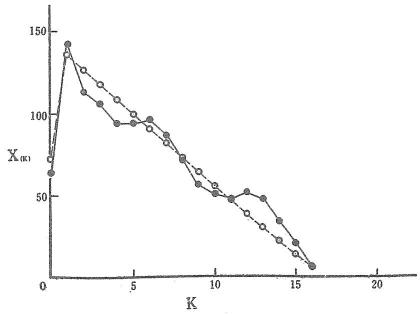


Fig. 17—Y—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 8, Series Ⅰ : unit is 10 consecutive basket width=*ca.* 2 km).

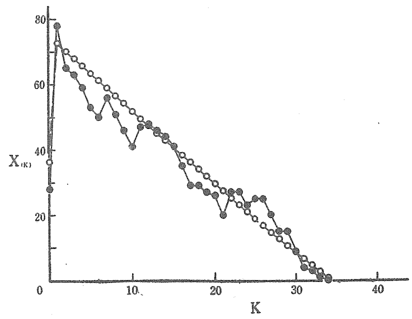


Fig. 17—Y—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 8, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

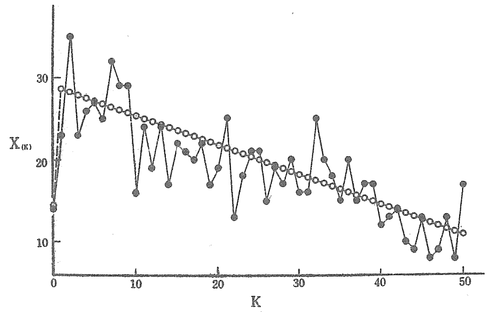


Fig. 17—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 8, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

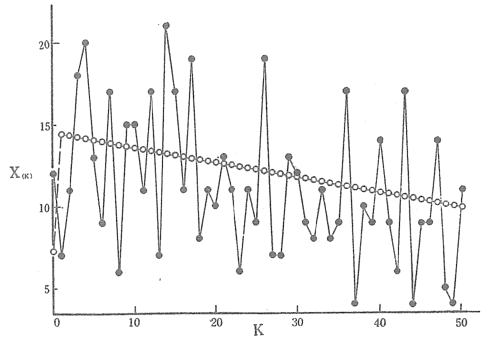


Fig. 17—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 8, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

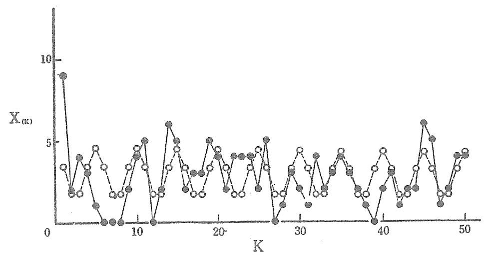


Fig. 17—Y—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 8, Series Ⅴ : unit is one hook-interval width= *ca.* 40 m).

of the observed-values in the diagrams of the following three series may seem to represent that there are some distinct structures of the subordinate orders. But it is probable that the above-mentioned structures of the subordinate orders actually indicate the distribution pattern of single individuals or clusters constituted of at most not so many individuals, because the hooked-individuals forming each school are not so many. Moreover, each peak is narrow; this means that the deviation is afraid to be strongly affected by the influence of accidental error. Therefore, I wish to give no interpretation of the further pattern deducible from the analyses of Series Ⅲ ~ Ⅴ because of being afraid of severe influence of accidental error. And only the diagrams are shown for reference' sake.

Big-eye tuna : The low observed-values and the estimated ones due to low occupied-rate emphasized by short length of a whole row of used gears make it impossible to analyze the pattern free from the influence of accidental error, although the pattern

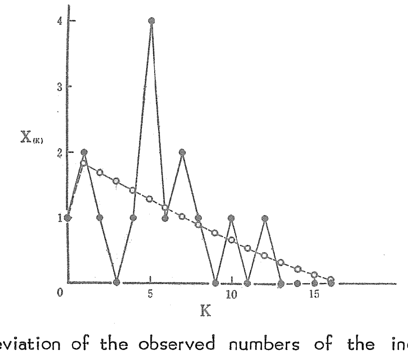


Fig. 17—B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 8, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

coinciding considerably well with that assumable from Fig. 16 can be deduced from the diagram of Series Ⅰ.

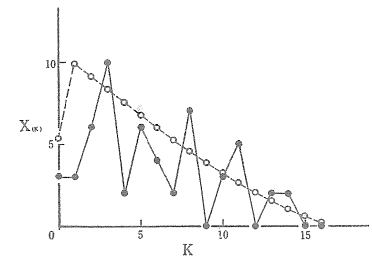


Fig. 17—A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 8, Series Ⅰ : unit is 10 consecutive basket width=*ca.* 2 km).

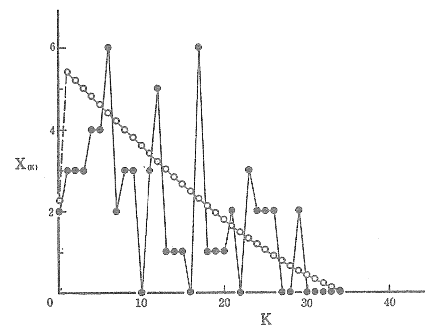


Fig. 17—A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 8, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

Albacore : The deviation of the observed-values in the diagram of Series I clearly shows that six schools, which are located at the positions evenly spaced by a width as long as about 30 baskets each other, are contained in so evenly scattered population that only less individuals than that expected from chance distribution are hooked in the lots spaced by a width as long as or shorter than two lots including the same one from any occupied one, although most of the observed-values are not so high enough as to be deducible any fact excerted on no influence of accidental error. Here, I am afraid that it brings into confusion to make an image of the pattern from the above-mentioned description. But, it may become clearly recognizable when we consider the image of the pattern together with the fact that most of schools, in such an example of low occupied-rate as this and in which the hooked-individuals are distributed self-spacingly, are actually single occupied-lots occupied usually by not so many individuals. The positions and population sizes of respective schools are easily found out from Fig. 16. Because of the low observed-values, nothing is found out from the results of the succeeding series, although the figure showing the result of the next series may be somewhat obscurely suggesting the same pattern as that mentioned above.

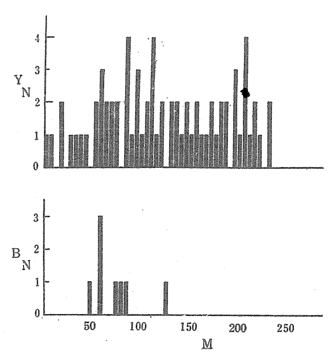


Fig. 18. Distribution of each species in each of five consecutive baskets in Example 9.

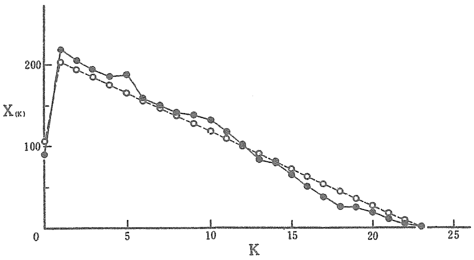


Fig. 19—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 9, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

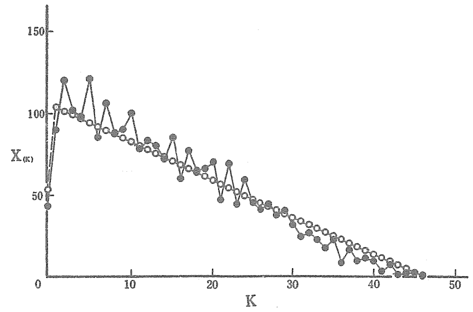


Fig. 19—Y—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 9, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

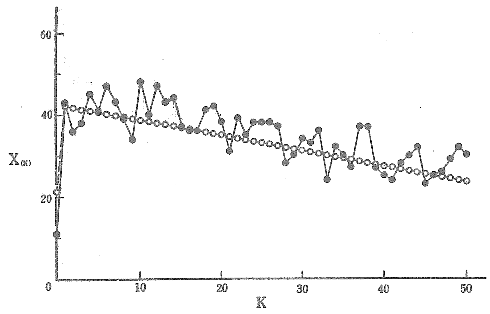


Fig. 19—Y—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 9, Series III : unit is 2 consecutive basket width=*ca.* 0.4 km).

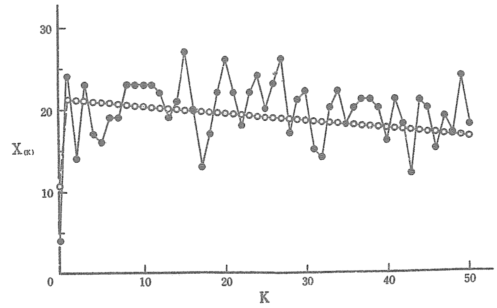


Fig. 19—Y—IV. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 9, Series IV : unit is 1 basket width=*ca.* 0.2 km).

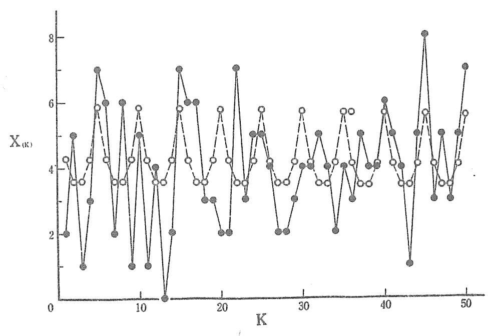


Fig. 19—Y—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 9, Series V : unit is one hook-interval width= *ca.* 40 m).

Example 9

Yellow-fin tuna : The analysis of Series I reveals that the population contains a large school covering a space a little shorter than 150 baskets; this school may correspond to the part of higher occupied-rates from the 50th to the 200th basket, moreover this is rather clearly constituted of two schools of the subordinate order, the centers of which are spaced by a width as long as 100 baskets each other; and they are thought to be located at the ranges from the 50th to the 100th and around the 200th baskets. And the two-lot periodicity of the observed-values clearly observable in the diagram of Series II represents such further structure of subordinate order as every other lot is heavily occupied, as assumable from Fig. 18. The characteristics of the distribution pattern most clearly represented in the following two series of analyses are that the hooked-individuals are so evenly scattered that the number of individuals caught in the lots spaced by a width shorter than 10 baskets from any occupied-lot including the same one can not reach the values expected from chance

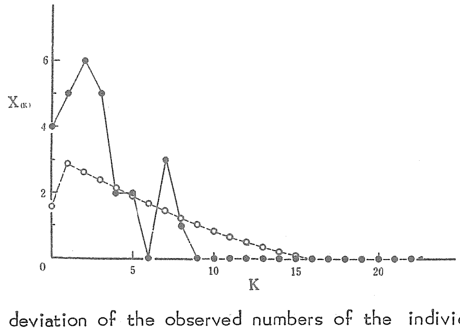


Fig. 19—B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 9, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

distribution, as noticeable from Fig. 18. The low observed-values make it impossible to deduce no further structure from the following series of analyses other than the fact that self-spacing pattern is assumable.

Big-eye tuna : Despite of the fact that total catch is not so good enough, it may well be said that the deviation of the observed-values in the analysis of Series I rather clearly shows the pattern coinciding well with that easily assumable from Fig. 18 —— *i.e.*, the population seems to contain two schools each aggregated clearly; their centers are spaced by an interval as long as 70 baskets or thereabout each other, although one of them is actually a single individual unfortunately hooked.

Albacore : Omitted, because no more than two individuals are hooked in a whole row of gears.

Example 10

Yellow-fin tuna : The pattern most clearly suggested from the analysis of Series I is that the population contains two schools each covering the width as wide as or

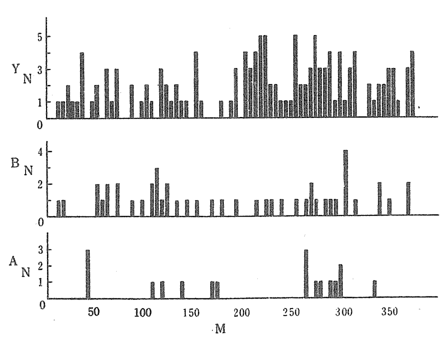


Fig. 20. Distribution of each species in each of five consecutive baskets in Example 10.

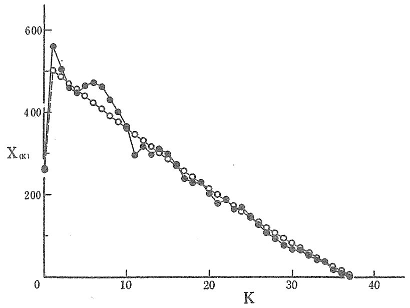


Fig. 21—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 10, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

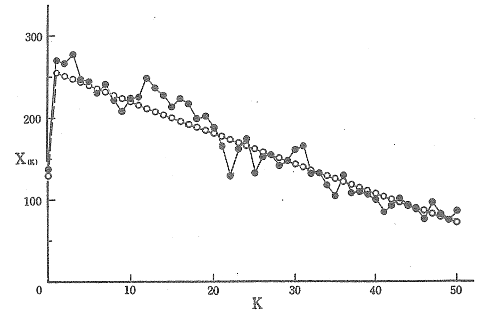


Fig. 21—Y—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 10, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

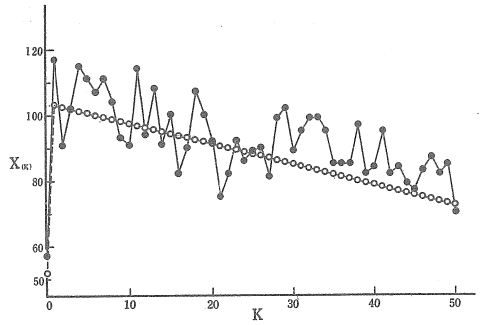


Fig. 21—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 10, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

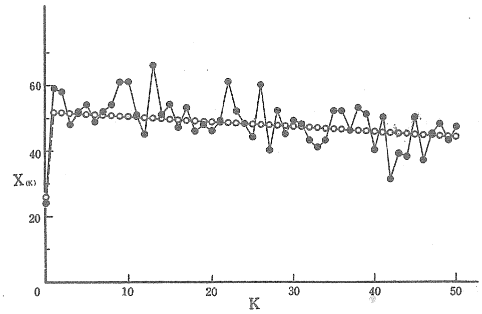


Fig. 21—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 10, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

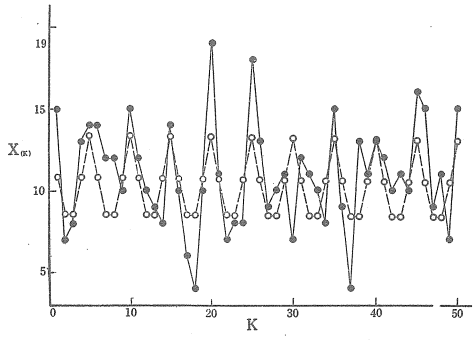


Fig. 21—Y—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 10, Series Ⅴ : unit is one hook-interval width=*ca.* 40 m).

wider than 30 baskets and their centers are spaced by an interval as long as or longer than 60 baskets, although hooked-individuals are scattered throughout a whole row of gears. Besides, the presence of another school is also suggested and this school is assumed to be spaced by a width a little longer than twice as long as the above-mentioned one. From Fig. 20, the schools represented clearly are thought to indicate the parts respectively around the 210th and the 270th baskets, and another is around the 345th basket. The analysis of Series Ⅱ shows almost the same fact, while the analysis of Series Ⅲ reveals that each of these schools is constituted of three clusters of the subordinate order or thereabout. And the analysis of Series Ⅳ represents the same fact less clearly. Adding the analysis of Series Ⅴ, we can find out the elemental structure widely influencing, sometimes reaching a width of $2\frac{1}{2}$ baskets, and this pattern is thought to be one of the most remarkable characteristics of the distribution pattern of this example.

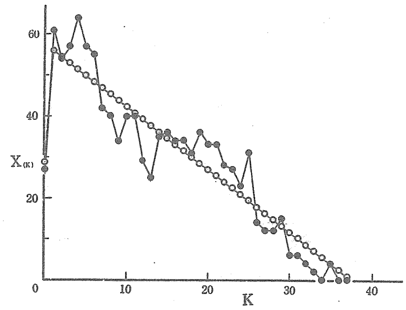


Fig. 21—B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 10, Series Ⅰ : unit is 10 consecutive basket width=*ca.* 2 km).

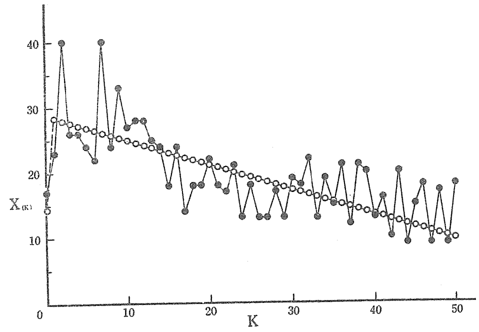


Fig. 21—B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 10, Series Ⅱ : unit is 5 consecutive basket width=*ca.* 1 km).

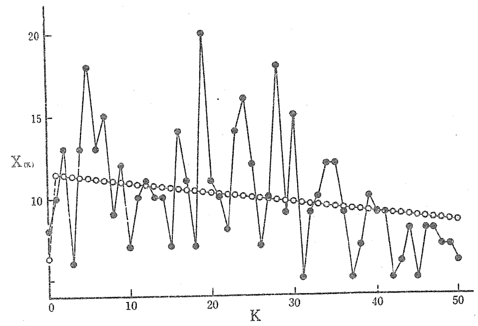


Fig. 21—B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 10, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

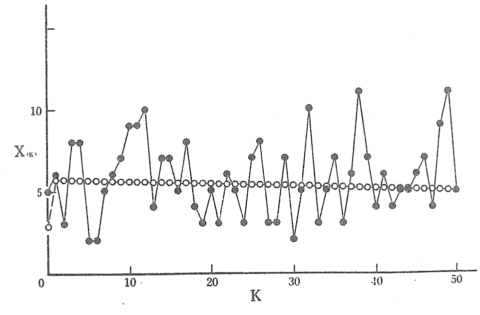


Fig. 21—B—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 10, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

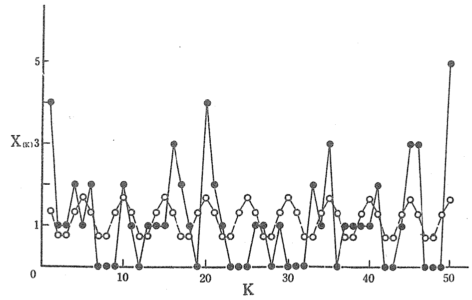


Fig. 21—B—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 10, Series V : unit is one hook-interval width= *ca.* 40 m).

Big-eye tuna : General tendency of the deviation of the observed-values in the diagram of Series I shows that the population seems to contain, generally speaking, two groups of schools, the centers of which are spaced by an interval as long as 200 baskets each other. And these groups of schools may be located at the ranges respectively from the 10th to the 125th basket and from the 230th to the hindmost basket. But this diagram examined more in detail, the peaks of the observed-values can be observed at k = 4, 10, 15, 19, 25, 29 and 35 —— *i.e.*, almost regularly at each five lots; this shows that eight or less number of heavily-occupied lots, which may perhaps be the schools, are arranged spaced by a width as long as $5A$ lots (A is a positive integer but not so large) one another. Accordingly, the groups of the individuals caught at about the 15th, the 65th, the 115th, the 270th, the 290th, the 305th, the 340th and the 370th baskets are thought to correspond to the schools mentioned above. The same facts may also be represented by the general tendencies of the deviations of the observed-values in the following series, although they are not so clear, owing to be influenced strongly by narrow but severe deviations indicating some structures of the subordinate orders.

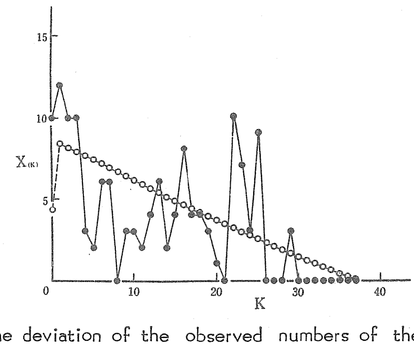


Fig. 21—A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 10, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

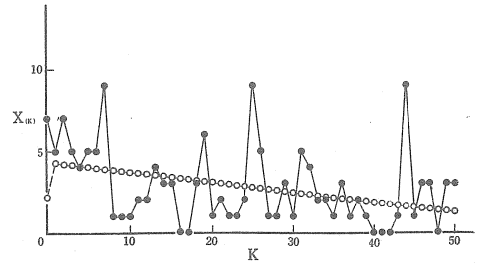


Fig. 21—A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 10, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

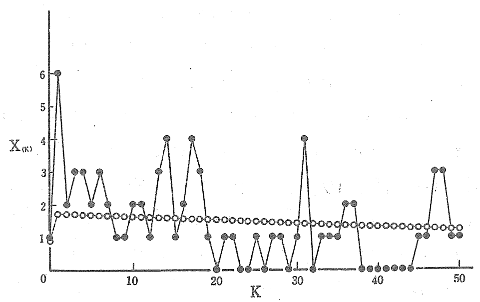


Fig. 21—A—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 10, Series III : unit is 2 consecutive basket width= *ca.* 0.4 km).

Albacore : General tendency of the deviations of the observed-values in the diagram of Series I shows that the population contains or is constituted of three schools, the centers of which are spaced by 15 and 25 lots (lot = 10 consecutive baskets) one another. From Fig. 20, it becomes clear that these schools may indicate single or groups of occupied-lots located about the 45th, the ranges from the 110th to the 175th basket and from the 265th to the 300th basket or including a single individual hooked at the 335th basket. And the short-periodic deviation shows the feature of the subordinate cluster-formation which is also easily recognizable from Fig. 20.

Example 11

Yellow-fin tuna : The deviation of the observed-values in the analysis of Series I reveals that the individuals are more frequently hooked in the parts near the both ends of a row of gears than regarded simply increasing with approach to the final end of hauling. This fact may seem to suggest that the sudden increase in occupied-

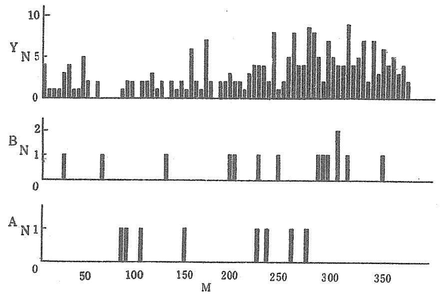


Fig. 22. Distribution of each species in each of five consecutive baskets in Example 11.

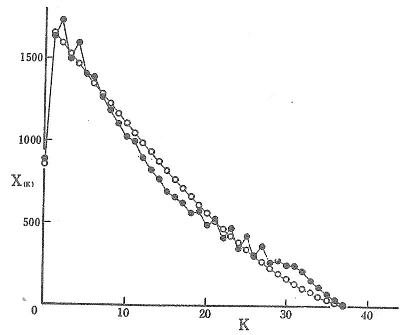


Fig. 23—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 11, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

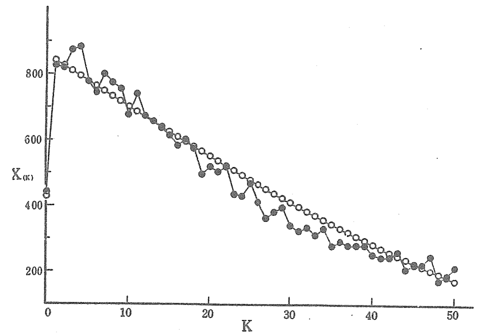


Fig. 23—Y—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 11, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

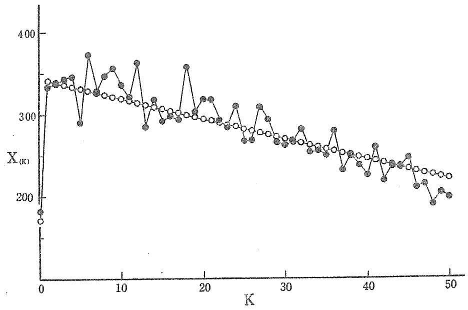


Fig. 23—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 11, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

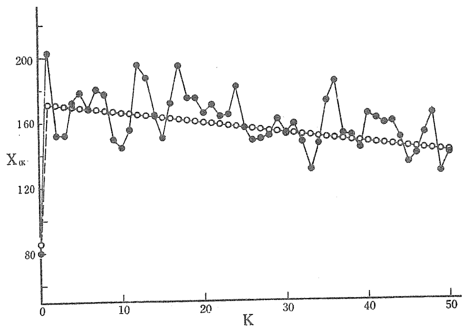


Fig. 23—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 11, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

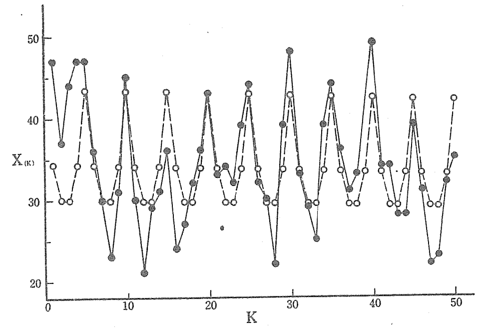


Fig. 23—Y—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 11, Series Ⅴ : unit is one hook-interval width=*ca.* 40 m).

rate in the parts latter than a certain basket is misregarded as if it is gradual one. But Fig. 22 shows that catch within the first 50 baskets is higher than those within the second (from the 51th to the 100th basket) and the third ones (from the 101th to the 150th basket). Therefore, it seems to be more probable to assume that two schools are hooked and their centers are spaced by a width as long as 300 baskets each other; and these schools may indicate the heavily-occupied parts respectively around the 25th and the 325th baskets. A little irregular periodicity of the observed-values of four-lot width in the diagram of Series II shows that the schools of the subordinate orders are frequently observable spaced by a width as long as $20A$ baskets each other (A is a positive integer but not so large). General tendency of the deviations of the observed-values in the following two series of analyses supports the presence of this pattern, while the short-periodic one adds such an information about the structures of the further subordinate orders as each subordinate school is spaced by a width as long as 20 or 20 ± 5 baskets from the adjoining ones or constituted of from single to all three schools of the subordinate orders arranged so as to be spaced by 15, 20 and 25 baskets from adjoining groups. And the analysis of Series V shows that each elemental cluster covers a space as long as or shorter than a basket, especially one hook-interval.

Big-eye tuna : The low observed-values and the estimated ones due to poor total-catch do not allow me to give any significance upon the facts deducible from the diagrams. Therefore, I wish to describe nothing else than that many schools comparing with total catch are scattered throughout a whole row of gears; and this fact indicates that most of the schools are constituted of a single or not so many hooked-individuals.

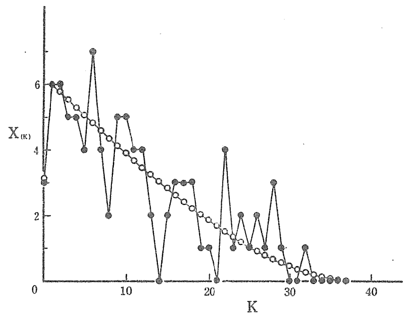


Fig. 23—B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 11, Series I : unit is 10 consecutive basket width $=ca.$ 2 km).

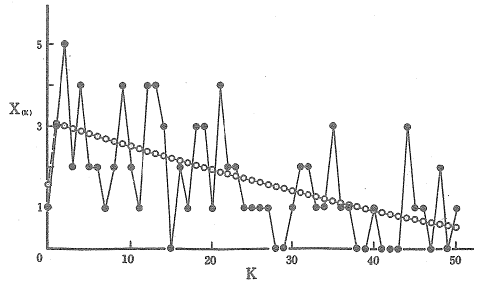


Fig. 23—B—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 11, Series II : unit is 5 consecutive basket width $=ca.$ 1 km).

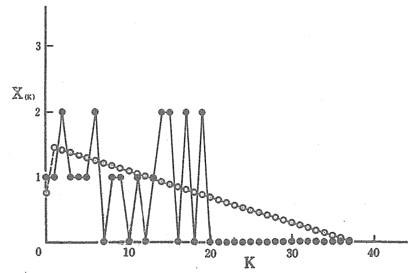


Fig. 23—A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 11, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

Albacore : I could not obtain the high observed-values and the estimated ones enough to deduce any fact capable of giving any significance owing to scarcity of the hooked-individuals. And even if committing against the presumably severe influence of accidental error, I can barely deduce the fact that, as represented in Fig. 22, all individuals are scattered not all over the whole row but restricted within a space as long as a half of a row —— *i.e.*, forming a loosely linked school covering a space as long as a half of whole row.

Example 12

Yellow-fin tuna : Slight gradient of counter direction to increase in soaking time is suggested from Fig. 24. Therefore, the influence of it is excluded from all series of the theoretical values, although whether it has to be excluded or not is doubtful. Usually, this spacing method is adopted for the purpose of finding out the probable number of schools contained and the distances among their centers as the most effective keys to decode the pattern. But we are already aware that, when the positions

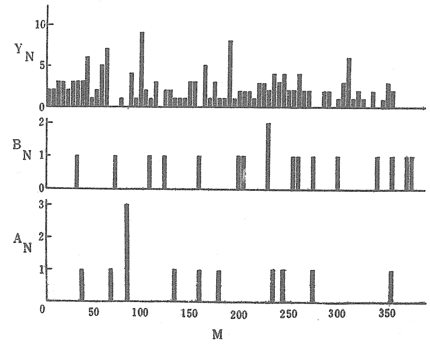


Fig. 24. Distribution of each species in each of five consecutive baskets in Example 12.

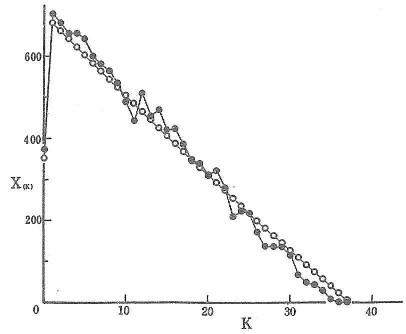


Fig. 25—Y—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 12, Series I : unit is 10 consecutive basket width=*ca.* 2 km).

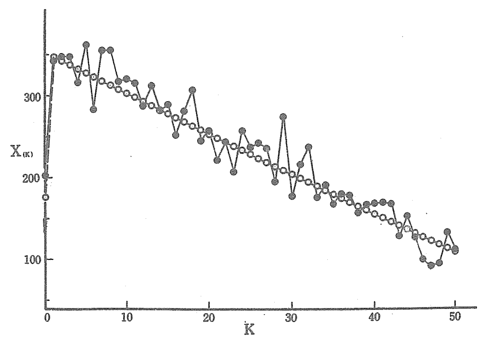


Fig. 25—Y—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 12, Series II : unit is 5 consecutive basket width=*ca.* 1 km).

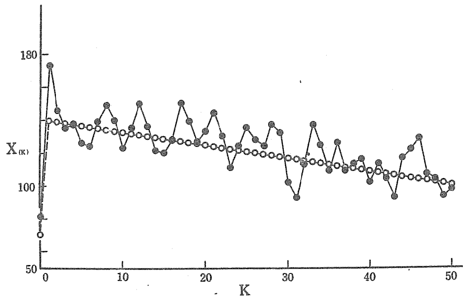


Fig. 25—Y—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 12, Series Ⅲ : unit is 2 consecutive basket width=*ca.* 0.4 km).

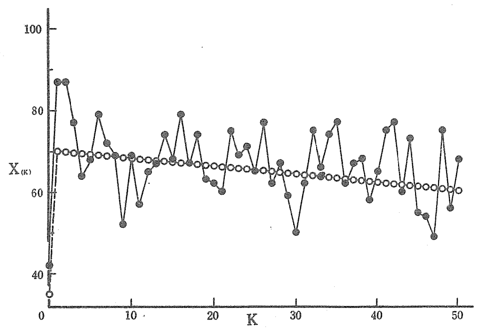


Fig. 25—Y—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 12, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

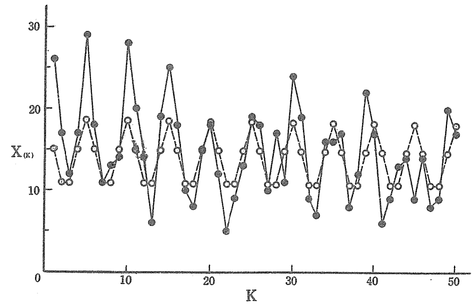


Fig. 25—Y—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Yellow-fin tuna, Example 12, Series Ⅴ : unit is one hook-interval width=*ca.* 40 m).

of some of schools are previously found out, the structures of the rests of them —— consequently all structures —— are decoded far easily. Fortunately this figure also strongly suggests the presence of schools hooked at the positions around the 60th, the 100th and the 185th baskets. Therefore, the diagrams showing the results of the spacing analyses considered together with the above-mentioned positions, the distribution pattern is analyzed. The peaks of the observed-values in the first series are found at $k = 4, 12, 14, 16, 21, 25$ and 29 lots (lot = 10 consecutive baskets). And the positions spaced by these key-lengths from the above-mentioned positions are the 220th, the 310th and the 350th baskets. Therefore, examining the corresponding parts in Fig. 24, Table 22 and the original records, I found that these parts were heavily occupied and able to be regarded as the positions of schools. Thus, the positions of six schools are estimated, and it is self-evident that all intervals among these schools do not take any value other than the above-mentioned key-lengths; but before ending the discussion of the pattern of this step, it is necessary to examine whether or not there is any key-length which does not occur among the intervals of these schools. And if there is any key-length showing the value other than the intervals among these schools, the schools causing the occurrence in such a key-length should be seaked about. But actually there is no such a key-length, accordingly no school else than the above-mentioned ones is thought to be contained. And the results of the following three series of analyses examined, the 6 ∼ 8 basket periodicity of heavily-occupied baskets is found out ; and this periodicity is expressed in a little regular one of four-lot width in Series III and the general tendency of the deviations of the observed-values in the diagram of Series IV. And also the last two series show that far more individuals than expected from chance distribution are hooked in the baskets spaced by a width shorter than three baskets from any occupied one. And the same pattern is also clearly represented in the analysis of Series V as one of the characteristics of the distribution pattern of this example.

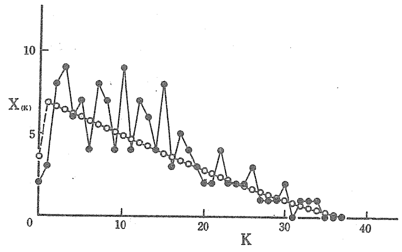


Fig. 25—B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 12, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

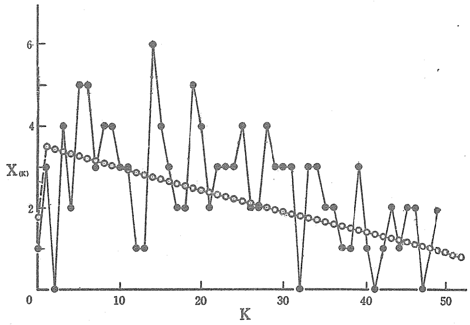


Fig. 25—B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 12, Series Ⅱ : unit is 5 consecutive basket width $=$*ca.* 1 km).

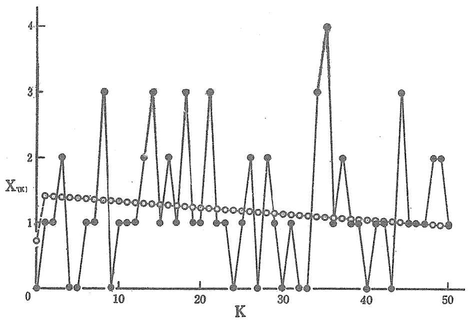


Fig. 25—B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Big-eye tuna, Example 12, Series Ⅲ : unit is 2 consecutive basket width $=$*ca.* 0.4 km).

Big-eye tuna : The following facts may be said, although both the observed-values and the estimated ones, especially those in the range $k > 15$, are not so large enough that they enable to deduce any fact: the individuals are hooked so self-spacingly that only less individuals than in the chance distribution are caught in respective occupied-lots and the lots adjoining to them. And the number of the schools contained is estimated to be from six at minimum to 12 at maximum, because the peaks of the observed-values are located at $k = 3, 5, 7, 10, 12, 15, 17, 22, 26, 30$ and 33. But, against the fact that the observed-values at $k = 17, 22$ and 33 are not so largely exceeding the estimated ones, sums of two other k rather frequently take these values, and the same fact can be said to the observed-value at $k = 15$ where it exceeds largely the estimated one. Accordingly, it may be more probable to consider that the maximum number of schools is 9. But I do not wish to give any significance upon these facts, and wish to consider that all individuals are hooked self-spacingly throughout a whole row of gears, because in any case, respective schools detected above indicate frequently a single or a pair of hooked-individuals and rarely three individuals at maximum.

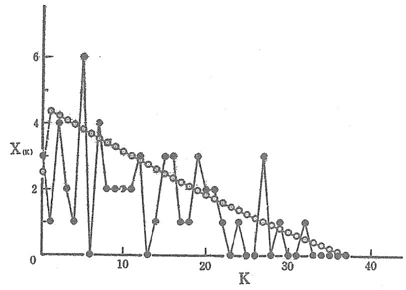


Fig. 25—A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 12, Series I : unit is 10 consecutive basket width $=ca.$ 2 km).

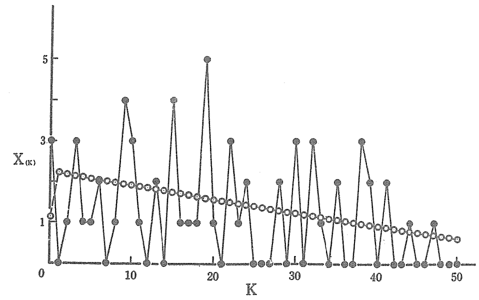


Fig. 25—A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of the same species, in contrast with that of the theoretically estimated ones (Albacore, Example 12, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

Albacore : Enough individuals capable of obtaining the results of analyses suffering from no influence of accidental error can not be hooked. Therefore, from the diagram showing the results of analyses, nothing can be drawn out else than that the individuals are scattered self-spacingly all over a whole row of gears.

2. Summarized results of the spacing analysis on the distribution patterns of three species of tuna

Yellow-fin tuna : Relatively many individuals of the yellow-fin tuna are caught by a row of gears in each operation. Accordingly, high significance can be given to the patterns deduced from the results of the analyses, even including those at the elemental step. And the patterns described in the exposition of particular example are summarized as follows:

1) No example showing clearly self-spacing pattern can be found out.

2) All examples show the patterns of several-fold contagiousness, although the contagious degree at each step is very weak, moreover influencing-widths of the schools of the highest order vary severely example by example —— the width from a few consecutive baskets to longer than a half of a whole row of gears.

3) There are some examples in which from one school to at most less than five schools of weak contagiousness each covering widely are contained. Further it is also discerned that most of these schools are constituted of many schools of subordinate orders, the width of each of which is 10 consecutive basket order; while other examples lack the structure covering widely and seem to be constituted of many schools of the same magnitude as the subordinate schools of the above-mentioned examples. But no fact having clear relation to the fact whether a certain example lacks the structure covering widely or not can be found out yet.

4) It is suspected that, when an example contains not so many schools, the centers of the schools occur a little frequently in the first and the hindmost two lots of 50 consecutive baskets, although this is not so strict.

Big-eye tuna : Generally speaking, the hooked density of the big-eye tuna in each operation does not reach a value as high as an individual per 10 consecutive baskets. Accordingly, I can not give so high significance upon the structures deduced from the results of the above-mentioned analyses. And if the results of the analyses may suggest the presence of many schools in a certain example, the population sizes of respective schools become extremely small and the structure within a short interval, which is expected to show the pattern specific to respective species and has much interests, can not be found out without unnegligible influence of accidental error due to the scarcity of hooked-individuals forming respective schools. But the following descriptions of the general tendency are given for reference' sake, although significance of some of them is doubtful.

1) Among 12 examples, Examples 8 and 9 are omitted, because total numbers of used gears are not so many enough.

2) Relatively clear school-formation can be admitted in Examples 1, 2 and 4, although population sizes of respective schools are not so large and each of them is occasionally constituted of one or few hooked-individuals. And the similar but not so clear structure is found out in Example 7.

3) A self-spacing pattern of the hooked-individuals is observable in Examples 3, 5 and 12. And the similar pattern is also suggested in Example 11 but at the same time this example alludes to slight school-formation to consider the structure as a whole.

4) The examples, which are constituted of relatively many individuals —— Examples 6 and 10 —— represent such a structure as they contain each two groups of schools although it is not so strict, and 20- and 40-basket periodicities of heavily-occupied baskets are alluded to in the former example while the latter example shows not so

clear 50- basket periodicity as the structure of the subordinate order.
5) But no factor having clear relation to these differences in the types of the distribution pattern is found out yet.

Albacore : Like the big-eye tuna, the scarcity of the hooked-individuals in each operation makes it impossible to give high significance upon the facts deduced from the results of the analyses. And also no description of the distribution pattern within a short range can be given. But the following general tendencies are described for reference' sake, although significance of some of them is somewhat doubtful.
1) Examples 1 and 9 are left aside the consideration, because of the extreme scarcity of the hooked-individuals. And Example 8 is also omitted because the total number of used gears is not so many.
2) As clearly represented in Examples 3, 5 and 6 and obscurely in Example 11, it seems to be one of the characteristics of the distribution pattern of this species that most of the hooked-individuals intend to form a single school covering widely in which the individuals are rather self-spacingly distributed.
3) But there are some examples in which the hooked-individuals are inclined to form many schools (clearly in Examples 2 and 10 while obscurely in Examples 4 and 7).
4) Otherwise, self-spacing pattern can be observed (in Example 12), which is thought to be one of the modified types of the distribution pattern classified into column 2 (whole of gears is entirely covered by a wide school) or in column 3 (not so large population is splited into too many schools scattered throughout a row, consequently each school is constituted of extremely small population).
5) No factor having clear relation to these differences in the types of the distribution pattern can be found out.

Results of the Correlation Analysis

The distribution patterns within the individuals of the same species were analyzed in detail in the preceding paragraph and in the preceding report. But among three species of tuna of commercial importance, the yellow-fin tuna and the big-eye tuna take the similar body size and rather common foods (roughly speaking piscivora), while only the albacore is rather plankton-feeder and its body size is a little smaller than the former two. Accordingly, the yellow-fin tuna and the big-eye tuna are probable to take the similar habitat or to form common schools when they are considered with large scale, and also probable to segregate their habitat each other when they are examined in detail, as suggested and certified to terrestorial animals. On the other hand, the hooked-population sizes of the yellow-fin tuna in these examples are large, in contrast with the fact that those of the big-eye tuna and the albacore are small. And it is one of the frequently observable characteristics of the social habits of fishes that, when population size or density of each species is not so high, fishes are inclined to form the common schools overcoming some differences in species moreover their food habits, swimming abilities, *etc.* Therefore, the big-eye tuna and the albacore are probable to form the common schools against the differences in their food habits and in body sizes. And it is of interest and of importance to know the social relation observable among the individuals of the different species——whether they are inclined to take common habitats (conveniently, called forming the common schools), to be distributed independently or repulsively of each other, because of not only the above-mentioned reasons but also from many other bio-sociological interests; this relation is represented, in the projected distribution-pattern along long-line, as that among the hooked-positions of the different species. And it is presupposable that this relation considered a row of gears as a whole can be easily assumable from the distribution patterns of respective species which are described in the above as the preliminary step; while the relation of the hooked-positions within a short range is hardly assumable from the distribution patterns of respective species, against the fact that it is thought to have more interests. Accordingly, at first, the expectant outline of the correlation to consider a row as a whole is forecasted from the distribution patterns of respective species; next, the differences in the actually obtained ones adopting the analysis method of correlation mentioned above from the forecasted ones are examined and then the reasons causing them are discussed in case by case although such differences are not so frequently observed. But, for the correlation observable within a short range, any description can hardly be given to it, despite of its importance and deep interests, because the hooked-population sizes of each one or both of the two species are not so large enough as to be deducible any pattern of significance, although predominance of the hooked-population size of a species superficially raises the observed-values and the estimated ones into the magnitude falsely large enough capable of giving some significance.

The unit-lengths of respective series-numbers of correlation analyses are the same as those of the spacing analyses. The solid circles in the diagrams showing the results of the correlation analyses show the observed-values; while the open ones are the theoretical-values estimated from Formulae (8) and (9) (for Series Ⅰ ~ Ⅵ) or Formulae (10) ~ (14) (for Series Ⅴ). And because of the same reason as that in the spacing analyses, some series are omitted based on the same criteria as those in the spacing analyses, in which the words "the catch of less abundant species" are substituted for the word "the catch".

1. Exposition of particular example

Example 1

No consideration can be given to the relation between the albacore and any other species, because no more than two individuals of the albacore are hooked.

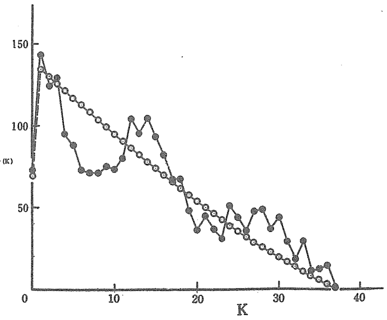


Fig. 26—Y B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 1, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

Notes (common to Figs. 26~37):

Solid circles show the observed values; while open ones indicate the estimated ones.

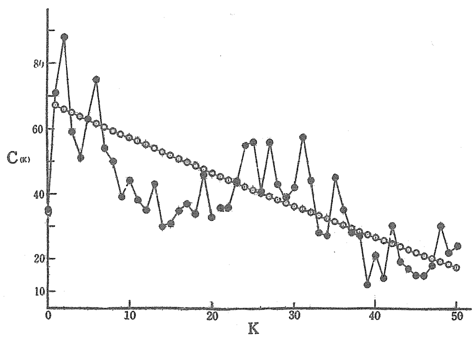


Fig. 26—Y B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 1, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

Yellow-fin tuna—Big-eye tuna : The diagram showing the results of the spacing analysis of the yellow-fin tuna suggests that most of the hooked-individuals form three schools located at the positions around the 80th, the 200th and the 350th baskets and two obscure ones located at the positions around the 140th and the 300th baskets; while that of the big-eye tuna tells us that population is constituted of two schools located at the positions arouud the 200th and the 350th baskets to which a single individual hooked at the first lot is attached. Thus all individuals of the big-eye tuna, except an individual, are hooked in the common parts occupied by the schools of the yellow-fin tuna. Therefore, aggregative tendency must be a little clearly suspected in the correlation-diagram. But it is also expected that this tendency will be not so clear because no individual of the big-eye tuna is hooked in the parts where the other distinct school of the yellow-fin tuna and two obscure ones are hooked. And the actually obtained correlation-diagram takes the features coinciding well with the pattern forecasted from the above-mentioned preliminary consideration.

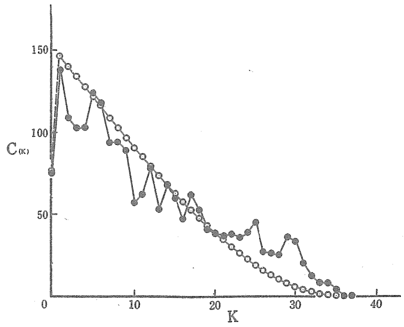


Fig. 27—Y B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 2, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

Example 2

Yellow-fin tuna—Big-eye tuna : The diagrams of the first series of the spacing analysis of both the yellow-fin tuna and the big-eye tuna show essentially the same patterns, which indicate that there are a school or isolated single-individual hooked at the position around the 50th basket and a group of schools, the center of which is spaced by a width as long as 250 baskets (= 50 km) or thereabout from the above-mentioned one. Accordingly, the tendency to form the common school or to occupy the common habitat should be suspected in the correlation-diagram. But the group of the yellow-fin tuna schools is clearly constituted of two schools spaced by a width as long as 50 baskets (= 10 km) each other. Therefore, another group of high observed-values in the correlation-diagram is expected to be observable at $k = 5$ or thereabout (unit = 10 consecutive baskets); this indicates the positional relation within the group of schools; besides, other groups of high observed-values are also expected to be observable around k = a little longer than 25 (unit = 10 consecutive baskets); they indicate the relation of positions of schools located at the position around the 50th basket between the groups of schools of each other's species located at the position around the 300th basket. But the general tendency of the observed-values in the correlation-diagram obtained actually shows the features coinciding well with the results of the preliminary consideration, except for the fact that the observed-values around $k = 0$ and 5 (unit = 10 consecutive baskets) exceed the adjoining ones but do not reach the theoretical-values. And this is thought to be, at least partly, due to the distribution pattern of the individuals of the yellow-fin tuna constituting the group of schools.

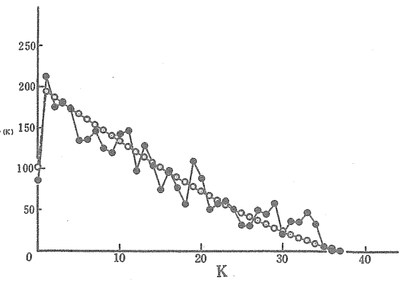


Fig. 27—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 2, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

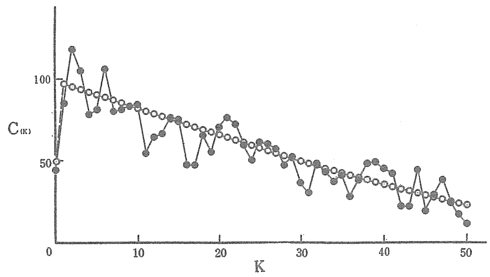


Fig. 27—Y A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 2, Series II : unit is 5 consecutive basket width = *ca.* 1 km).

Yellow-fin tuna—Albacore : The hooked-population of the albacore is constituted of three individuals aggregated at the position around the 20th basket and of a scattered school covering a space from the 170th to the 350th basket. Therefore, both species are superficially thought to be hooked in the same or the adjoining parts in a row. But the tendency of the deviations showing the aggregative relation is expected to be not so clear, because the albacore forms extremely scattered school; moreover, even if obtained, not so high significance can be given to it, because of the scarcity of the hooked-individuals of the albacore. And the observed-values in the correlation-diagram are expected to be strongly reflecting the relation of the positions of schools of the yellow-fin tuna between those of the individuals of the albacore, but not so clear relation can be expected because of many positions of respective species. Therefore, it is highly probable that the deviation of the observed-values in the correlation diagram reflects the relation of the positions of three individuals of the albacore aggregated densely and hooked at the position around the 20th basket between the positions of the schools of the yellow-fin tuna. The occurrence of most peaks of the observed-values in the correlation-diagram obtained actually can be explained from the above-mentioned reasons. But there are some other peaks observable at $k = 1$, 16 and 23, the occurrence of which is unable to be explained from the above-mentioned reasons and they are thought to reflect the relation of the positions of schools or individuals of the yellow-fin tuna and the individuals of the albacore forming a scattered school.

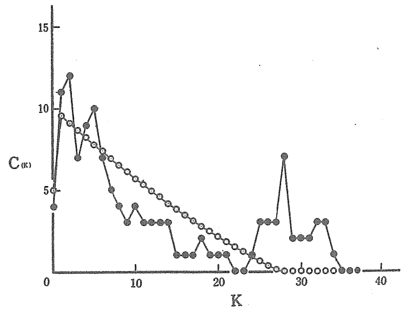


Fig. 27— B A — I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 2, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

Big-eye tuna—Albacore : Two schools of the big-eye tuna are hooked in the same parts covered by a scattered school of the albacore, especially overlapping the heavily-occupied parts and the centers of these big-eye tuna schools are spaced by a width as long as 50 baskets (= 10 km) each other. Besides, a single isolated-individual of the big-eye tuna is hooked in the basket not so apart from another school of the albacore constituted of three hooked-individuals aggregated densely. Accordingly, the observed-values in the correlation-diagram in the range from $k = 0$ to 2 or 3 and around 5 (unit = 10 consecutive baskets) are easily expected to exceed the theoretical-values; this means that the individuals of both species are inclined to form the common schools or to take the common habitat. Besides, an albacore school located at the position around the 20th basket is spaced by a little longer width than 300 baskets (= 60 km) from two schools of the big-eye tuna, while a single individual of the big-eye tuna hooked at the position around the 50th basket is spaced by a width a little shorter than 300 baskets (= 60 km) from another school of the albacore constituted of scattered individuals. Therefore, high observed-values in the correlation-diagram are expected to be observable around $k = 30$. Taking these results of preliminary consideration, I examined the actually obtained correlation-diagram, but no fact else than that expected preliminarily could be found out.

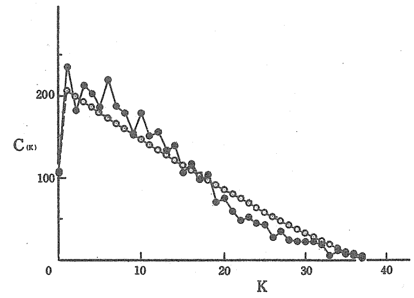


Fig. 28—Y B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 3, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

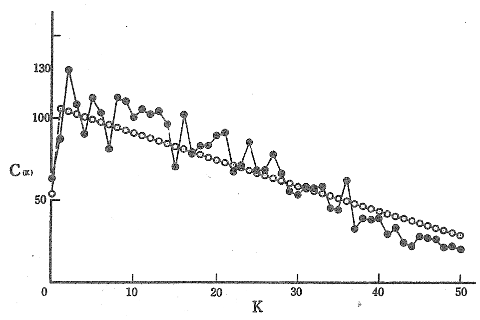


Fig. 28—Y B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 3, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

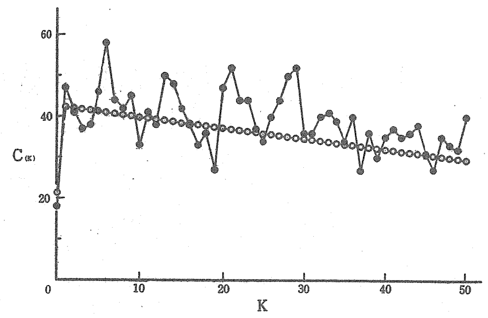


Fig. 28—Y B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 3, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

Example 3

Yellow-fin tuna—Big-eye tuna : The yellow-fin tuna constitutes a single wide-school covering a space from the 140th to the 315th basket. But the individuals of the big-eye tuna seem to scatter rather self-spacingly throughout a row. Accordingly, the correlation-diagram is expected to show the similar feature to the spacing-diagram of the yellow-fin tuna, *i.e.*, the correlation-diagram is expected to indicate that the pairs of the individuals, one of which is the individual of the yellow-fin tuna and the other is the big-eye tuna spaced by a width from 0 to as long as the width of the yellow-fin tuna school [315 − 140 = 175 baskets (= 35 km)], are more frequently observable than expected from independent distribution. And the actually obtained correlation-diagram takes the features coinciding quite with the pattern assumed theoretically.

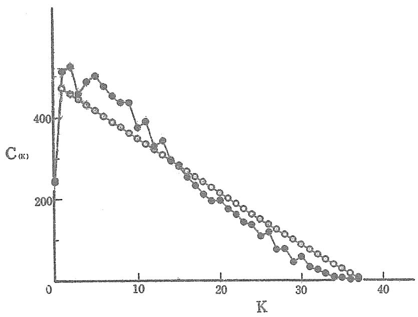


Fig. 28—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

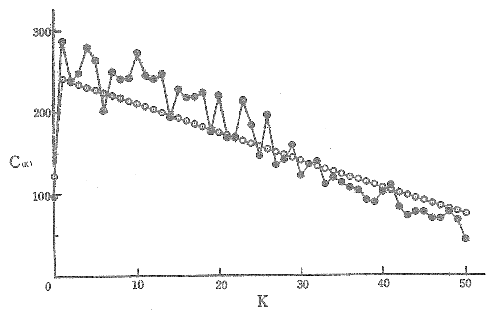


Fig. 28—Y A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

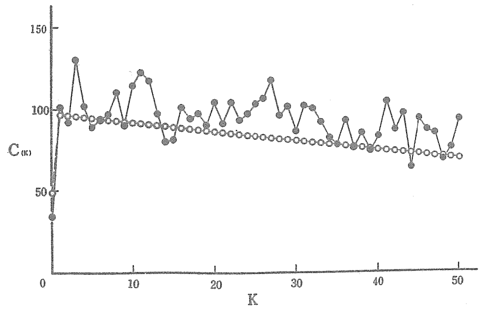


Fig. 28—Y A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

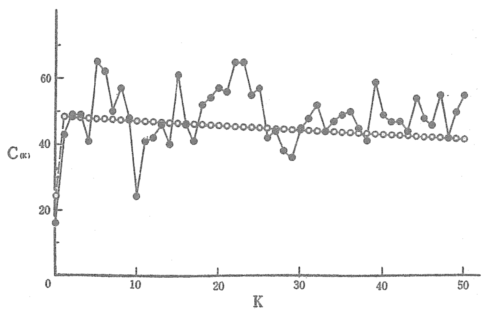


Fig. 28—Y A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

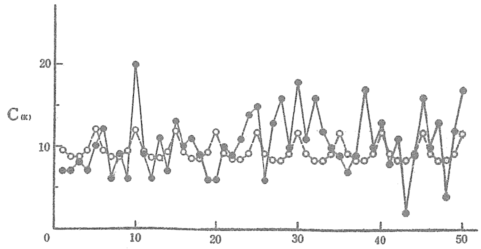


Fig. 28—Y A—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series Ⅴ : unit is one hook-interval width=*ca.* 40 m).

Yellow-fin tuna—Albacore : The hooked-individuals of the albacore also form a single school scattered widely. Therefore, the observed-values in the correlation-diagram in the range corresponding to the width of the overlapping part of the schools of both species are expected to exceed the theoretical-values continuously and distinctly, while those of the rests of them decrease at first gradually then sharply with increase in k and take the values lower than the theoretical ones. And the actually obtained correlation-diagram does not show any other pattern than that assumed, except for the fact that less individuals of each species than expected are hooked by the hooks spaced by the width shorter than a basket (= 0.2 km) from any hook occupied by the individual of other species.

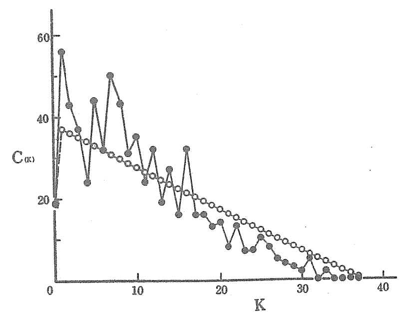


Fig. 28—B A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

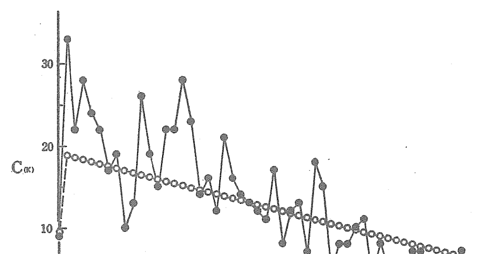


Fig. 28—B A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

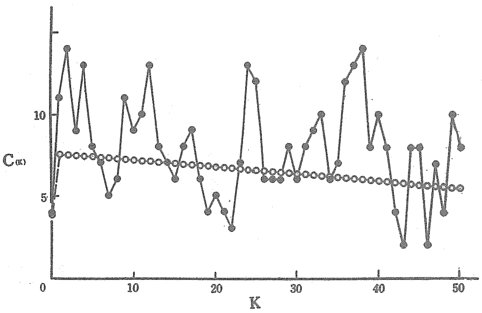


Fig. 28—B A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 3, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

Big-eye tuna—Albacore : As mentioned above, the hooked-individuals of the albacore, to see generally, form a single school, against the fact that the hooked-individuals of the big-eye tuna are scattered self-spacingly. Therefore, the correlation-diagram is preliminarily expected to show the similar pattern to that between the yellow-fin tuna and the big-eye tuna of this example. And the actually obtained correlation-diagram shows that both species have no special relation except those easily assumable from the distribution patterns of both species.

Example 4

Yellow-fin tuna—Big-eye tuna : The hooked-individuals of the yellow-fin tuna are scattered throughout a whole row of gears, in which heavily-occupied lots are distributed showing a little irregular four-lot periodicity. But the hooked-individuals of the big-eye tuna clearly form five schools, although the population sizes of the schools

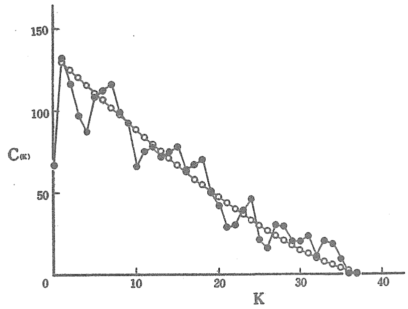


Fig. 29—Y B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 4, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

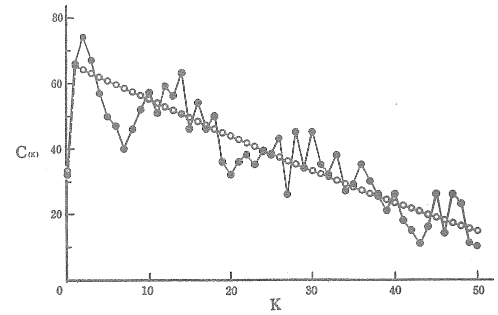


Fig. 29—Y B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 4, Series Ⅱ : unit is 5 consecutive basket width = *ca.* 1 km).

other than that located at the hindmost part are not so large. Accordingly, the correlation-diagram is expected to show emphasizing the same tendency of the deviations as the spacing-diagram of the subordinate species having the clear structure, the big-eye tuna. Taking this fact into consideration, I examined the actually obtained correlation-diagram, but no symptom suggesting any other relation worthy to be described was found out except the high observed-value at $k = 33$, which showed the relation of the hooked-individuals near the both terminal parts of a row and was thought to have not so high significance.

Yellow-fin tuna—Albacore : Like the big-eye tuna, the hooked-individuals of the albacore also clearly form several schools. Accordingly, the same fact as mentioned above is expected. And this is supported by the peaks observable at $k = 6$, around 13, 19, around 25 and 32. But the correlation-diagram obtained actually adds another fact than those expected preliminarily, *i.e.*, the individuals of both species are so repulsively distributed that, to see generally, only less individuals than expected are hooked in the lots spaced by a width shorter than six lots from any occupied one

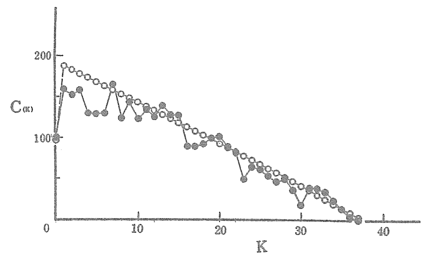


Fig. 29—Y A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 4, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

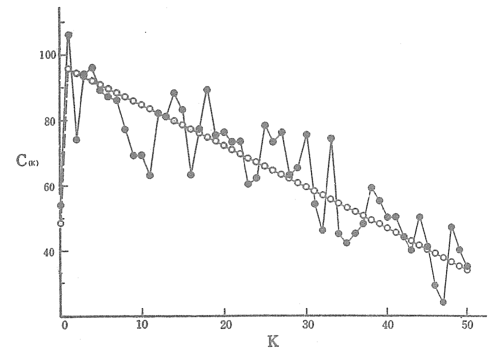


Fig. 29—Y A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 4, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

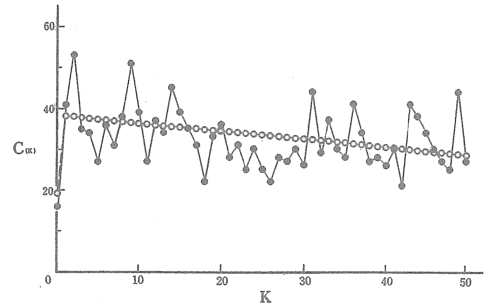


Fig. 29—Y A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 4, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

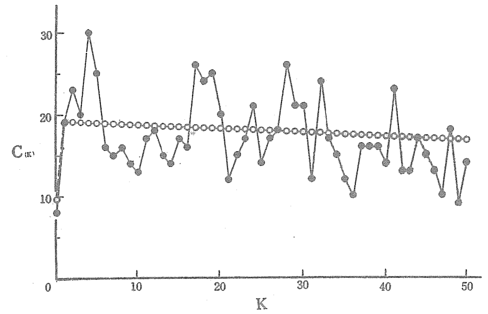


Fig. 29—Y A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 4, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

by the individuals of each other's species, although as many individuals as expected, when the individuals of both species are distributed independently, are hooked by the same lots occupied by the individuals of each other's species.

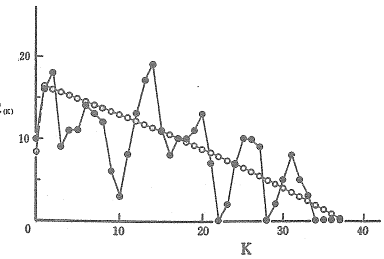


Fig. 29—B A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 4, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

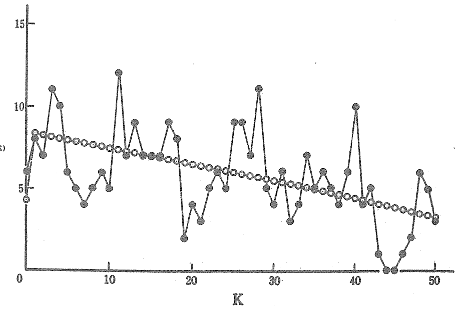


Fig. 29—B A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 4, Series II : unit is 5 consecutive basket width = *ca.* 1 km).

Big-eye tuna—Albacore : As already mentioned above, the hooked-individuals of the big-eye tuna clearly form five schools, but the correlation-diagram is expected to be inclined to show the positional relation of schools of the albacore between the school of the big-eye tuna located at the position around the 350th basket, *i.e.*, the peaks of the observed-values are expected to be found at k = 0, 10, 20, 25 and 31, because the population sizes of all schools of the big-eye tuna other than that located at the hindmost part are extremely small. But, in the actually obtained correlation-diagram, one more peak is observable around k = 6 ∼ 8, although this does not exceed the theoretical-values. And this group of high observed-values is expected to represent the relation of positions of the schools of the albacore between some other schools of the big-eye tuna. And the symptom supporting it is easily found out from the positions of the schools shown in Figs. 9—B and 9—A. Besides, no symptom suggesting the presence of any other structure can be found out, because of clear school-formation of the hooked-individuals of both species.

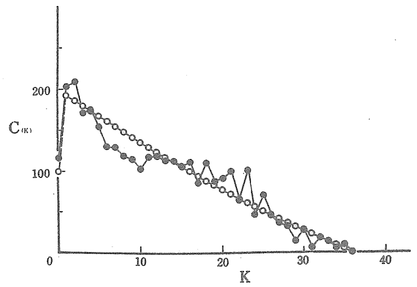


Fig. 30—Y B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 5, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

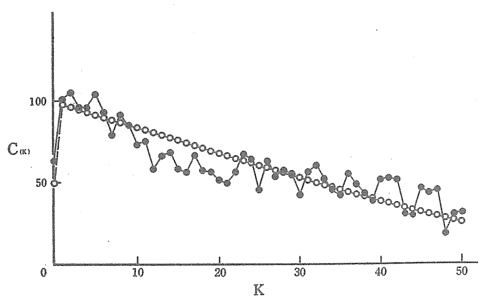


Fig. 30—Y B—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 5, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

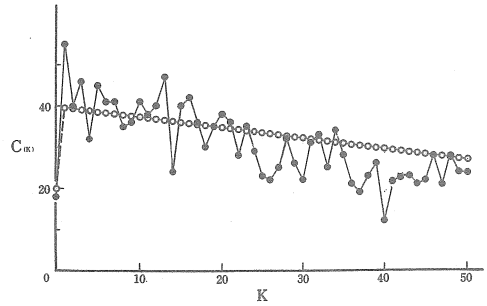


Fig. 30—Y B—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 5, Series III : unit is 2 consecutive basket width= *ca.* 0.4 km).

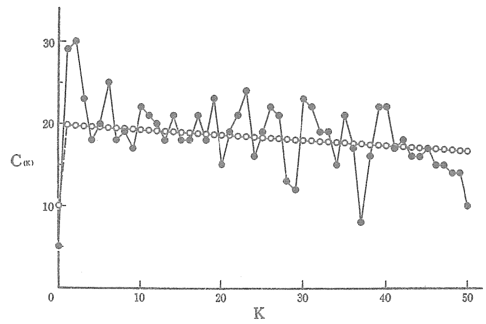


Fig. 30—Y B—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

Example 5

Yellow-fin tuna—Big-eye tuna : Taking the influence of the strong gradient of the distribution into consideration, I found that the hooked-individuals of the yellow-fin tuna seemed to contain two schools, the centers of which were located at the positions around the 100th and the 350th baskets respectively, the latter of which was constituted of many individuals and covering a wider range than the former; while generally speaking, the hooked-individuals of the big-eye tuna formed a scattered school covering a space as wide as 250 baskets (= 50 km). And examining the actually obtained correlation-diagram, I found that the both terminal parts of the school of the big-eye tuna were overlapping the schools of the yellow-fin tuna and the distance between the overlapping parts was estimated to be 200 baskets (= 40 km). And the following series of analyses are added for the purpose of finding out the relation of the positions within the overlapping parts, although significance of the pattern suggested from these series of analyses is somewhat doubtful. These diagrams show that more individuals are hooked by the hooks spaced by a width shorter than three or four baskets (0.6 ~ 0.8 km) from any occupied hook by the individual of each other's species, *i.e.*, the hooked-individuals of both species are inclined to take the same micro-habitats or to form the common clusters of the subordinate orders.

Yellow-fin tuna—Albacore : Relatively many individuals of the albacore are hooked, and the most of the hooked-individuals form a single school scattered widely and covering a space from the 80th to the 240th basket. Accordingly, the correlation-diagram is expected preliminarily to represent that the schools of both species are not distributed overlapping each other but the heavily-occupied parts by the individuals of each other's species are spaced by a width from 50 to 170 baskets or thereabout (10 ~34 km), that is to say in short, the individuals of both species are repulsively distributed. And well coincident patterns with the above-mentioned preliminary consideration is represented in the actually obtained correlation-diagram.

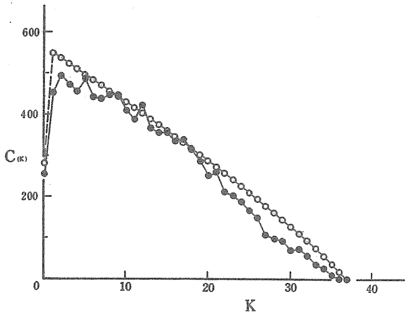


Fig. 30—Y A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

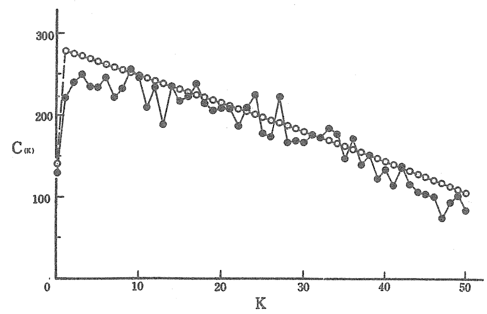


Fig. 30—Y A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

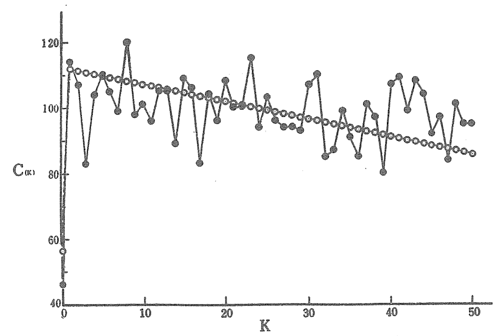


Fig. 30—Y A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

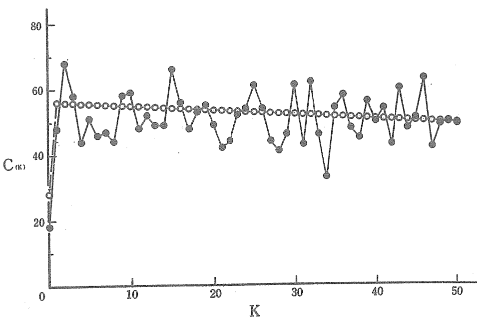


Fig. 30—Y A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

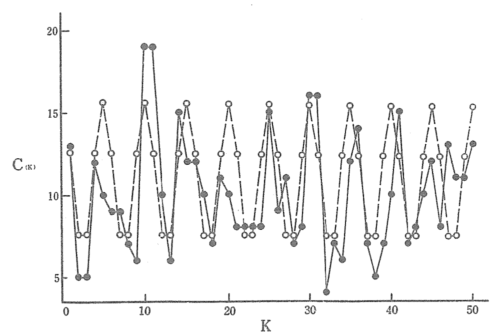


Fig. 30—Y A—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅴ : unit is one hook-interval width= *ca.* 40 m).

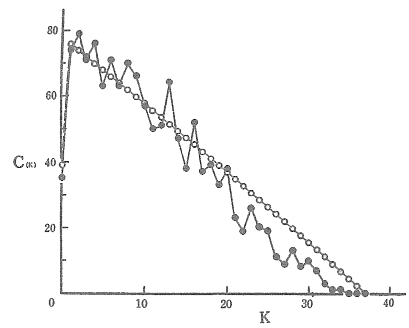


Fig. 30—B A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

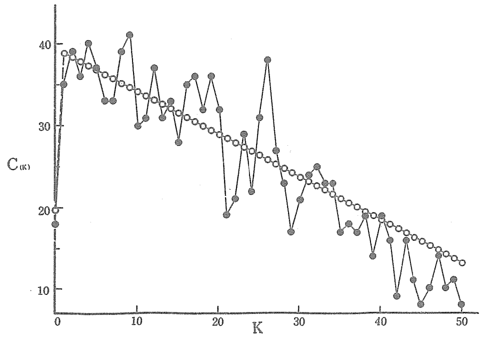


Fig. 30— B A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

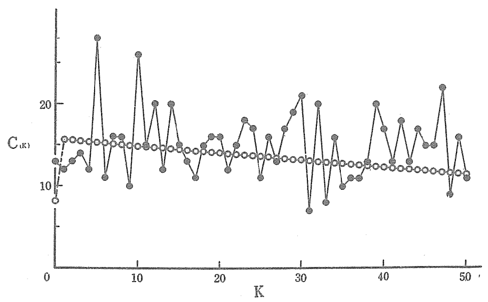


Fig. 30— B A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

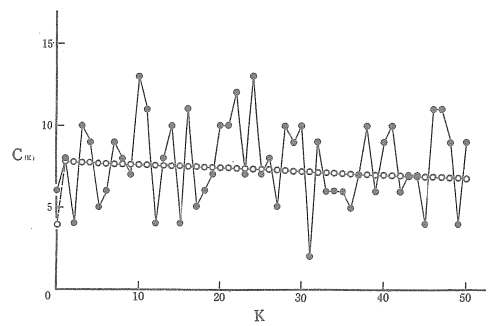


Fig. 30— B A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 5, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

Big-eye tuna—Albacore : Not so many individuals as expected from independent distribution are hooked by the same or adjoining lots (lot = 10 consecutive baskets) occupied by the individuals of each other's species; this fact alludes to the repulsive relation between both species affecting in a short range; while aggregative relation affecting to the long range is suggested from the continuously high general-tendency of the observed-values and this is thought to be caused as the results of schooling-tendency of the individuals of the albacore, because the big-eye tuna is scattered in a wider range than the albacore.

Example 6

Yellow-fin tuna—Big-eye tuna : To see generally, the yellow-fin tuna forms two schools located at the ranges respectively from the 85th to the 135th basket and from

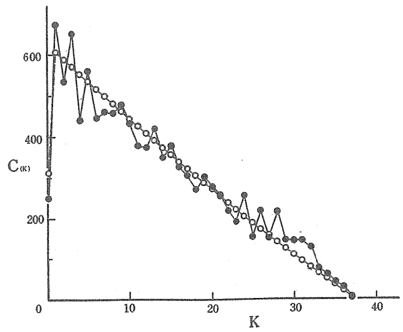


Fig. 31—Y B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅰ : unit is 10 consecutive basket width = *ca.* 2 km).

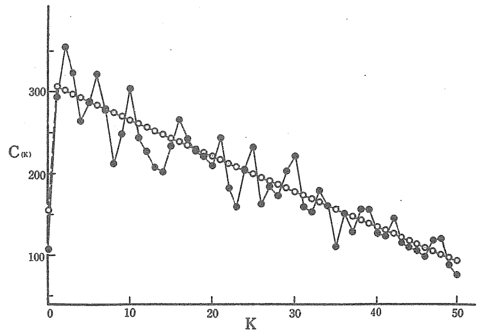


Fig. 31—Y B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅱ : unit is 5 consecutive basket width = *ca.* 1 km).

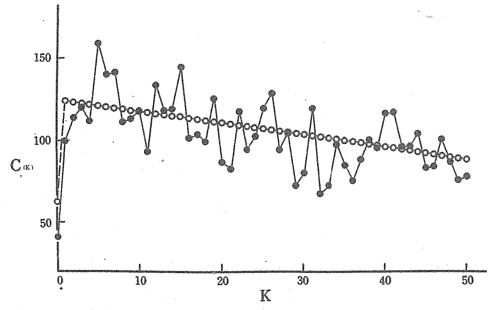


Fig. 31—Y B—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 6, Series III : unit is 2 consecutive basket width= *ca.* 0.4 km).

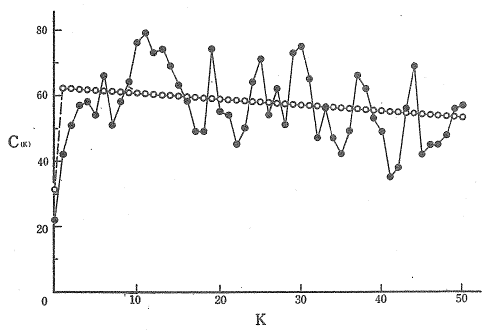


Fig. 31—Y B—IV. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 6, Series IV : unit is 1 basket width=*ca.* 0.2 km).

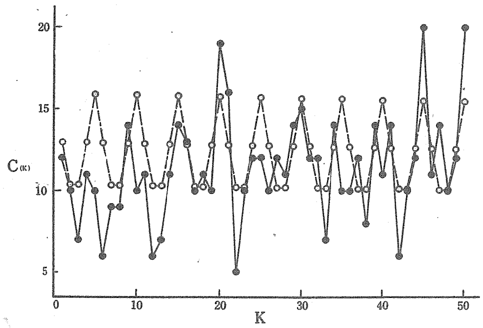


Fig. 31—Y B—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 6, Series V : unit is one hook-interval width=*ca.* 40 m).

the 275th to the 360th one; while the hooked-individuals of the big-eye tuna form also two schools respectively located at the ranges from the first to the 60th basket and from the 200th to the hindmost one. Accordingly, the observed-values of the correlation-diagram in the range from $k = 0$ to 5 or thereabout are expected to exceed slightly the estimated ones. Besides them, on the positions of the schools, the observed-values around $k = 13$ and 28 are also expected to be higher than the estimated ones. On the other hand, two-lot periodicity is suggested in the distribution pattern of the hooked-individuals of the yellow-fin tuna while strong periodicity of four-lot width and a little weak two-lot one are clearly observable in the distribution pattern of the hooked-individuals of the big-eye tuna. Therefore, the observed-values in the correlation-diagram are also expected to show two-lot periodicity. And examining on the actually obtained correlation-diagram, I found that the deviations of the observed-values showed quite the same features as the expected ones, except the fact that the expectant high observed-values around $k = 13$ were not so distinct. And this difference is thought to be due to the structure of the subordinate orders of respective species. Then, for the purpose of confirming the structures in the projected distribution pattern causing this difference, whether the individuals of the big-eye tuna are hooked in the parts spaced by a width as long as 13 lots (= 25 km) from any part occupied heavily by the individuals of the yellow-fin tuna or not is examined. And I found that only as many as a half of the assumed positions were occupied heavily by the individuals of the big-eye tuna. The following series of the correlation-diagrams add the information about the spatial relation within a short range, and they suggest that less individuals than expected are hooked in the baskets spaced by an interval shorter than 10 baskets (= 2 km) from any occupied basket by the individuals of each other's species.

Yellow-fin tuna—Albacore : A school of the albacore covers a space from the 40th to the 240th basket. Accordingly, one of the yellow-fin tuna school located in the

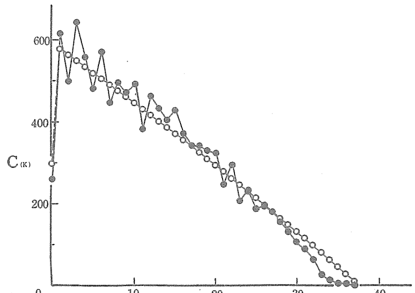


Fig. 31—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

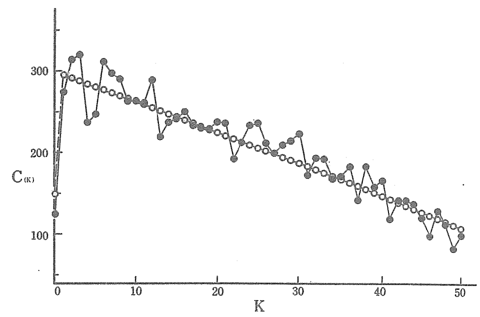


Fig. 31—Y A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

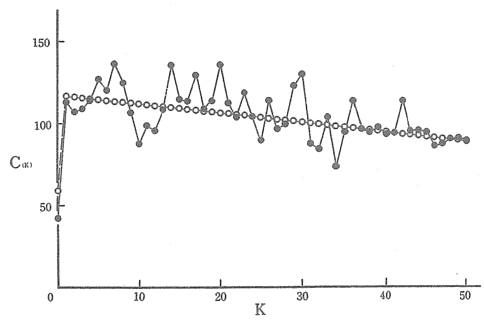


Fig. 31—Y A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

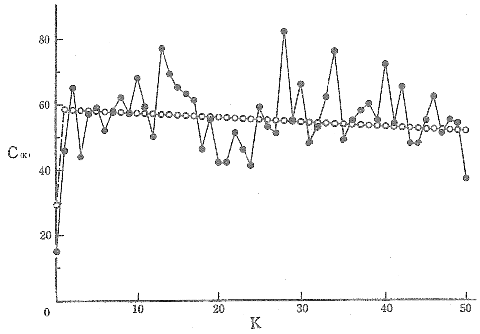


Fig. 31—Y A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

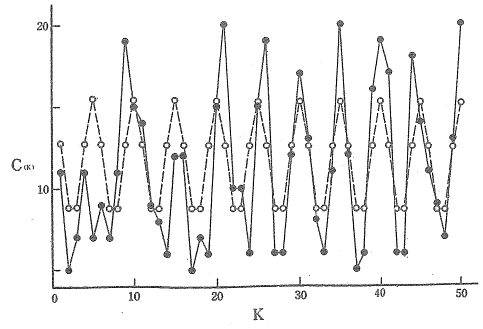


Fig. 31—Y A—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series V : unit is one hook-interval width=*ca.* 40 m).

range from the 85th to the 135th basket is hooked in the common part covered by the school of the albacore, while the other school of the yellow-fin tuna is hooked out of the school of the albacore. These facts are expected to raise the observed-values in the range from $k = 0$ to 5. Moreover, the following facts are deduced out from the relation between the positions of the schools of each other's species: 1) let us consider the parts spaced by k towards the same direction as the hauling from the school of the yellow-fin tuna located in the range from the 85th to the 135th basket. When $0 < k < 10$, all the parts are covered by the school of the albacore; while when $10 < k < 15$, some parts; but when $15 < k$, no part is located in it. 2) And let us consider the similar parts from the other school of the yellow-fin tuna located in the range from the 275th to the 360th basket. No part is put in the school of the albacore regardless of k. 3) But let us consider the parts spaced by k towards the counter direction to the hauling from the school of the yellow-fin tuna hooked in the range from the 85th to the 135th basket. When $0 < k < 4$, all the parts are covered by the school of the albacore; when $4 < k < 10$, only a part is located in it; while when $10 < k$, no part is put in it. And 4) let us consider the similar parts from the other school of the yellow-fin tuna located in the range from the 275th to the 360th basket. When $0 < k < 4$, no part is put in the school of the albacore, but when $4 < k < 12$, only a part; when $12 < k < 20$, whole part; while when $20 < k < 32$, some parts are put in the school of the albacore; while when $32 < k$, no part is put in it. Therefore, the observed-values in the range from $k = 0$ to 20 or thereabout are expected to exceed the theoretical-values, then they decrease more sharply than the theoretical-values. But some short-periodic deviations are also expected, because in company with the facts easily assumable from the above-mentioned descriptions the individuals of the yellow-fin tuna are not distributed uniformly throughout the parts covered by the schools of the yellow-fin tuna. And the actually obtained correlation-diagram of Series I reveals that the deviations of the observed-values in this diagram are fearly explained from the above-mentioned prediction.

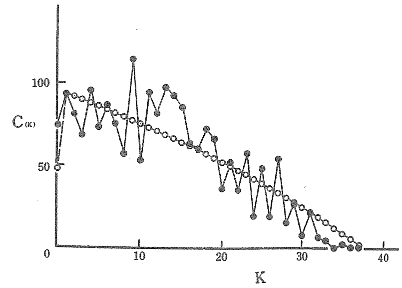


Fig. 31—B A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

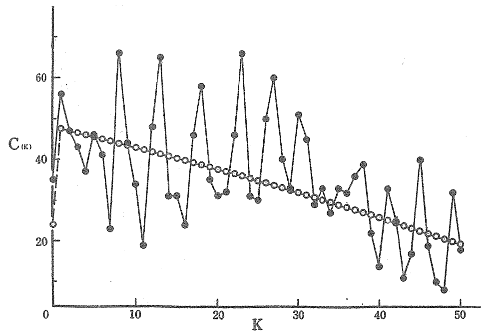


Fig. 31—B A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

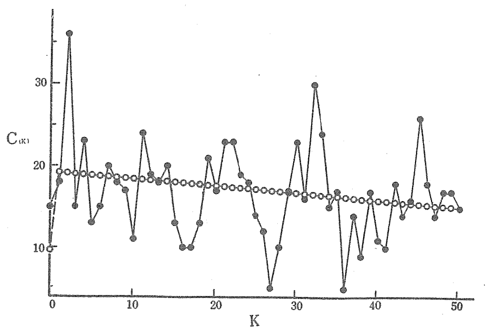


Fig. 31—B A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

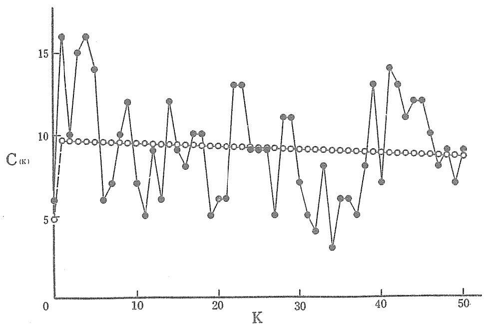


Fig. 31—B A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

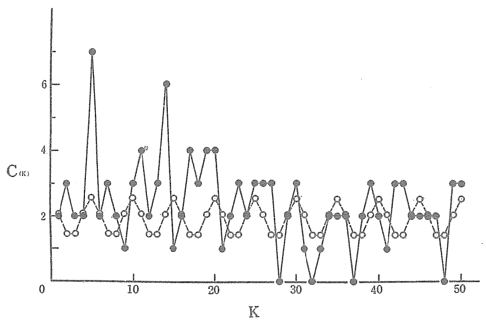


Fig. 31—B A—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 6, Series Ⅴ : unit is one hook-interval width=*ca.* 40 m).

Big-eye tuna—Albacore : As mentioned above, the schools of the big-eye tuna cover the spaces from the first to the 60th basket and from the 200th to the hindmost one, while the school of the albacore covers a space from the 40th to the 240th basket. Accordingly, the correlation-diagram is expected to show clearly repulsive relation. And the actually obtained correlation-diagram shows the features coinciding well with this prediction. Besides the general tendency, the observed-values, including those of the following series, deviate severely showing short periodicity. And these deviations are thought to indicate the relation of the positions of the narrow but heavily-occupied parts and are chiefly due to the scarcity of the hooked-individuals of respective species and partly to the fact that both species show rather distinct periodicity of deviations.

Example 7

Yellow-fin tuna—Big-eye tuna : The hooked population of the yellow-fin tuna of

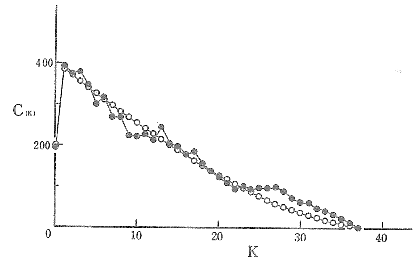


Fig. 32—Y B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 7, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

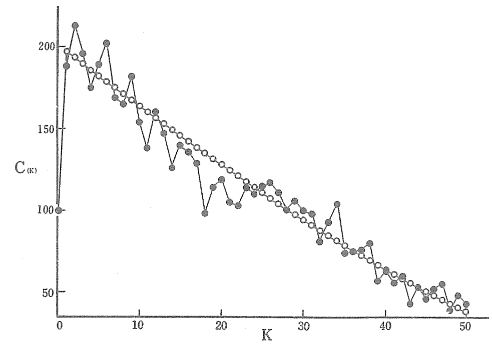


Fig. 32—Y B—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 7, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

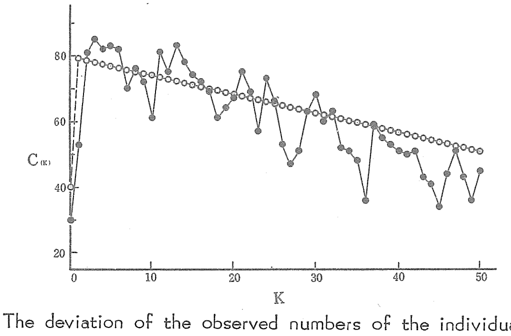


Fig. 32—Y B—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 7, Series III : unit is 2 consecutive basket width= *ca.* 0.4 km).

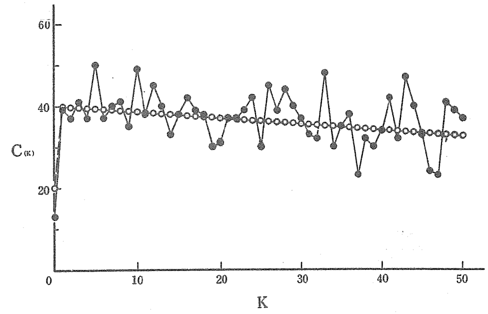


Fig. 32—Y B—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅳ : unit is 1 basket width = *ca.* 0.2 km).

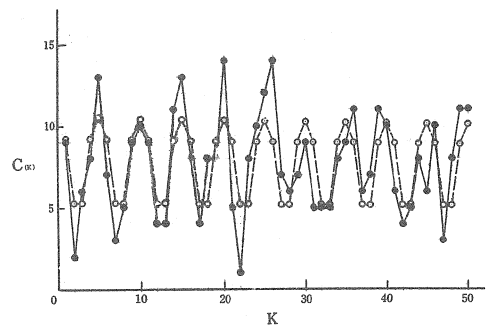


Fig. 32—Y B—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅴ : unit is one hook-interval width = *ca.* 40 m).

this example contains three schools hooked respectively at the positions around the 50th, the 200th and the 350th baskets, of which the second one is constituted of the largest population; while the hooked population of the big-eye tuna contains two schools and the most heavily-occupied parts in respective schools are the 100th and the 300th baskets. Therefore, the intervals between the schools of each other's species are expected to take 50, 100 and 250 baskets (= 10,20 and 50 km). But each of the schools covers a space wider than 50 baskets (= 10 km); accordingly, some parts of the schools of each other's species are overlapping. Therefore, high observed-values are expected to occur in the range from $k = 0$ to 5 lots (lot = 10 consecutive baskets) or longer, but there is no school of the big-eye tuna located at the position around the 200th basket, where the largest school of the yellow-fin tuna is hooked. Consequently, the above-mentioned group of the observed-values is expected to exceed not so largely or sometimes is afraid to be not exceeding the theoretical ones. And the deviations coinciding well with the above-mentioned predictions are found out in the actually obtained correlation-diagram in the range from $k = 0$ to 7. The assumable high observed-values in the correlation-diagram around $k = 10$ lots are thought to be derived from the largest school of the yellow-fin tuna. But this group of high observed-values is expected to be not so strongly exceeding while covering a wide range of k, because all of the three schools causing this group of high observed-values (a school of the yellow-fin tuna and two schools of the big-eye tuna) are widely dispersed. These estimations are also coincident well with the deviations of the observed-values in the correlation-diagram obtained actually. And two pairs of schools each constituted of different species, the school of the yellow-fin tuna located at the position around the 50th basket——the big-eye tuna one around the 300th basket and a school of the yellow-fin tuna around the 350th basket —— the big-eye tuna one around the 100th basket, are expected to cause a group of high observed-values around $k = 25$. And this group is also expected to cover a wide range, because a school of the big-eye tuna in the former pair and a school of the yellow-fin tuna in the latter pair are widely dispersed. The deviation of the observed-values in the actually obtained correlation-diagram supporting this is clearly observable, but the observed deviation seems to be somewhat severer than the assumed one. And no symptom suggesting any other structure is observable in the correlation-diagram obtained actually.

Yellow-fin tuna—Albacore : The largest school of the albacore is hooked at the position around the 50th basket and the second one is at the position around the 250th basket, while the smallest one is at the position around the 150th basket. Accordingly, the parts around the 50th basket are occupied by the schools of both species, although a school of the yellow-fin tuna hooked there is not so large. And this fact is represented in the correlation-diagram as the slightly high observed-values in the range from $k = 0$ to 2; but examining the relation more in detail by the aids of the following series of analyses, I found that the individuals were not so frequently hooked in the same or adjoining baskets but frequently hooked in the baskets spaced by three baskets (= 0.6 km) from any occupied one by the individual of each other's

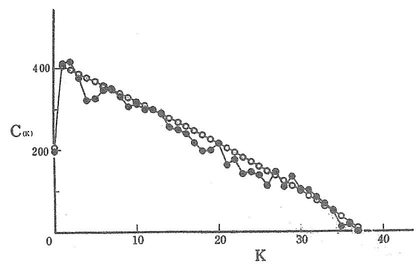


Fig. 32—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

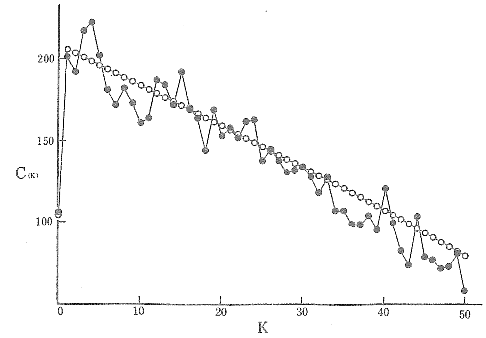


Fig. 32—Y A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

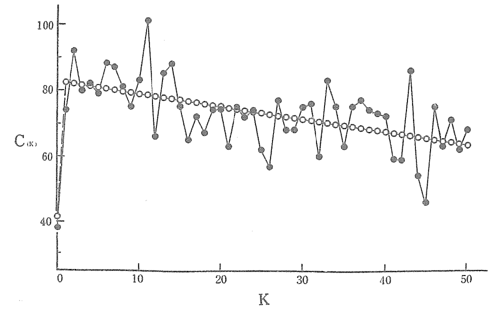


Fig. 32—Y A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

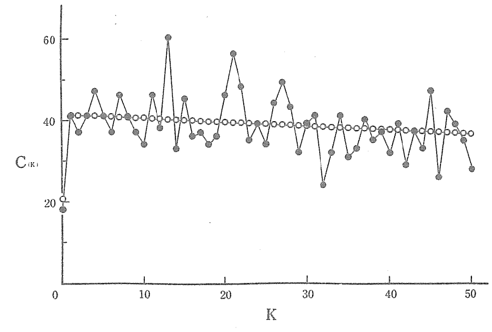


Fig. 32—Y A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

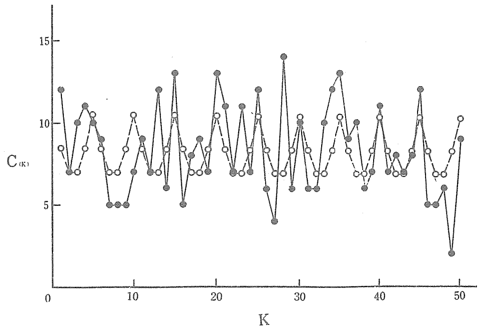


Fig. 32—Y A—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅴ : unit is one hook-interval width=*ca.* 40 m).

species. On the other hand, the centers of the schools of each other's species are spaced by 50, 100, 150, 200 and 300 baskets (= 10, 20, 30, 40 and 60 km), *i.e.*, nearly each 50-basket interval (10 km); but each of the expectant peak is supposed to be not discontinuous but successive, owing to being influenced by the fact that when k is increased into the width, which combinations of the individuals of the yellow-fin tuna and the big-eye tuna from a certain pair of the schools begin to decrease, combinations from other pairs of the schools begin to appear, because the schools of the yellow-fin tuna cover wide ranges. Therefore, the correlation-diagram is expected to show such a pattern that the individuals of both species are distributed independently of each other's species. And no remarkable relation other than that assumed preliminarily is observable from the correlation-diagram obtained actually.

Big-eye tuna——Albacore : The distribution patterns of both species suggest that the heavily-occupied parts by the individuals of each other's species are frequently spaced

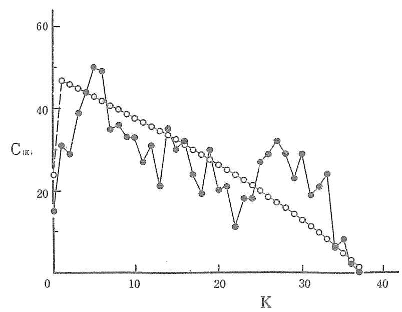


Fig. 32—B A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅰ : unit is 10 consecutive basket width= *ca.* 2 km).

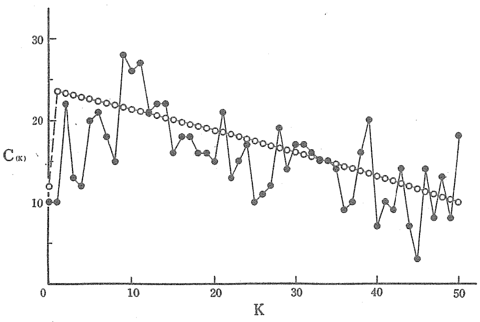


Fig. 32—B A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

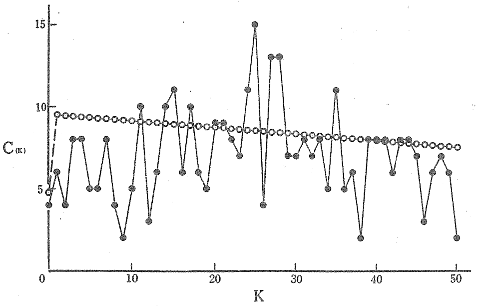


Fig. 32—B A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

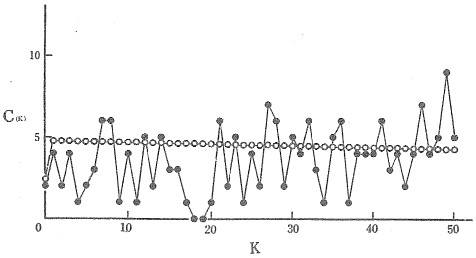


Fig. 32—B A—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

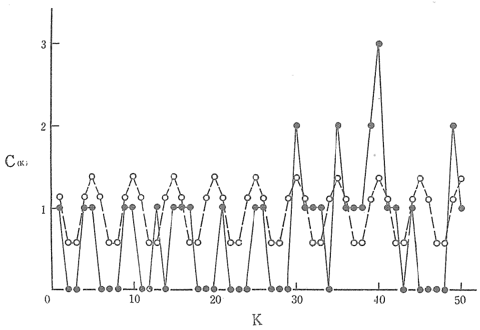


Fig. 32—B A—V. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 7, Series V : unit is one hook-interval width=*ca.* 40 m).

by 5 and 15 lots (10 and 30 km), consequently groups of rather high observed-values in the correlation-diagram are expected to be observable at $k = 5$ and around 15 lots; while the most heavily-occupied part by the individuals of the big-eye tuna is located at the position around the 50th basket; this is expected to cause a group of the observed-values around $k = 25$ exceeding largely the corresponding estimated ones. And no fact worthy to be described newly is deducible from the actually obtained correlation-diagram, except the fact easily assumable from the distribution patterns of respective species. And it may well be said, as the conclusion of the relation between the hooked positions of both species in this example, that the individuals of both species are hooked not at the same parts but in the adjoining ones.

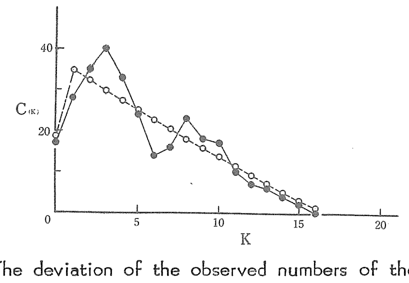


Fig. 33—Y B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 8, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

Example 8

Yellow-fin tuna——Big-eye tuna : The extreme scarcity of the hooked-individuals of the big-eye tuna does not allow me to give so high significance upon the facts deducible from the correlation-diagram, despite of the fact that the correlation-diagram rather clearly shows that, as assumable from the distribution patterns of both species, relatively many individuals are hooked in the lots spaced by a width as long as 3 or 8 lots (6 or 16 km) from any lot occupied heavily by the individuals of each other's species.

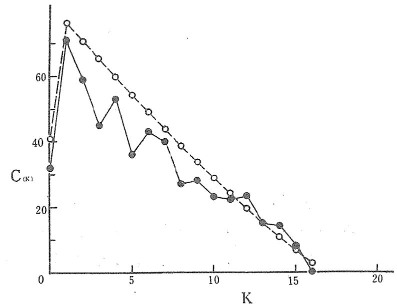


Fig. 33—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 8, Series I : unit is 10 consecutive basket width= *ca.* 2 km).

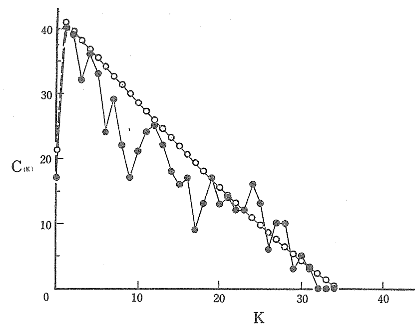


Fig. 33—Y A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 8, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

Yellow-fin tuna——Albacore : A slight but widely affecting repulsive tendency is suggested. And the continuously lower observed-values support to give some significance; while the small difference in the observed-values from the estimated ones and the scarcity of the hooked-individuals of the albacore do not accept to give so high significance as to be impressed simply from the magnitude of the observed-values and the estimated ones.

Big-eye tuna——Albacore : Some patterns may seem to be deducible but the scarcity of the hooked-individuals of both species introduces the unnegligible influence of

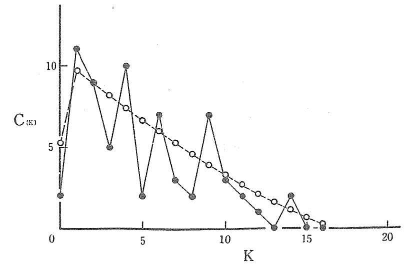


Fig. 33—B A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 8, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

accidental error and no significance can be given to the deduced facts.

Example 9

This example is not suitable for the analyses on the correlations of the hooked positions between the individuals of the different species, because the extreme scarcity of the hooked-individuals of the albacore makes it impossible to give any consideration upon the correlation between the hooked positions of the albacore and those of the others; moreover it is also hard to get any correlation-diagram free from the severe influence of accidental error, because not so many individuals of the big-eye tuna are hooked.

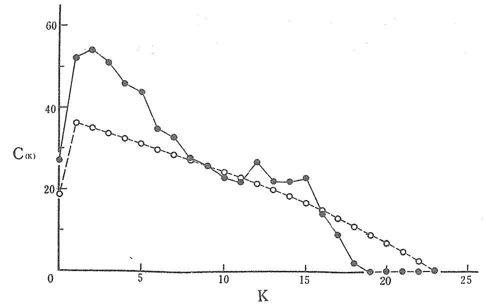


Fig. 34—Y B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 9, Series I : unit is 10 consecutive basket width = *ca.* 2 km).

Yellow-fin tuna——Big-eye tuna : The hooked population of the yellow-fin tuna contains two schools; while the catch of the big-eye tuna is constituted of a single school to which an individual spaced by *ca.* 70 baskets (= 15 km) is attached. Accordingly, a school of the yellow-fin tuna occupies the common habitat or forms the common school with the big-eye tuna, while almost no individual of the big-eye tuna is hooked in the part where the other school of the yellow-fin tuna is hooked. But the actually obtained correlation-diagram adds such an information about the correlation of the hooked positions that the individuals of the big-eye tuna are not uniformly distributed in the school and the center of the distribution of the big-eye tuna is biased a width as long as 40 baskets (= 8 km) from that of a school of the yellow-fin tuna.

Example 10

Yellow-fin tuna——Big-eye tuna : Most of the hooked-individuals of the yellow-fin tuna are distributed forming three schools respectively located at the positions around the 210th, the 270th and the 345th baskets; while the hooked-individuals of the big-eye tuna are scattered all over a row, but they are rather densely hooked

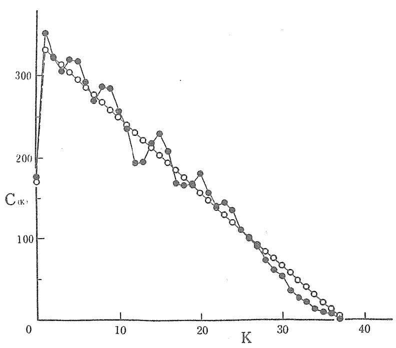


Fig. 35—Y B—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 10, Series I : unit is 10 consecutive basket width $= ca.$ 2 km).

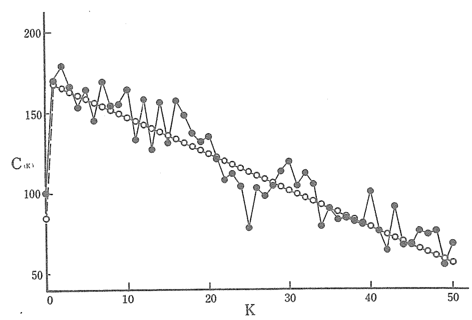


Fig. 35—Y B—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 10, Series II : unit is 5 consecutive basket width = *ca.* 1 km).

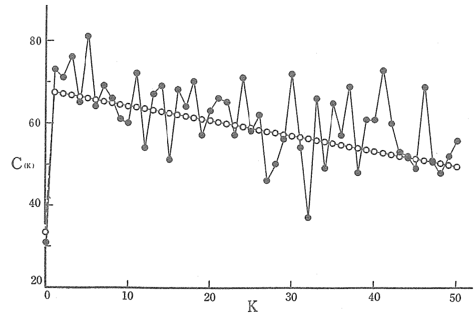


Fig. 35—Y B—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 10, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

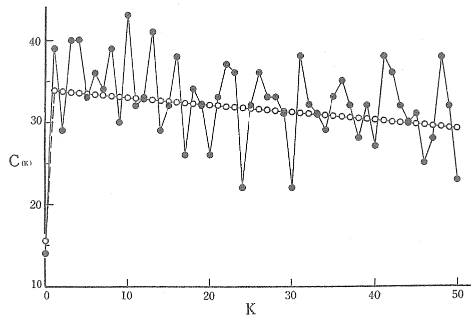


Fig. 35—Y B—Ⅳ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 10, Series Ⅳ : unit is 1 basket width=*ca.* 0.2 km).

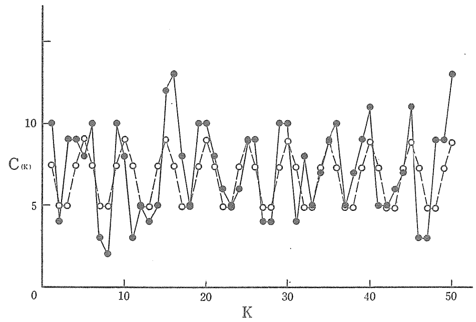


Fig. 35—Y B—Ⅴ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 10, Series Ⅴ : unit is one hook-interval width=*ca.* 40 m).

in the ranges from the 10th to the 125th and from the 230th to the hindmost basket, especially dense population is observable at the positions around the 65th, the 115th and the range from the 270th to the 305th basket. Therefore, a school of the yellow-fin tuna is hooked in the lots occupied heavily by the individuals of the big-eye tuna, and another school of the yellow-fin tuna is hooked in the lots where the individuals of the big-eye tuna are a little densely hooked, while the other school of the yellow-fin tuna is located between two groups of heavily-occupied lots by the individuals of the big-eye tuna. Accordingly, the observed-values in the correlation-diagram in the range from $k=0$ to 2, which is the range of the observed-values in the spacing-diagram of the yellow-fin tuna exceeding the estimated-values and is thought to be the average width of the yellow-fin tuna schools, are also expected to exceed the estimated ones. Next, from the positions of the schools or heavily-occupied parts by the individuals of respective species, the observed-values at $k=5$, 9, 15, about 20, 23 and 28 are expected to show higher values. And the actually obtained correlation-diagram shows quite coinciding pattern with the above-mentioned prediction, except that any symptom supporting the occurrence in the expectant high observed-value at $k=28$ can not be found out. And this difference is thought to be due to the fact that, when the gradient is taken into consideration, the schooling tendency of the yellow-fin tuna school located at the position around the 345th basket can not be regarded to be so strong. And the correlation-diagrams, not only that of Series I but also including the following series, are examined more in detail, yet no symptom suggesting any other structure worthy to be described is found out except the short-periodic deviation to which we can not give so high significance.

Yellow-fin tuna——Albacore : The hooked-individuals of the albacore are distributed forming three schools located at the positions respectively around the 45th basket, in the ranges from the 110th to the 175th basket and from the 265th to the 300th basket. Therefore, the observed-values in the correlation-diagram in the range from $k=0$ to

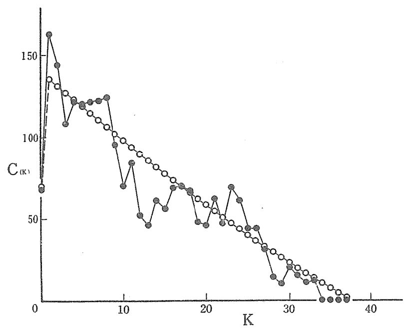


Fig. 35—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 10, Series I : unit is 10 consecutive basket width $=ca.$ 2 km).

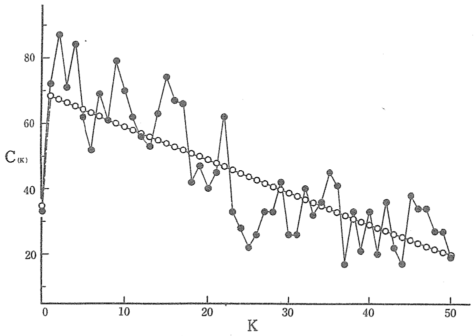


Fig. 35—Y A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 10, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

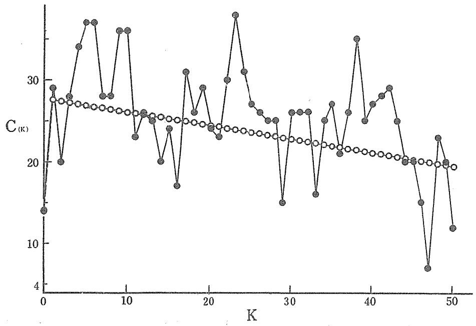


Fig. 35—Y A—Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 10, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

2, which is thought to be the width of the yellow-fin tuna school, are expected to exceed the theoretical-values. And from the positions of the centers of the schools of respective species, the observed-values at k = 7, 13, 17, 21, 23 and 30 in the correlation-diagram are expected to exceed the theoretical ones; and also the width of each group of high observed-values is expected to be wide, because each school of the albacore covers a space nearly as wide as the interval between the adjoining centers of the schools of the yellow-fin tuna, moreover some differences in the positions showing high observed-values in the correlation-diagram from the above-mentioned k are expected. Keeping these results of the prediction in mind, we examined the actually obtained correlation-diagram. Then, we will notice the fact easily that the actually obtained correlation-diagram takes quite the same features as those assumed preliminarily and no symptom suggesting any other structure worthy to be described can be found out.

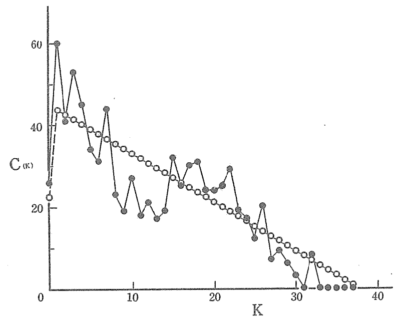


Fig. 35—B A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 10, Series I : unit is 10 consecutive basket width $=ca.$ 2 km).

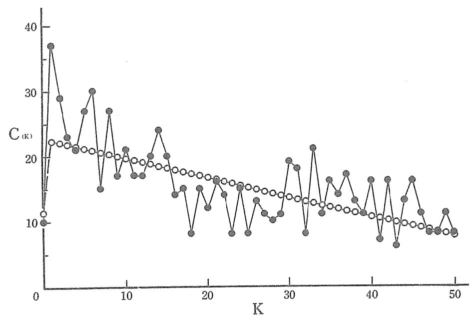


Fig. 35—B A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 10, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

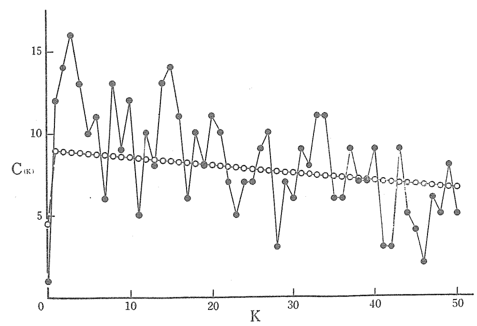


Fig. 35—B A—III. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 10, Series III : unit is 2 consecutive basket width= *ca.* 0.4 km).

Big-eye tuna——Albacore : As assumable from the distribution patterns of respective species, the parts, where the individuals of the big-eye tuna are densely hooked, are covered by two schools of the albacore. Moreover, the peripheries of the other school of the albacore are overlapping the parts where the individuals of the big-eye tuna are densely hooked. Therefore, the distinct aggregative-tendency is expected to be suggested. And the continuously high observed-values in the range from $k = 0$ to 4 in the actually obtained correlation-diagram support these predictions; while the high observed-value in the diagram at $k = 7$ is thought to be caused by the positional relation among respective schools of the subordinate order, but not so high significance can be given to it for fear of the severe influence of accidental error. And the other group of high observed-values around $k = 20$ indicates the relation of positions between the schools of the big-eye tuna and the albacore except one of the latters located near the middle of a row.

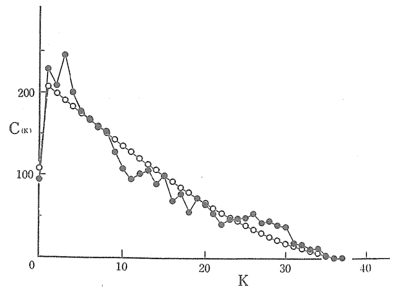


Fig. 36—Y B—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 11, Series Ⅰ : unit is 10 consecutive basket width =*ca.* 2 km).

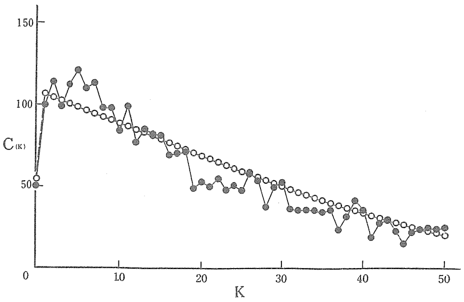


Fig. 36—Y B—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 11, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

Example 11

Yellow-fin tuna——Big-eye tuna : No remarkable structure can be found out except the fact that the distances between the individuals of the yellow-fin tuna and of the big-eye tuna frequently take the width not so long or about 300 baskets because the individuals of the big-eye tuna are hooked scattered throughout a row against the fact that the population of the yellow-fin tuna contains two schools spaced by a width as long as 300 baskets each other.

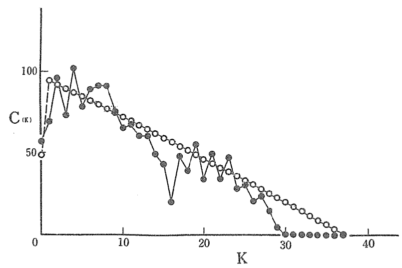


Fig. 36—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 11, Series I : unit is 10 consecutive basket width =*ca.* 2 km).

Yellow-fin tuna——Albacore : The hooked-individuals of the albacore form a single diversed school. Accordingly, relatively clear relation is expected against the scarcity of the hooked-individuals of the albacore. And the actually obtained correlation-diagram suggests, as expected, that the distances between the individuals of both species frequently take 20 (= 40 km) and a little shorter than 10 lots (= 20 km), *i.e.*, school of the albacore is located between the schools of the yellow-fin tuna.

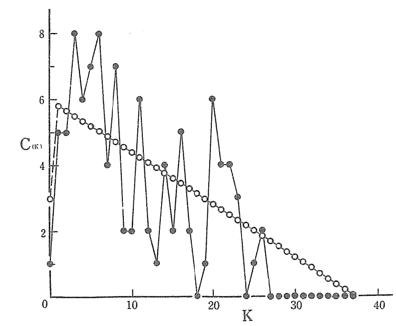


Fig. 36—B A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 11, Series I : unit is 10 consecutive basket width =*ca.* 2 km).

Big-eye tuna——Albacore : The distribution patterns of both species suggest that it is difficult to expect any clear relation. Moreover, if suspected, the scarcity of the hooked-individuals of both species makes it impossible to give any significance.

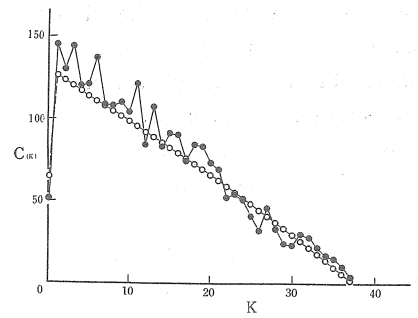


Fig. 37— Y B — Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 12, Series Ⅰ : unit is 10 consecutive basket width =*ca.* 2 km).

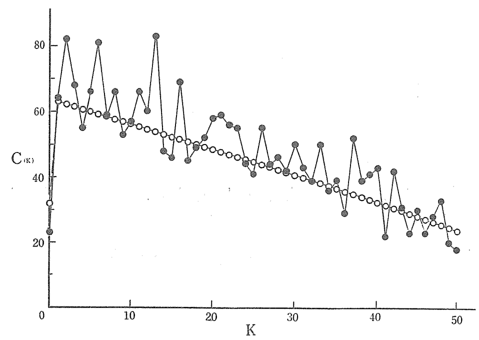


Fig. 37— Y B — Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 12, Series Ⅱ : unit is 5 consecutive basket width= *ca.* 1 km).

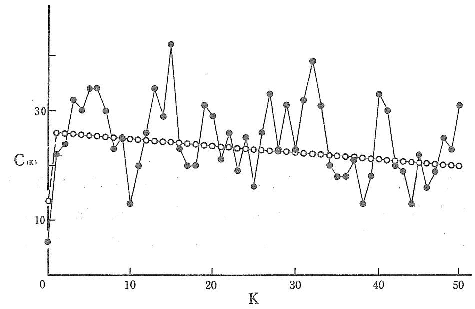


Fig. 37— Y B — Ⅲ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and big-eye tuna, in contrast with that of the theoretically estimated ones (Example 12, Series Ⅲ : unit is 2 consecutive basket width= *ca.* 0.4 km).

Example 12

Yellow-fin tuna——Big-eye tuna : Most of the hooked-individuals of the yellow-fin tuna are thought to form many small schools scattered throughout a row showing 6～8 basket periodicity; while the hooked-individuals of the big-eye tuna, which are not so many enough as deducible some patterns of significance, are self-spacingly scattered throughout a row. Accordingly, the distribution patterns of both species tell us that the clear relation is hardly expectable. Therefore, we can not give high significance upon the deviation —— consequently the decoded relation —— in the correlation-diagram, although the deviations of the observed-values in the actually obtained correlation-diagram may seem to allude to aggregative-pattern affecting widely; and for the short-periodic deviations in this diagram, I wish to give no description, because the same reasons mentioned above are far strongly influential.

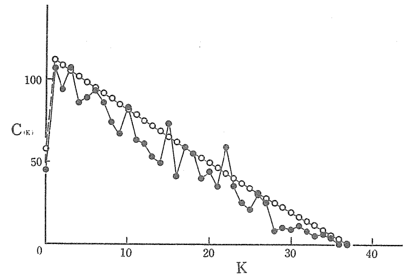


Fig. 37—Y A—I. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 12, Series I : unit is 10 consecutive basket width =*ca.* 2 km).

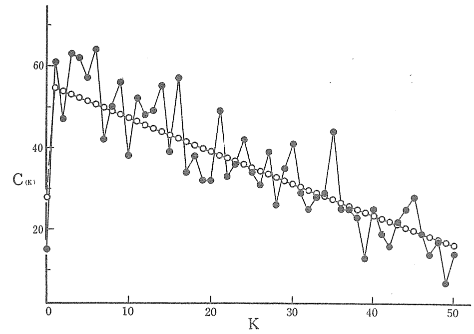


Fig. 37—Y A—II. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of yellow-fin tuna and albacore, in contrast with that of the theoretically estimated ones (Example 12, Series II : unit is 5 consecutive basket width= *ca.* 1 km).

Yellow-fin tuna——Albacore : Clear relation is hardly expectable, because not so many individuals of the albacore are hooked moreover they are scattered self-spacingly throughout a row. And even if any relation is obtained, not so high significance as superficially impressed from the magnitude of the observed-values can be given to it. But some high observed-values can be found in the actually obtained correlation-diagram, but it seems to be difficult to give high significance because of the scarcity of the hooked-individuals in company with the facts that the observed-values exceed the estimated ones neither so largely nor so continuously, moreover they do not show so clear periodicity. From the following series of analyses, it may well be said that less individuals than expected are hooked in the baskets spaced by a width shorter than five baskets but more individuals are hooked in the baskets spaced by $7A$ baskets (A is a positive integer but not so large) from any basket occupied by the individuals of each other's species. And these facts are thought to be, at least partly, due to the periodicity in the distribution pattern of the yellow-fin tuna.

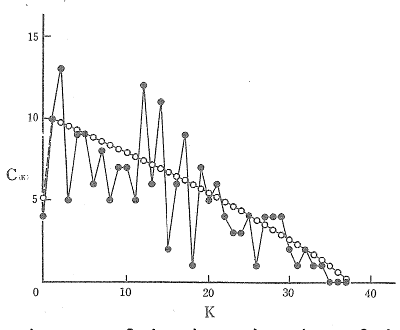


Fig. 37—B A—Ⅰ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 12, Series Ⅰ : unit is 10 consecutive basket width $= ca.$ 2 km).

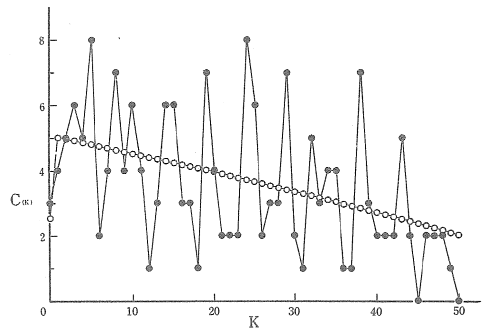


Fig. 37—B A—Ⅱ. The deviation of the observed numbers of the individual-pairs of respective widths and constituted of big-eye tuna and albacore, in contrast with that of the theoretically estimated ones (Example 12, Series Ⅱ : unit is 5 consecutive basket width $=$ *ca.* 1 km).

Big-eye tuna——*Albacore* : The deviation of the observed-values in the correlation-diagram showing some clear relation can hardly be expected, because the hooked-individuals of each species are not so many enough, moreover they are scattered rather self-spacingly. But the observed-values in the actually obtained correlation-diagram in the range $10 < k < 20$ seem to be higher than the estimated ones, which may seem to allude to a repulsive relation. And also severely deviating 2.5-lot periodicity of them can be found out. But, for fear of unnegligible influence of accidental error due to poor catch, whether we can give any significance to it or not is highly doubtful.

2. Summarized results of the correlation analysis

Yellow-fin tuna——Big-eye tuna : The correlation of the hooked positions of both species observable within a short range is thought to be more strongly affected by the social relation between the individuals of each other's species, while that extending to wide range is rather strongly influenced by the distribution patterns of both species to consider with the large scale. Therefore, the interests of this report should be naturally paid to the correlation within a short range, but the scarcity of the hooked-individuals of the big-eye tuna makes it impossible to analyze any correlation of significance but that extending to a wide range, although the large population size of the hooked-individuals of the yellow-fin tuna superficially raises the observed-values falsely high enough as if to be deducible significant correlation even within a short range. Accordingly, I was obliged to restrict the discussion on the relation between the hooked positions of the individuals to consider with the large scale. And these correlations deduced from respective examples are classified into as follows:

A. The individuals of each species form rather clear and widely covering schools, and aggregative-relation can be suspected between the individuals of both species.
   1) All the individuals of both species are hooked in *entirely* the common parts………Example 2
   2) All the individuals of a certain species (big-eye tuna) are hooked in the common parts with the individuals of the other species (yellow-fin tuna), while there are some other parts occupied only by the individuals of the latter species………Examples 1 and 9
   3) Most of the individuals of both species are hooked in some common parts, while a part of the individuals of both species is hooked separately in each other's part in a row………Examples 6, 7 and 10, of which the last example has some characteristics of the examples classifiable into column (6)
   4) Most of the individuals of both species are hooked in some common parts, while other individuals of both species are hooked almost separately but some peripherial parts of the schools of the different species are overlapping……… None

B. The individuals of each species form rather clear schools but rather repulsive relation is suspected between the individuals of each other's species.

5) Schools of both species are hooked in *entirely* the different parts…………No example shows such perfectly repulsive relation

6) Schools of both species are hooked in *almost* the different parts while some peripherial parts of the schools of the different species are overlapping……… Example 5 (roughly speaking, the common cluster-formation of the subordinate order is suspected).

C. No clear relation is observable, because the individuals of each one or both of the two species do not form any clear school, but are scattered.

7) The individuals of a species are scattered, while those of the other species form clear schools ………… Examples 3, 4, 11 and 12, of which the last one shows the feature classifiable into the next column

8) The individuals of both species are scattered …………… There is no example classified into this group, although Example 12 shows the relation somewhat resembling this type.

Thus, no repulsive relation is admitted, but rather aggregative relation is suggested in many examples.

Yellow-fin tuna——Albacore : The scarcity of the hooked-individuals of the albacore makes it impossible to give any consideration upon the correlation within a short range; and the significance of the deduced relation extending to wide space also does not rid of the influence due to the same fact, but the general tendencies of the correlation of the hooked positions of the individuals of the yellow-fin tuna and the albacore of respective examples are, for reference' sake, classified into as follows:

A 1) No example shows such perfectly aggregative relation.
2) Example 3
3) Examples 2, 6 and 10
4) Example 7

B 5) Examples 5 and 11
6) There is no example classified into this column.

C 7) Examples 4 and 8
8) Example 12

Thus, the relation of the hooked positions between the individuals of the yellow-fin tuna and the albacore seems to be less aggregative or more repulsive than that between the yellow-fin tuna and the big-eye tuna. And this fact may be more or less due to the fact that food habits and body size of the individuals of the yellow-fin tuna and those of the albacore differ rather markedly, while those of the big-eye tuna are rather similar to those of the yellow-fin tuna.

Big-eye tuna——Albacore : Examples 1 and 9 are omitted from the consideration, because of the extreme scarcity of the hooked-individuals of the albacore; while the number of gears used in Example 8 is not so large enough and this example is also omitted. For the other examples, the hooked population-sizes of both species are not so large enough as to be deducible any relation capable of giving some significance. But the following description may be shown as the conclusion of this relation, although significance of some of them is doubtful.

A 1) No example shows such perfectly aggregative relation.

2) Also no example shows such relation.

3) Exapmle 2

4) Examples 4 and 10, of which the relation observable in the former one is too complicated to be classified simply into this type, but may well be said that the individuals of both species are distributed rather independently of each other's species, while the latter one shows somewhat strongly aggregative tendency.

B 5) Example 7 This example is inclined to show the relation classified into column (3).

6) Example 6 This example has some characteristics classified into the next column.

C 7) Examples 3, 5 and 11, of which the second one shows the relation somewhat resembling that of column (1) and at the same time repulsive tendency within a short range is observable against the fact that the last one has some characteristics of column (8).

8) Example 12

Thus, as slightly repulsive relation as or a little more repulsive one than that between the hooked-individuals of the yellow-fin tuna and those of the albacore is observable between the individuals of the big-eye tuna and the albacore.

The above-mentioned three relations summarized, it may well be concluded that the aggregative relation is observable between the individuals of the yellow-fin tuna and the big-eye tuna while the individuals of the albacore are distributed rather repulsively against the individuals of the yellow-fin tuna and the big-eye tuna, moreover strongly to the latter, despite of the fact that the hooked-population sizes of the yellow-fin tuna are large while those of the big-eye tuna and the albacore are small. And these relations are thought to be strongly reflecting on the relation of food habits and body sizes observable among the individuals of these three species.

Part II Interval analysis (Modified type of the order method)

Method of Analysis

The spacing method does not touch on the fact whether some of the inserted hooks are occupied or not, and this sometimes makes it into confusion to translate the results of the analysis into the actual pattern, although the same fact has such advantages as being able to give consideration upon the relation extending to a wide range compared with the unit-length. Accordingly, changing the mind, I have deviced out another trial. This method treats of the length of the interval from any hooked-individual to the next one, *i.e.*, whether some of the inserted hooks are occupied or not is taken into consideration. Therefore, this method is thought to be one of the modified types of the method called the order method or the n-th neighbouring one, in which the frequency distribution of the distance from any individual to the n-th neighbouring individual is treated. And recently there have been deviced out many methods (MORISITA 1954 and THOMPSON 1956) but most of them are applicable to the distribution in space and any of them is scarcely applicable to the analysis on the distribution along a line, moreover no one satisfy all or most of the peculiar conditions specific to long-line gears. Accordingly, the constructing-method and the processes of the exclusion of the influence of the gradient of occupied-rate due to soaking time and that of the difference in the occupied-rates due to that of the depth levels of the hooks will be described in detail step by step, because I am afraid that the description given in the first report was too short to understand clearly, moreover no example of the analysis actually adopting this method was illustrated.

1. Original form

This is the group of the formulae in which the theoretical process of the construction is most easily and clearly recognizable. But this is applicable to only the ideal conditions, in which neither significant gradient nor significant difference in the occupied-rate due to soaking time and depth levels of hooks is expected.

Let us set that N individuals are scattered by chance along a row of gears constituted of m consecutive baskets of equal length and having four hooks a basket. And by the same manner as the spacing analysis, k is represented as $a(H+1)+R$, when it is separated into the part divisible by the length of a basket and remainder. Here, when $R=0$, there are H hooks in the $(i+a)th$ basket, each of which is spaced by k hook-intervals from any hook in the ith basket as shown in Table 2; while when $R \neq 0$, there are $(H-R)$ hooks in the $(i+a)th$ basket and $(R-1)$ hooks in the

Table 7. Probability of occurrence in two occupied hooks spaced by k hook-intervals each other and inserted no occupied hook, with particular reference to partial probabilities, when one starts to count k from respective hooks in the ith basket at respective R. (As a process of understanding easily the construction of the formulae of the interval analysis, in which neither significant gradient nor significant difference in occupied rate due to soaking time and depth levels of the hooks is expected.)

R	Order of hook in the i-th basket starting to count k	Order of hook spacing k from it	Occupied probability of both terminal hooks	Consecutively unoccupied prob. of residual hooks in the i-th basket	That of inserted baskets
0	1	1	p^2	q^3	$q^{4(a-1)}$
	2	2	p^2	q^2	$q^{4(a-1)}$
	3	3	p^2	q^1	$q^{4(a-1)}$
	4	4	p^2	q^0	$q^{4(a-1)}$
1	1	2	p^2	q^3	$q^{4(a-1)}$
	2	3	p^2	q^2	$q^{4(a-1)}$
	3	4	p^2	q^1	$q^{4(a-1)}$
	4	B	0	—	—
2	1	3	p^2	q^3	$q^{4(a-1)}$
	2	4	p^2	q^2	$q^{4(a-1)}$
	3	B	0	—	—
	4	1	p^2	q^0	q^{4a}
3	1	4	p^2	q^3	$q^{4(a-1)}$
	2	B	0	—	—
	3	1	p^2	q^1	q^{4a}
	4	2	p^2	q^0	q^{4a}
4	1	B	0	—	—
	2	1	p^2	q^2	q^{4a}
	3	2	p^2	q^1	q^{4a}
	4	3	p^2	q^0	q^{4a}

R	That of hooks in the $(i+a)$-th basket* arranged earlier than a terminal	Product of these prob.	Range of i capable of varying	
			Smallest	Largest
0	q^0	$p^2\ q^{4a-1}$	1	$(M-a)$
	q^1	$p^2\ q^{4a-1}$	1	$(M-a)$
	q^2	$p^2\ q^{4a-1}$	1	$(M-a)$
	q^3	$p^2\ q^{4a-1}$	1	$(M-a)$
1	q^1	$p^2\ q^{4a}$	1	$(M-a)$
	q^2	$p^2\ q^{4a}$	1	$(M-a)$
	q^3	$p^2\ q^{4a}$	1	$(M-a)$
	—	0	—	——
2	q^2	$p^2\ q^{4a+1}$	1	$(M-a)$
	q^3	$p^2\ q^{4a+1}$	1	$(M-a)$
	—	0	—	——
	q^0	$p^2\ q^{4a}$	1	$(M-a-1)$
3	q^3	$p^2\ q^{4a+2}$	1	$(M-a)$
	—	0	—	——
	q^0	$p^2\ q^{4a+1}$	1	$(M-a-1)$
	q^1	$p^2\ q^{4a+1}$	1	$(M-a-1)$
4	—	0	—	——
	q^0	$p^2\ q^{4a+2}$	1	$(M-a-1)$
	q^1	$p^2\ q^{4a+2}$	1	$(M-a-1)$
	q^2	$p^2\ q^{4a+2}$	1	$(M-a-1)$

* For the columns, in which i varies from 1 to $(m-a-1)$, the $(i+a+1)th$ is substituted for the $(i+a)$th.

$(i+a+1)th$ basket. But there are a buoy-lines, consequently $(k-a-1)$ inserted hooks, between the two hooks spaced by k hook-intervals each other and one is in the ith basket and the other is in the $(i+a)th$ basket; while there are $(a+1)$ buoy-lines, consequently $(k-a-2)$ inserted hooks, between the two hooks spaced by k hook-intervals each other and one is in the ith and the other is in the $(i+a+1)th$ basket. Accordingly, the probabilities of all the inserted hooks unoccupied continuously are $q^{(k-a-1)}$ and $q^{(k-a-2)}$, respectively, here $P=\frac{N}{Hm}$ and $q=1-P$. Therefore, the expectant number of the two occupied-hooks spaced by k hook-intervals each other and without any occupied inserted-hook, $\Psi_{(k)}$, is represented as follows:

at $R=0$

$$\Psi_{(k)}=H(m-a)P^2 q^{(k-a-1)} \cdots\cdots (15)$$

while at $R \neq 0$

$$\Psi_{(k)}=(H-R)(m-a)P^2 q^{(k-a-1)}+(R-1)(m-a-1)P^2 q^{(k-a-2)}$$
$$=P^2 q^{(k-a-2)}[(H-R)(m-a)q+(R-1)(m-a-1)] \cdots\cdots (16)$$

Notes:

1) Test-method, examining the significance of the difference in the observed-values from the estimated ones at respective k, has not yet found out.
2) Total number of $\Psi_{(k)}$, $\sum_{k=1}^{m(H+1)-2} \Psi_{(k)}$, is limited to be as large as $(N-1)$ which is as equal as the number of the intervals nipped by two individuals among N individuals hooked along a line.
3) Accordingly, this method can be effectively tried only when N is large.
4) Some computation error due to q is expected to be rather severely affecting to the theoretical-values, especially those at longer k.
5) When P is not so small, the estimated-values decrease rapidly with increase in k, which results that there is no need or impossible to compute $\Psi_{(k)}$ at longer k.
6) Accordingly, the distribution pattern observable even in a considerably wide range is analyzible by only one series of analysis, the unit-length of which is so short as to a hook-interval. But, it is undesirable to adopt a long unit-length.
7) It is far easier to count the observed-value of this method than that of the spacing one.

2. Exclusion of the influence of the difference in the occupied-rates due to that of the fishing depths of the hooks

The formulae, in which the influence of this factor is taken into consideration, take the different forms with that in the number of hooks attaching to each basket. Therefore, the constructing-process of the formulae applicable to the gears constituted of a series of main-lines attaching to four hooks a basket is illustrated, as an example, because the gears used in this study are constituted of a connected series of main-lines attaching to four hooks a basket.

Let us set that N_1 and N_2 individuals are distributed by chance along shallower hooks and deeper ones of a row of gears constituted of m consecutive baskets attaching to four hooks a basket. For the purpose of understanding the constructing-process easily, it seems better to treat the probability of the occurrence in the two hooks spaced by k hook-intervals each other and without any occupied hook separating into 1) the occupied probability of both terminal hooks, 2) the unoccupied probability of the hooks in the *ith* basket located in the range latter than the hook starting to count k, 3) the successively unoccupied probability of the inserted baskets and 4) the unoccupied probability of the hooks in the $(i+a)th$ or the $(i+a+1)th$ basket coming earlier than the ending hook to count k. Represent k as $a(4+1)+R$, and the above-mentioned partial probabilities when starting to count k from respective hooks in the *ith* basket at respective R are represented in Table 8. And the probability of occurrence in the two occupied-hooks spaced by k hook-intervals each other and without any occupied inserted-hook, starting to count k from respective hooks in the *ith* basket at respective R, is the product of the four probabilities arranged horizontally in Table 8. Here, when one hook is located in the *ith* basket and the other

Table 8. Probability of occurrence in two occupied hooks spaced by k hook-intervals each other and inserted no occupied hook, with particular reference to partial probabilities, when one starts to count k from respective hooks in the *ith* basket at respective R. (As a process of understanding easily the construction of the formulae of the interval analysis, in which the influence of the difference in the occupied rates due to that of the fishing depths of the hooks is taken into consideration.)

R	Order of hook in the *i-th* basket starting to count k	Order of hook spacing k from it	Occupied probability of both terminal hooks	Consecutively unoccupied prob. of residual hooks in the *i-th* basket	That of inserted baskets
0	1	1	P_1^2	$q_1q_2^2$	$(q_1q_2)^{2(a-1)}$
	2	2	P_2^2	q_1q_2	$(q_1q_2)^{2(a-1)}$
	3	3	P_2^2	q_1	$(q_1q_2)^{2(a-1)}$
	4	4	P_1^2	1	$(q_1q_2)^{2(a-1)}$
1	1	2	P_1P_2	$q_1q_2^2$	$(q_1q_2)^{2(a-1)}$
	2	3	P_2^2	q_1q_2	$(q_1q_2)^{2(a-1)}$
	3	4	P_1P_2	q_1	$(q_1q_2)^{2(a-1)}$
	4	B	0	—	—
2	1	3	P_1P_2	$q_1q_2^2$	$(q_1q_2)^{2(a-1)}$
	2	4	P_1P_2	q_1q_2	$(q_1q_2)^{2(a-1)}$
	3	B	0	—	—
	4	1	P_1^2	1	$(q_1q_2)^{2a}$
3	1	4	P_1^2	$q_1q_2^2$	$(q_1q_2)^{2(a-1)}$
	2	B	0	—	—
	3	1	P_1P_2	q_1	$(q_1q_2)^{2a}$
	4	2	P_1P_2	1	$(q_1q_2)^{2a}$
4	1	B	0	—	—
	2	1	P_1P_2	q_1q_2	$(q_1q_2)^{2a}$
	3	2	P_2^2	q_1	$(q_1q_2)^{2a}$
	4	3	P_1P_2	1	$(q_1q_2)^{2a}$

R	That of hooks in the $(i+a)$-*th* basket arranged earlier than a terminal	Product of these prob.	Range of i capable of varying	
			Smallest	Largest
0	1	$P_1{}^2q_2 \ (q_1q_2)^{2a-1}$	1	(M−a)
	q_1	$P_2{}^2q_1 \ (q_1q_2)^{2a-1}$	1	(M−a)
	q_1q_2	$P_2{}^2q_1 \ (q_1q_2)^{2a-1}$	1	(M−a)
	$q_1q_2{}^2$	$P_1{}^2q_2 \ (q_1q_2)^{2a-1}$	1	(M−a)
1	q_1	$P_1P_2 \ (q_1q_2)^{2a}$	1	(M−a)
	q_1q_2	$P_2{}^2 \ (q_1q_2)^{2a}$	1	(M−a)
	$q_1q_2{}^2$	$P_1P_2 \ (q_1q_2)^{2a}$	1	(M−a)
	—	—	—	—
2	q_1q_2	$P_1P_2q_2 \ (q_1q_2)^{2a}$	1	(M−a)
	$q_1q_2{}^2$	$P_1P_2q_2 \ (q_1q_2)^{2a}$	1	(M−a)
	—	—	—	—
	1	$P_1{}^2 \ (q_1q_2)^{2a}$	1	(M−a−1)
3	$q_1q_2{}^2$	$P_1{}^2q_2{}^2 \ (q_1q_2)^{2a}$	1	(M−a)
	—	—	—	—
	1	$P_1P_2q_1 \ (q_1q_2)^{2a}$	1	(M−a−1)
	q_1	$P_1P_2q_1 \ (q_1q_2)^{2a}$	1	(M−a−1)
4	—	—	—	—
	1	$P_1P_2q_1q_2(q_1q_2)^{2a}$	1	(M−a−1)
	q_1	$P_2{}^2q_1{}^2 \ (q_1q_2)^{2a}$	1	(M−a−1)
	q_1q_2	$P_1P_2q_1q_2(q_1q_2)^{2a}$	1	(M−a−1)

is in the $(i+a)th$ one, "i" varies from 1 to $(m-a)$, while for the rests of it, "i" varies from 1 to $(m-a-1)$. Accordingly, the expectant number is estimative from the following formulae:

at $R=0$

$$\Psi_{(k)}=2(m-a)(q_1q_2)^{(2a-1)}(P_1{}^2q_2+P_2{}^2q_1) \quad \cdots\cdots (17)$$

at $R=1$

$$\Psi_{(k)}=(m-a)(q_1q_2)^{2a}(2P_1P_2+P_2{}^2) \quad \cdots\cdots (18)$$

at $R=2$

$$\Psi_{(k)}=2(m-a)(q_1q_2)^{2a}P_1P_2q_2+(m-a-1)(q_1q_2)^{2a}P_1{}^2 \quad \cdots\cdots (19)$$

at $R=3$

$$\Psi_{(k)}=(m-a)P_1{}^2q_2{}^2(q_1q_2)^{2a}+2(m-a-1)(q_1q_2)^{2a}P_1P_2q_1 \quad \cdots\cdots (20)$$

while at $R=4$

$$\Psi_{(k)}=(m-a-1)(q_1q_2)^{2a}(2P_1P_2q_1q_2+P_2{}^2q_1{}^2) \quad \cdots\cdots (21)$$

Here, $P_1=\dfrac{N_1}{2m}$, $P_2=\dfrac{N_2}{2m}$, $q_1=1-P_1$ and $q_2=1-P_2$.

Note: See the notes under the preceding form.

3. Exclusion of the influence of the gradient of the occupied-rate due to soaking time

Let us set that the occupied-rate of a hook in the *ith* basket is set to be $(P+i\Delta P)$ for the purpose of representing the gradient and that $k=a(H+1)+R$. For convenience' sake of explanation, the probability of occurrence in the two occupied-hooks spaced by k hook-intervals each other and without any occupied inserted-hook is treated separately by the same manner as the preceding form. And the partial probabilities are represented in Table 9. And the formulae applicable to this type can be obtained by the same manner as the constructing-process of the preceding form; these are shown in the below:

at $R=0$

$$\Psi_{(k)}=\sum_{i=1}^{m-a}\left\{(P+i\Delta P)(P+\overline{i+a}\Delta P)\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^{H}\sum_{r=0}^{H-1}(q-i\Delta P)^{H-1-r}(q-\overline{i+a}\Delta P)^{r}\right\} \qquad \cdots\cdots\cdots\cdots\cdots\cdots (22)$$

Table 9. Probability of occurrence in two occupied hooks spaced by k hook-intervals each other and inserted no occupied hook, with particular reference to partial probabilities, when one starts to count k from respective hooks in the ith basket at respective R. (As a process of understanding easily the construction of the formulae of the interval analysis in which the influence of the gradient of the occupied rate due to soaking time is taken into consideration.)

R	Order of hook in the i-th basket starting to count k	Order of hook spacing k from it	Occupied probability of both terminal hooks	Consecutively unoccupied prob. of residual hooks in the i-th basket	That of inserted baskets	That of hooks in the $(i+a)$-th basket arranged earlier than a terminal
0	1	1	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)^3$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1
	2	2	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)^2$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)$
	3	3	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)^2$
	4	4	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	1	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)^3$
1	1	2	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)^3$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)$
	2	3	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)^2$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)^2$
	3	4	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)^3$
	4	B	0	—	—	—
2	1	3	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)^3$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)^2$
	2	4	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)^2$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)^3$
	3	B	0	—	—	—
	4	1	$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)$	1	$\prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1
3	1	4	$(P+i\Delta P)\quad(P+\overline{i+a}\Delta P)$	$(q-i\Delta P)^3$	$\prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a}\Delta P)^3$
	2	B	0	—	—	—
	3	1	$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)$	$(q-i\Delta P)$	$\prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1
	4	2	$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)$	1	$\prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a+1}\Delta P)$
4	1	B	0	—	—	—
	2	1	$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)$	$(q-i\Delta P)^2$	$\prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1
	3	2	$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)$	$(q-i\Delta P)$	$\prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a+1}\Delta P)$
	4	3	$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)$	1	$\prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	$(q-\overline{i+a+1}\Delta P)^2$

while at $R \neq 0$

$$\Psi_{(k)} = \sum_{i=1}^{m-a} \left\{ (P+i\Delta P)(P+\overline{i+a}\Delta P) \prod_{b=1}^{a-1} (q-\overline{i+b}\Delta P)^{H} \sum_{r=R}^{H-1} (q-i\Delta P)^{H+R-1-r} (q-\overline{i+a}\Delta P)^{r} \right\}$$

$$+ \sum_{i=1}^{m-a-1} \left\{ (P+i\Delta P)(P+\overline{i+a+1}\Delta P) \prod_{b=1}^{a} (q-\overline{i+b}\Delta P)^{H} \right.$$

$$\left. \sum_{r=0}^{R-2} (q-i\Delta P)^{R-2-r} (q-\overline{i+a+1}\Delta P)^{r} \right\} \cdots\cdots (23)$$

Here, m is the number of gears connected into a row and $q=1-P$. When $H-1<R$, treat the former half of the Formula (23) as equal as 0; while when $R-2<0$, treat

Product of these prob.	Range of i capable of varying	
	Smallest	Largest
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)^3 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)^2(q-\overline{i+a}\Delta P) \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)(q-\overline{i+a}\Delta P)^2 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-\overline{i+a}\Delta P)^3 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)^3(q-\overline{i+a}\Delta P) \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)^2(q-\overline{i+a}\Delta P)^2 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)(q-\overline{i+a}\Delta P)^3 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
————	—	—
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)^3(q-\overline{i+a}\Delta P)^2 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)^2(q-\overline{i+a}\Delta P)^3 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
————	—	—
$(P+i\Delta P)(P+\overline{i+a+1}\Delta P) \prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1	(M−a−1)
$(P+i\Delta P)(P+\overline{i+a}\Delta P)(q-i\Delta P)^3(q-\overline{i+a}\Delta P)^3 \prod_{b=1}^{a-1}(q-\overline{i+b}\Delta P)^4$	1	(M−a)
————	—	—
$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)(q-i\Delta P) \prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1	(M−a−1)
$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)(q-\overline{i+a+1}\Delta P) \prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1	(M−a−1)
————	—	—
$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)(q-i\Delta P)^2 \prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1	(M−a−1)
$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)(q-i\Delta P)(q-\overline{i+a+1}\Delta P) \prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1	(M−a−1)
$(P+i\Delta P)(P+\overline{i+a+1}\Delta P)(q-\overline{i+a+1}\Delta P)^2 \prod_{b=1}^{a}(q-\overline{i+b}\Delta P)^4$	1	(M−a−1)

the latter half of it as equal as 0.

Notes:

1) Besides the fact mentioned in the notes of the original form, attention should be paid to the following facts.

2) On account of the gradient, the estimation of the theoretical-values, especially those at longer k, becomes too troublesome to compute actually, which has much risk to introduce high computation-error.

3) Accordingly it is highly doubtful whether it is worthy to dare to compute actually with much effort such a value for fear of being uncertain. And it may be sufficient to take the magnitude of the influence of the gradient into consideration, deducing from the difference in the theoretical-value of this type at $k=0$ from that of the original form, both of which take the same values as those of the spacing analysis of the corresponding types and are easily computable.

Table 10. Probability of occurrence in two occupied hooks spaced by k hook-intervals each other and inserted no occupied hook, with particular reference to partial probabilities, when one starts to count k from respective hooks in the ith basket at respective R. (As a process of understanding easily the construction of the formulae of the interval analysis, in which the influences of both factors are taken into consideration.)

R	Order of hook in the i-th basket starting to count k	Order of hook spacing k from it	Occupied probability of both terminal hooks	Consecutively unoccupied prob. of residual hooks in the i-th basket	That of inserted baskets	That of hooks in the $(i+a)$-th basket arranged earlier than a terminal
0	1	1	$(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1
	2	2	$(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)$
	3	3	$(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)$	$(q_1-i\Delta P_1)$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)$
	4	4	$(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)$	1	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2$
1	1	2	$(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)$
	2	3	$(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)$
	3	4	$(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)$	$(q_1-i\Delta P_1)$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2$
	4	B	0	—	—	—
2	1	3	$(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)$
	2	4	$(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2$
	3	B	0	—	—	—
	4	1	$(P_1+i\Delta P_1)(P_1+\overline{i+a+1}\Delta P_1)$	1	$\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1
3	1	4	$(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2$	$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2$
	2	B	0	—	—	—
	3	1	$(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\Delta P_1)$	$(q_1-i\Delta P_1)$	$\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1
	4	2	$(P_1+i\Delta P_1)(P_2+\overline{i+a+1}\Delta P_2)$	1	$\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a+1}\Delta P_1)$
4	1	B	0	—	—	—
	2	1	$(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\Delta P_1)$	$(q_1-i\Delta P_1)(q_2-i\Delta P_2)$	$\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1
	3	2	$(P_2+i\Delta P_2)(P_2+\overline{i+a+1}\Delta P_2)$	$(q_1-i\Delta P_1)$	$\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a+1}\Delta P_1)$
	4	3	$(P_1+i\Delta P_1)(P_2+\overline{i+a+1}\Delta P_2)$	1	$\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	$(q_1-\overline{i+a+1}\Delta P_1)(q_2-\overline{i+a+1}\Delta P_2)$

4. Exclusion of the influence of both factors, the gradient of occupied-rate due to that of soaking time and the difference in the occupied-rate due to the depth levels of the hooks

The formulae applicable to this most complicated condition are obtained from the original form by double transformation —— first, by the same manner as that of Formulae (15) and (16) into (17) ~ (21) for the purpose of excluding the influence of the difference in the occupied-rate due to that of fishing depth of hooks, then by the same manner as that of Formulae (15) and (16) into (22) and (23) in order to exclude the influence of the gradient of the occupied-rate due to soaking time. Consequently, the formulae are obliged to take the different forms with the difference in the number of hooks attaching to each basket. And only those applicable to the gears constituted of a connected series of baskets attaching to four hooks a basket are illustrated in the below, as an example.

Product of these prob.	Range of i capable of varying	
	Smallest	Largest
$(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
$(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_2-i\Delta P_2)(q_1-\overline{i+a}\Delta P_1)\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
$(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
$(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
$(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_2-i\Delta q_2)^2(q_1-\overline{i+a}\Delta P_1)\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
$(P_2+i\Delta P_2)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_2-i\Delta q_2)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_3)\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
$(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
—	—	—
$(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
$(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
—	—	—
$(P_1+i\Delta P_1)(P_1+\overline{i+a+1}\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a−1)
$(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a)
—	—	—
$(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\Delta P_1)(q_1-i\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a−1)
$(P_1+i\Delta P_1)(P_2+\overline{i+a+1}\Delta P_2)(q_1-\overline{i+a+1}\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a−1)
—	—	—
$(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a−1)
$(P_2+i\Delta P_2)(P_2+\overline{i+a+1}\Delta P_2)(q_1-i\Delta P_1)(q_1-\overline{i+a+1}\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a−1)
$(P_1+i\Delta P_1)(P_2+\overline{i+a+1}\Delta P_2)(q_1-\overline{i+a+1}\Delta P_1)(q_2-\overline{i+a+1}\Delta P_2)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2$	1	(M−a−1)

In order to represent the gradient of the occupied-rate of the hooks at respective depth levels, the occupied-rates of respective hooks are set to take the values shown in Table 5 (c) and that $q_1 = 1 - P_1$ and $q_2 = 1 - P_2$. Then, the total number of the gears connected into a row is set to be m and the interval k is represented as $a(4+1)+R$. The partial probabilities——the occupied probability of the two hooks spaced by a width as long as k hook-intervals each other, the unoccupied probability of the hooks in the ith basket located in the range latter than the hook starting to count k, the successively unoccupied probability of the inserted baskets and the unoccupied probability of the hooks in the $(i+a)th$ or in the $(i+a+1)th$ basket coming earlier than the ending hook to count k ——, when one starts to count k from respective hooks in the ith basket at respective R, are listed in Table 10. And the probability of occurrence in the two occupied-hooks spaced by k hook-intervals each other and inserted no occupied-hook, starting to count k from respective hooks in the ith basket at respective R is the product of the four probabilities arranged horizontally in Table 10. But the expectant number of respective cases is computable by summing the respective products in which "i" is increased step by step from 1 to $(m-a)$ or to $(m-a-1)$. And the expectant number at respective R is obtained by summing from these sums started to count k from the first hook in the basket to those from the hindmost hook in it, which are shown in the below:

at $R = 0$

$$\begin{aligned}
\Psi_{(k)} = & \sum_{i=1}^{m-a} \Big\{ (P_1 + i\Delta P_1)(P_1 + \overline{i+a}\Delta P_1)(q_1 - i\Delta P_1)(q_2 - i\Delta P_2)^2 \\
& \prod_{b=1}^{a-1} (q_1 - \overline{i+b}\Delta P_1)^2 (q_2 - \overline{i+b}\Delta P_2)^2 \Big\} \\
& + \sum_{i=1}^{m-a} \Big\{ (P_2 + i\Delta P_2)(P_2 + \overline{i+a}\Delta P_2)(q_1 - i\Delta P_1)(q_2 - i\Delta P_2)(q_1 - \overline{i+a}\Delta P_1) \\
& \prod_{b=1}^{a-1} (q_1 - \overline{i+b}\Delta P_1)^2 (q_2 - \overline{i+b}\Delta P_2)^2 \Big\} \\
& + \sum_{i=1}^{m-a} \Big\{ (P_2 + i\Delta P_2)(P_2 + \overline{i+a}\Delta P_2)(q_1 - i\Delta P_1)(q_1 - \overline{i+a}\Delta P_1)(q_2 - \overline{i+a}\Delta P_2) \\
& \prod_{b=1}^{a-1} (q_1 - \overline{i+b}\Delta P_1)^2 (q_2 - \overline{i+b}\Delta P_2)^2 \Big\} \\
& + \sum_{i=1}^{m-a} \Big\{ (P_1 + i\Delta P_1)(P_1 + \overline{i+a}\Delta P_1)(q_1 - \overline{i+a}\Delta P_1)(q_2 - \overline{i+a}\Delta P_2)^2 \\
& \prod_{b=1}^{a-1} (q_1 - \overline{i+b}\Delta P_1)^2 (q_2 - \overline{i+b}\Delta P_2)^2 \Big\} \qquad (24)
\end{aligned}$$

at $R=1$

$$\Psi_{(k)}=\sum_{i=1}^{m-a}\Big\{(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2(q_1-\overline{i+a}\Delta P_1)$$
$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}$$
$$+\sum_{i=1}^{m-a}\Big\{(P_2+i\Delta P)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_2-i\Delta P_2)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)$$
$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}$$
$$+\sum_{i=1}^{m-a}\Big\{(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2$$
$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}\cdots\cdots\cdots\cdots (25)$$

at $R=2$

$$\Psi_{(k)}=\sum_{i=1}^{m-a}\Big\{(P_1+i\Delta P_1)(P_2+\overline{i+a}\Delta P_2)(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)$$
$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}$$
$$+\sum_{i=1}^{m-a}\Big\{(P_2+i\Delta P_2)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2$$
$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}$$
$$+\sum_{i=1}^{m-a-1}\Big\{(P_1+i\Delta P_1)(P_1+\overline{i+a+1}\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}\cdots (26)$$

at $R=3$

$$\Psi_{(k)}=\sum_{i=1}^{m-a}\Big\{(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2(q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2$$
$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}$$
$$+\sum_{i=1}^{m-a-1}\Big\{(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\Delta P_1)(q_1-i\Delta P_1)$$
$$\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2(q_2-\overline{i+b}\Delta P_2)^2\Big\}$$

$$+\sum_{i=1}^{m-a-1}\Big\{(P_1+i\varDelta P_1)(P_2+\overline{i+a+1}\varDelta P_2)(q_1-\overline{i+a+1}\varDelta P_1)$$

$$\prod_{b=1}^{a}(q_1-\overline{i+b}\varDelta P_1)^2(q_2-\overline{i+b}\varDelta P_2)^2\Big\} \cdots\cdots (27)$$

while at $R=4$

$$\varPsi_{(k)}=\sum_{i=1}^{m-a-1}\Big\{(P_2+i\varDelta P_2)(P_1+\overline{i+a+1}\varDelta P_1)(q_1-i\varDelta P_1)(q_2-i\varDelta P_2)$$

$$\prod_{b=1}^{a}(q_1-\overline{i+b}\varDelta P_1)^2(q_2-\overline{i+b}\varDelta P_2)^2\Big\}$$

$$+\sum_{i=1}^{m-a-1}\Big\{(P_2+i\varDelta P_2)(P_2+\overline{i+a+1}\varDelta P_2)(q_1-i\varDelta P_1)(q_1-\overline{i+a+1}\varDelta P_1)$$

$$\prod_{b=1}^{a}(q_1-\overline{i+b}\varDelta P_1)^2(q_2-\overline{i+b}\varDelta P_2)^2\Big\}$$

$$+\sum_{i=1}^{m-a-1}\Big\{(P_1+i\varDelta P_1)(P_2+\overline{i+a+1}\varDelta P_2)(q_1-\overline{i+a+1}\varDelta P_1)(q_2-\overline{i+a+1}\varDelta P_2)$$

$$\prod_{b=1}^{a}(q_1-\overline{i+b}\varDelta P_1)^2(q_2-\overline{i+b}\varDelta P_2)^2\Big\} \cdots\cdots (28)$$

Note : See the notes under the preceding forms.

Results of the Interval Analysis

Far sharper decrease of the observed-values with increase in k is introduced into the interval analysis by taking the fact whether the interval has any occupied inserted-hook or not into consideration; this makes it impossible to be tried this method on the analysis of the examples in which the individuals are not so densely hooked, even if some of them are so dense as to be available for the spacing analysis. Therefore, of course, it is the important subjects not only to know the distribution patterns of respective species but also to find out the difference in the patterns with species. But the actual analyses are tried only on the examples of the yellow-fin tuna, because I am afraid that the number of the hooked-individuals of the other species than the yellow-fin tuna by each row is too scarce to obtain the results somewhat rid of the influence of accidental error; while even the theoretical-values of the original form and the excluded form of the influence of the difference in the occupied-rates of the hooks located at the different depth levels in such examples of high occupied-rates as those of the yellow-fin tuna have much risk to bear some computation error, because the unoccupied-rates of the inserted-hooks are introduced into the form of product.

Moreover, for the forms in which the influence of the gradient of the occupied-rate is excluded, especially for the values at longer k, the treatment of the unoccupied-rates of the inserted-hooks got too complicated, which not only makes it too troublesome to compute the theoretical-values but also has far more risk to introduce high computation-error into them. Accordingly, for the influence of the gradient no further consideration is given except that some attention is paid to the magnitude of the influence of this fact comparing the unexcluded value at $k = 1$ with the corresponding excluded one. Moreover, against the fact that the structure extending to wide range can be analyzed by the spacing analysis in which a little long unit-length is adopted, the difference in the treatment of the inserted-hooks of the interval method from that of the spacing one makes it impossble to give any consideration upon the structures extending to a wide range however the unit-length may be elongated. This interval method is thought to prove its merits only when this method is adopted as a preliminary step to the arrangement analysis which will be mentioned in the next part. Therefore, no description of the results of the interval analysis except the brief notes on some characteristics of the deviation in the observed-values and the difference in them from the estimated ones, are illustrated; and the meanings of respective descriptions will be easily understood from the descriptions of the results of the arrangement analysis.

1. Exposition of particular example

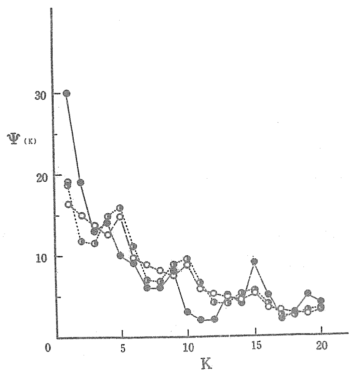


Fig. 38. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 1).

Notes (common to Figs. 38~49):

Solid circles represent the observed numbers; the open ones do the theoretical ones computed from Formulae (15) & (16), in which the occupied-rates of all the hooks are set to be the same; the marks, ◑, do those from Formulae (17)~(21), in which the influence of the periodicity of occupied-rate due to the fishing depths of hooks is taken into consideration; while the mark, ◒, does that from Formula (25), in which the influences of both the gradient and periodicity of occupied-rate are taken into consideration.

Example Y 1 : 1) The influence of the gradient of the occupied-rate is negligibly weak. 2) Rather strong contagiousness is observable within the width of two hook-intervals. 3) The observed-values in the range $4 \leqq k \leqq 14$ take continuously lower values than the estimated ones. 4) The second peak of the observed-values is at $k=15$.

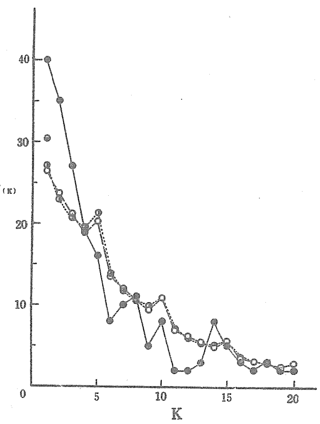


Fig. 39. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 2).

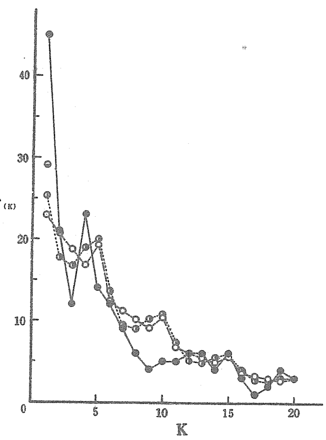


Fig. 40. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 3).

Example Y 2 : 1) The influence of the gradient raises 10 % of the estimated-values, while the difference in the occupied-rates of the hooks at the different depth levels is not so strongly influential. 2) The strong contagiousness is observable within the width of three hook-intervals. 3) But the observed-values of the rests of it are continuously lower than the estimated ones, except that at $k = 14$.

Example Y 3 : 1) Both the gradient and the difference in the occupied-rate due to fishing depths influence strongly on the values. 2) The strong contagiousness is admitted as long as one hook-interval width. 3) The second peak of the observed-values is at $k=4$. 4) The observed-values in the range $5 \leqq k \leqq 12$ continuously take lower values than the estimated ones. But those of the rests of them do not differ from the estimated ones too much.

Example Y 4 : 1) The difference in the occupied-rates due to fishing depths of hooks is significantly influential, while the influence of the gradient is negligible. 2) The strong contagiousness is observable within the width of three hook-intervals, especially strong at $k = 1$ and 3; while for the rests of it, no high observed-value is found except that at $k = 20$.

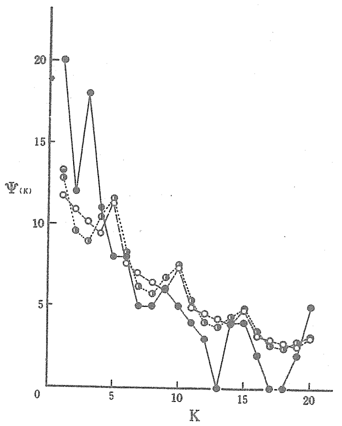


Fig. 41. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 4).

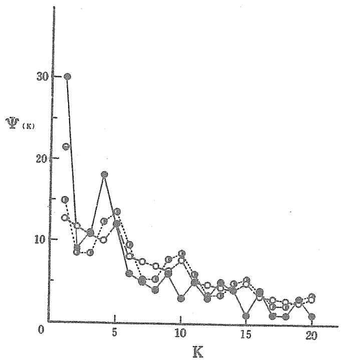


Fig. 42. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 5).

Example Y 5: 1) Both factors are strongly influential, of which the gradient is severer. 2) Contagiousness is admitted only as long as one hook-interval width, although it is extremely strong. 3) No high observed-value is found in the parts k of which is longer than a basket width.

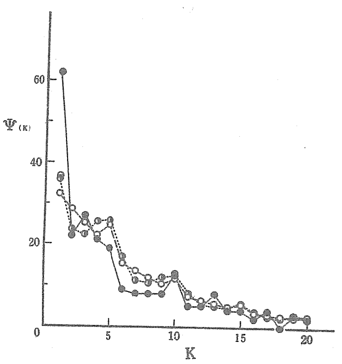


Fig. 43. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 6).

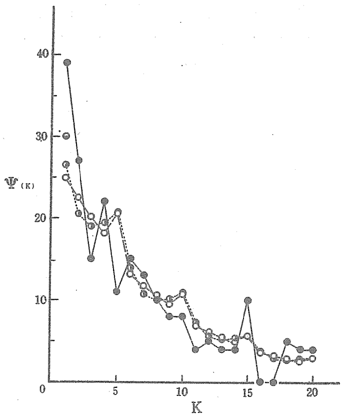


Fig. 44. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 7).

Example Y 6: 1) The influence of the gradient of the occupied-rate is negligibly weak, contrary to the fact that the difference in the occupied-rates due to fishing depths of hooks is affecting strongly on the values. 2) No contagious structure is suspected else than the fact that the observed-values at $k = 1$, 3 and 13 seem to be slightly higher than the estimated ones.

Example Y 7: 1) The gradient of the occupied-rate influences strongly on the values. 2) Rather strong contagiousness is admitted within two hook-intervals. 3) The observed-values in the rests of it slightly deviate around the estimated ones. But the observed-value at $k = 15$ seems to be higher than the estimated one.

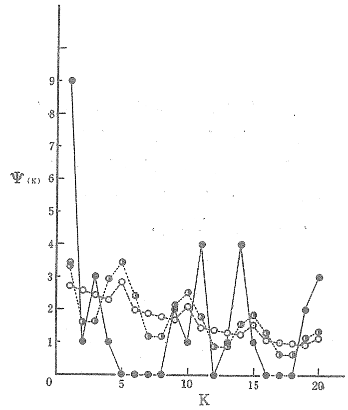


Fig. 45. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 8).

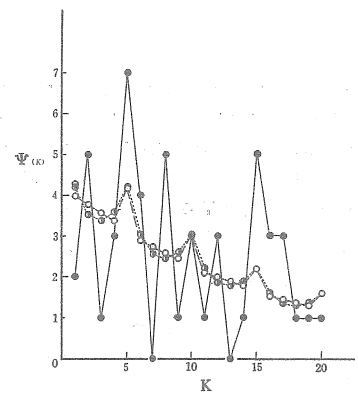


Fig. 46. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 9).

Example Y 8: 1) The poor total-catch causes the low estimated-values and the high probability to introduce accidental error into the observed-values. 2) The difference in the occupied-rates of the hooks located at the different depth levels is strongly influential, while the influence of the gradient is negligible. 3) The expectant severe influence of accidental error allows us to tell nothing but the fact that the strong contagiousness is admitted within one hook-interval width.

Example Y 9: 1) The poor total-catch has much risk to introduce severe influence of accidental error into the observed-values. 2) Not only the influence of the gradient but also that of the difference in the occupied-rates are negligibly weak. 3) The observed-values within a short interval seem to allude to a self-spacing pattern, while whether we can give any significance to it or not is highly doubtful.

Example Y 10: 1) It is one of the characteristics of the distribution pattern of this example that, if the small deviations are neglected, the observed-values exceed continuously the estimated ones rather longer hook-intervals (to $k = 8$), which suggests that even the pair of individuals hooked spaced by the width so long as to $1\frac{1}{2}$ basket can be regarded as contagious.

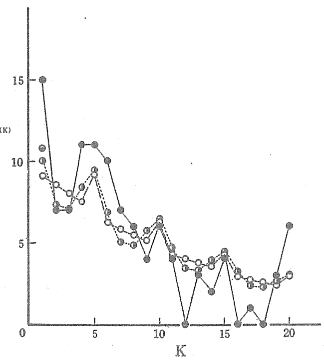


Fig. 47. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 10).

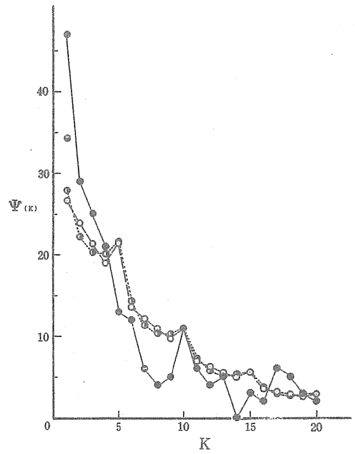


Fig. 48. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 11).

Example Y 11 : 1) The influence of the gradient is rather strong; while that of the difference in the occupied-rate due to the fishing depth of the hooks is negligibly weak. 2) Even if the influence of the gradient is taken into consideration, the observed-values deviate in showing rather long periodicity. 3) The observed-values within three hook-intervals exceed the theoretical-values, of which that at $k = 1$ is the most predominant. 4) Some significance may well be given to the high observed-values at $k = 17 \sim 19$.

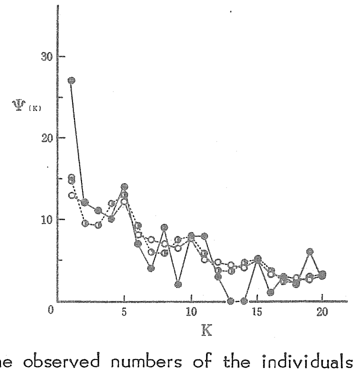


Fig. 49. The deviation of the observed numbers of the individuals spaced by respective widths from next individuals, in contrast with that of the theoretically estimated ones (Example Y 12).

Example Y 12 : 1) The difference in the occupied-rates influences strongly on the values, while contagiousness the influence of the gradient is almost negligible. 2) Nothing but strong contagiousness at $k = 1$ is alluded to.

2. Comparison of the results of the spacing analysis with those of the interval one

Before closing this part, some attention should be paid to what kinds of differences between the results are caused by the difference in the treatment of the inserted hooks. Moreover, it is far more important to give some consideration upon what structures in the pattern projected along long-line are suggested from these differences. Therefore, the results of the interval analysis are compared with those of the spacing one example by example and the deduced facts will be briefly described in the below.

Example Y 1 : The high observed-values at $k = 1, 2, 15, 16, 19$ and 20 are in common with both analyses; while for the differences in the results of both analyses, it becomes clear that the high observed-values at $3 \leqq k \leqq 5$ in the spacing analysis are chiefly due to the fact that the numbers of the intervals inserted no occupied-hook and covering respective widths are not so many while the intervals inserted some occupied ones —— constituted of two or more successively arranged intervals of one or two hook-interval width —— are more frequently observable than expected.

Example Y 2 : The results of the spacing analysis and the interval one, if dare to say, tell us superficially considerably different patterns, and this fact may chiefly be due to the following reasons: the continuously high observed-values of the spacing analysis within three hook-intervals may be thought as if to allude to the same results as those of the interval analysis. Yet, for even these high observed-values, the more careful examination reveals that the intervals inserted no occupied-hook and covering respective widths are, of course, a little more frequently observable, but such fact surely contributes to emphasizing the high observed-values in the spacing analysis that two or more intervals, each covering one or two hook-intervals arranged successively and covering within three hook-intervals, are also more frequently observable than expected. And, this second reason —— two or more intervals of shorter width arranged successively are far more frequently observable than expected— is more heavily influential at $k=4, 5, 8$ and from 10 to 18, consequently, the observed-values at these k in the spacing analysis become higher than expected, overcoming the low observed-values in the interval analysis, which are each as equal as the number of the intervals of respective lengths and inserted no occupied-hook.

Example Y 3 : The pattern deducible from the results of both analyses seems to be somewhat different from each other. Yet, if we suppose as follows, the pattern alluded to from the results of the spacing analysis can be expected from the results of the interval analysis: the intervals of one hook-interval width are far more frequently observable than expected; accordingly the number of the intervals of a certain length (k') constituted of some intervals of one hook-interval wide and of some ones shorter than this length (k') are expected to be far more frequently observable; and the deficiency of the intervals covering the width longer than one hook-interval, or —— if neglecting the small deviations —— longer than a basket and inserted no occupied-hook is complemented and the observed-values in the spacing analysis come to deviate around the estimated ones, just the same pattern as the results of the spacing analysis.

Example Y 4 : The differences between the results of both analyses, except those observed at $k = 4$ and 5, are not so significant and can be easily explained by the same reason mentioned already in the preceding example. Moreover, even the differences observable at $k = 4$ and 5 are also easily recognizable by the same reason —— *i.e.*, even if the number of the intervals each covering 4 or 5 hook-intervals may be observed as frequently as or somewhat less frequently than that expected in the chance distribution, the intervals covering as long as or shorter than three hook-intervals occur more frequently, consequently, the numbers of the intervals covering 4 or 5 hook-intervals inserted any occupied-hook (= constituted of some successively arranged intervals) must be also far more frequently observable, which result to show high observed-values in the spacing analysis, because by which ways the intervals of 4 or 5 hook-interval width may be sectioned, most of the compornents are as long as or shorter than three hook-intervals.

Example Y 5 : The gradient influences rather severely on the values and its influence raises $1/3$ of the estimated-value at $k = 1$. And if the series of the theoretical-values in the interval analysis at longer k might be computed, I am afraid that considerably high computation-error may be introduced. Accordingly, exactly speaking, no probable suggestion can be found out for the problem that the estimated-values in the interval analysis at longer k should be corrected how largely, or, if dare to say, even for the problem whether they should be increased or decreased. Furthermore, not only the estimated-values in which the influence of the gradient is not excluded but also the observed ones of the interval analysis in the range $k \geqq 10$ do not reach five; accordingly the results are thought to be strongly influenced by accidental error. Therefore, no description is given to the difference between the patterns deduced from the results of the spacing analysis and those of the interval one but somewhat similar pattern may be deducible from both methods.

Example Y 6 : In such example of high occupied-rate as this, the theoretical-values of the interval analysis decrease rapidly (this means that the absolute difference itself of the theoretical-values at shorter interval from longer one is the larger, when the occupied-rate P is the higher, although the rate of decrease per increase in hook-interval is nearly as equal as q which is the smaller). Thus, the large difference between the theoretical-values in the interval analysis from those in the spacing one at longer k is expected, because the theoretical-values in the spacing analysis do not decrease so sharply. And the intervals in the spacing analysis corresponding to this difference are those with occupied-hook, in other words, those constituted of some shorter intervals arranged successively. Therefore, the difference in the treatment of the inserted occupied-hook in the interval analysis from that in the spacing one is severely influential in such example of high occupied-rate as this.

For the results of the interval analysis of this example, the observed-value at one hook-interval width exceeds largely the estimated one, while those of the rests of it are rather lower than the estimated ones. And the observed-values in the spacing analysis seem to be strongly affected by the predominance of the intervals of one hook-interval wide, consequently, such results as represented in the spacing analysis can be easily presumed, *i.e.*, the observed-values in the spacing analysis at $k \leq 13$ exceed continuously the estimated ones, and those in the range from $14 \leq k \leq 20$ are increased into the values as high as the estimated ones.

Example Y 7 : The intervals covering one or two hook-interval width are far more frequently observable, which slightly raises all the observed-values in the spacing analysis. This fact considered together, most of the deviations of the observed-values in the spacing analysis can be easily recognized, but the slightly high value at $k = 11$ and the conspicuously low value at $k = 12$ may be thought to be due to some specific structures or accidental error because no symptom suggesting the possibility in the occurrence of them can be found out from the interval analysis.

Example Y 8 : All the estimated-values in the interval analysis do not reach five, because of the scarcity of the hooked-individuals. Accordingly, I am afraid of the fact that considerably severe influence of accidental error is introduced. And also the low occupied-rate results in the small difference in the observed-values as well as in the estimated ones between the spacing analysis and the interval one, as actually obtained.

Example Y 9 : Despite of the low observed-values and the estimated ones which have much risk to introduce severe influence of accidental error, quite the same pattern is suggested from both analyses.

Example Y 10 : Although some differences seem to be observable between the results of both analyses at the parts where $k \geqq 10$, we can not give any significance upon them, because both the observed-values and the estimated ones of the interval analysis in the range from $k = 10$ to 20 are not so high enough as to be deducible any fact excerting on not so severe influence of accidental error. Accordingly, it may well be considered that considerably well coincident pattern is suggested from the results of both analyses, against the fact that the intervals covering one hook-interval width are observable 150 % as frequently as expected, which is probable to increase all the observed-values in the spacing analysis.

Example Y 11 : Pay heed to the fact that the same special attention as Example Y 5 (strong gradient) and as Example Y 6 (high occupied-rate) should be paid to the comparison of the results of both analyses. Then the apparent differences in the results between both analyses come to be recognizable. That is to say, the continuously high observed-values within three hook-intervals are in common with both analyses. But the observed-value at $k = 4$ in the spacing analysis largely exceeds the estimated one against the fact that the observed one in the interval analysis, if taking the influence of the gradient into consideration, is a little lower than the estimated one. And the higher value at $k = 5$ than the estimated one is observable in the spacing analysis, despite of the fact that the observed one in the interval analysis is far lower than the estimated one. And the similar but enfeebled differences can be observed at $k = 6$ and 7; while for the range from $k = 8$ to 20, the tendency to the difference in the observed-values between both analyses becomes weaker and weaker with increase in k and the deviations of the observed-values in both analyses tend to show the features capable of regarding as the same, if accidental error due to the low observed-values and the estimated ones are taken into consideration. These phenomena are thought to be due to the fact that the most of the compornent-intervals constituting not so long intervals are those covering one or two hook-interval width and the predominance of them affects conspicuously on the occurrence in the intervals of not so long width, but the proportion of such shorter intervals to total compornent-intervals decreases with increase in k and the predominance of shorter ones becomes less influential.

Example Y 12 : The deviation of five hook-interval periodicity of the observed-values in the spacing analysis is rather conspicuously represented, against the fact that no clear symptom suggesting the possibility in the occurrence of it is observable in the results of the interval analysis. Accordingly, this may be thought to be due to the specific structure. Besides this, more detailed examination suggests the presence of some other differences. For examples, the observed-value in the spacing analysis at $k = 3$ is not so high as to be supposed from the predominance in the observed-value in the interval analysis at $k = 1$; at $k = 7$, the observed-value in the spacing analysis is a little higher than the estimated one but the observed-value in the interval analysis is lower than the estimated one; while at $k = 8$, the observed-value in the spacing analysis is lower than the estimated one although the observed-value in the interval analysis exceeds the estimated one; and at $k = 14$, the observed-value in the spacing analysis exceeds the estimated one against the fact that the observed-value in the interval analysis is lower than the estimated one.

Summarized results of the comparison

The observed-values and the estimated ones in the interval analysis do not contain any interval with any occupied-hook. Accordingly, the difference in the values of the spacing analysis from the interval one represents theoretically the number of the intervals of respective lengths with any occupied-hook. Accordingly, the difference in the observed-value from the estimated one in the spacing analysis at any k_1 represents the differences in the interval analysis in the range $k \leqq k_1$ cumulatively. And, the most of the apparent differences in the results in the spacing analysis from those in the interval one are easily explained from the above-mentioned reasons, but only a little of them can do so, which is thought to be based on the specific structure.

Part III Arrangement Analysis

Method of Analysis

Adding the interval analysis makes the distribution pattern analyzable more easily and clearly overcoming the influence of the fact whether any of the inserted-hook in the interval under consideration is occupied or not; but we can certify from the results of this analysis only the fact that the intervals how longly covering are more frequently observable than expected from the chance distribution. But there remains another factor untouched —— this is the manner of the arrangement of the intervals covering respective widths. And if we want to find out any clear conclusion of the distribution pattern, the interval analysis is not sufficient, but the following series of analysis should be added, which is, for convenience' sake, called "arrangement analysis".

The school commonly recognized may indicate the aggregation of the individuals having some psychological interrelations one another. But, for the population certified by the distribution pattern of the hooked-individuals along long-line, it is very hard to certify the presence of any psychological relation, because the individuals are swimming in too deep layer and scattering about too wide space. And even if dare to know, nothing else than static characteristics such as body length, body weight, stomach contents, radioactive contamination degree *etc.* is the factor actually applicable. But they can not effectively tell us the possibility of the presence or absence of the psychological relation nor can be the proof capable of supporting its presence. Thus, there is no factor more suitable for finding out the feature of school-formation than the distribution of the hooked-individuals along long-line. Therefore, I wish to, hereafter, analyze the distribution pattern of the hooked-individuals along longline as in detail as possible; then by evolving from the results of the analyses, as many suggestions about the pattern as possible are guessed.

Now, let us give some consideration to "the school projected along long-line". For beneficial to the methodological meaning, I wish to define here what-we-call school the individuals forming the short intervals arranged successively, although I treated hitherto it involuntary like this. Accordingly, if the length, k, which is the maximum length capable of being regarded as the short interval, is determined, the number of the intervals each as long as or shorter than k, when all individuals are distributed by chance, is estimative from the theoretical-values in the interval analysis. But it is naturally able to be expected that there will be some short intervals arranged successively, even if all individuals are distributed by chance; and the expectant number of the lots constituted of W successive intervals each of which is as long as or shorter than k, when all individuals are scattered by chance, is computable adopting the method mentioned in the below.

Let us set that N individuals are hooked by a row. Then, total number of the intervals nipped by the individuals is $(N-1)$; while the number of the intervals as long as or shorter than k hook-interval width is $\sum_{k=1}^{k} \Psi_{(k)}$, which is estimative from the formulae in the interval analysis. Therefore, the probability of any interval as long as or shorter than k hook-interval width is $P_{i(k)} = \frac{\sum_{k=1}^{k} \Psi_{(k)}}{N-1}$. And the number of the manner picking up the lot of W successive intervals from $(N-1)$ intervals arranged along a line is $\{(N-1)-(W-1)\}$. Among them, to begin counting W successive intervals from the foremost interval or to end in the hindmost interval lack each one of the preceding or succeeding interval, but other W successive intervals of $\{(N-1)-(W-1)-2\}$ manner are nipped by other intervals. Accordingly, the expectant number in the occurrence of W successive intervals, each of which is as long as or shorter than k hook-intervals and located between the intervals longer than k hook-interval width, is

$$(N-W-2)\,[P_{i(k)}]^{W}[q_{i(k)}]^{2}$$

while that of the terminal W successive intervals sectioned by longer interval is

$$2[P_{i(k)}]^{W}[q_{i(k)}]$$

And the sum is

$$S_{(Wk)} = [P_{i(k)}]^{W}[q_{i(k)}][(N-W-2)q_{i(k)}+2] \cdots\cdots (29)$$

while when $W=N-1$,

$$S_{(Wk)} = [P_{i(k)}]^{W}$$

Then, the number of the schools constituted of $(W+1)$ individuals caused as the results of the schooling tendency is estimated to be as equal as the difference in the observed-value from the corresponding estimated one.

Accordingly, the most important key point is how to determine the key-length, k. And when the observed-values of the interval analysis in the range from 0 to k_1 exceed continuously the estimated-values, this k_1 seems to be, of course, one of the most valid key-lengths (for the school in which the individuals are hooked self-spacingly, the maximum length of the first peak of the observed-values may be substituted in place of this length); while it can not be the exclusive key-length, but may be the key-length of considering the most basic structure, and the structures of higher orders may be able to be discussed substituting respective k, where the observed-values in the interval analysis exceed the estimated ones, into this k_1.

But before discussing the actually analyzed examples, I must call some attention to the fact that this method can be effectively adopted only in the example in which considerably many individuals are hooked, because of the following reasons: the total number of the intervals is limited to be $(N-1)$ and each apparent school is constituted chiefly of group of the intervals and partly of single ones, consequently, the total number of even the apparent schools has to be far less than $(N-1)$ and the number of the apparent schools of respective population sizes must be, naturally, far less, moreover the number of the actual schools of respective population sizes due to the schooling tendency is extremely scarce, because the number of the actual schools due to the schooling tendency is as equal as the difference in the observed number from the estimated one. Accordingly, the actual analyses are tried only on the distribution patterns of the yellow-fin tuna, because I am afraid that the poor total-catch has much risk to introduce severe influence of accidental error, although the fact we know earnestly is rather the difference in the pattern with species. Moreover, during the decoding, the following fact should be kept in mind that the influence of the presence of the buoy-lines is not yet excluded from the theoretical-values. Accordingly, despite of the fact that the formula shows as if to be observable the lots constituted of more than three intervals of each one hook-interval wide arranged successively, although they are not so many, none of such a lot can occur actually, because the buoy-lines interrupt the occurrence in such a case. But so far as I have been concerned, —— within such a number of main-lines (from 350 to 400 baskets) and within such a low occupied-rate (lower than 20 %) as in the actual examples——, these imaginal theoretical-values can not reach such a high value as incapable of being regard as equal as zero. And also a half number of the lots of two or three intervals of each two hook-intervals long arranged successively is, in fact, the imaginal one occurrence of which is interrupted by the buoy-lines, and the ratio of such imaginal ones decreases with increase in k and with decrease in W. Accordingly, the presence of the buoy-lines makes the theoretical-values computed from this formula involuntary to show a slightly contagious distribution. But there seems to be no need to exclude the influence of the presence of the buoy-lines committing against many difficulties, because the observed-values are usually biased from the estimated ones with this error to the counter direction to the expectant theoretical-values free from this error, or, even if the same direction, large difference incapable of neglecting can not be found between the observed-values and the estimated ones with this error; these mean that the distribution pattern actually observable in the examples is more contagious than or as contagious as the estimated-values with this error. Therefore, the estimated-values, in which the influence of the presence of the buoy-lines is not excluded, are computed and the distribution patterns of the yellow-fin tuna in respective examples are examined.

Results

1. Exposition of particular example

Example Y 1

Structure at the elemental step ($k = 2$): The groups of the individuals forming the lots constituted of single or successively arranged intervals of as long as or shorter than two hook-intervals are regarded to be the apparent elemental-clusters,

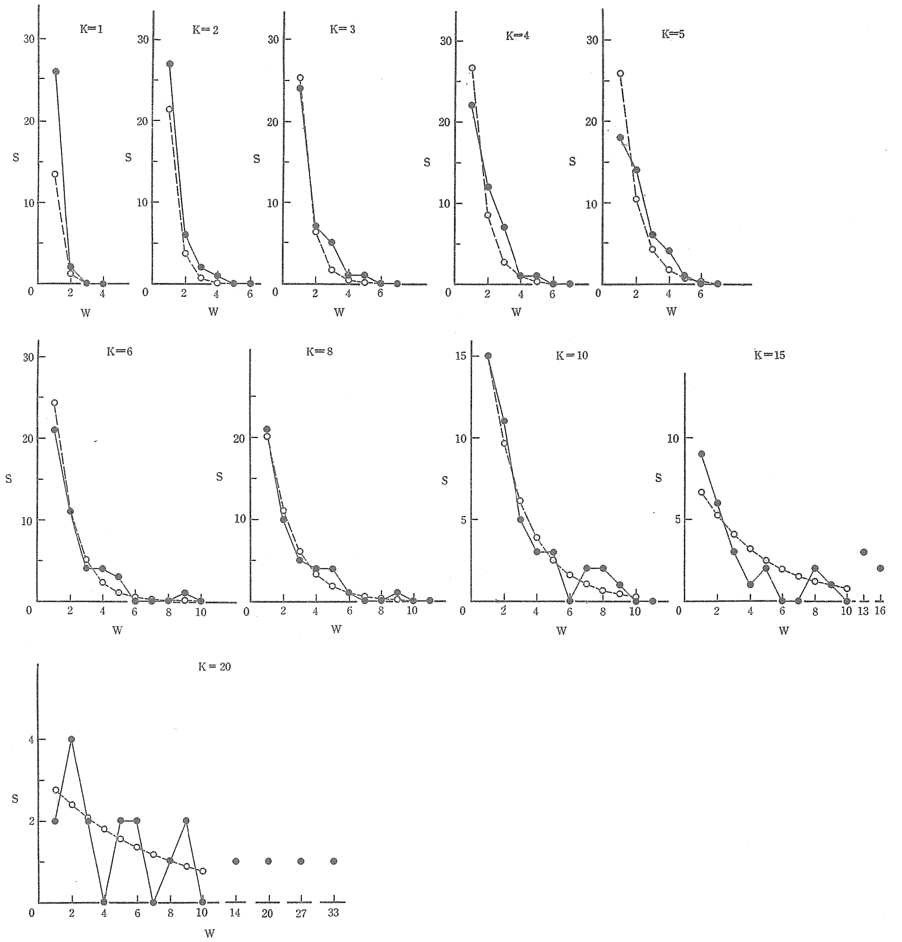


Fig. 50. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 1).

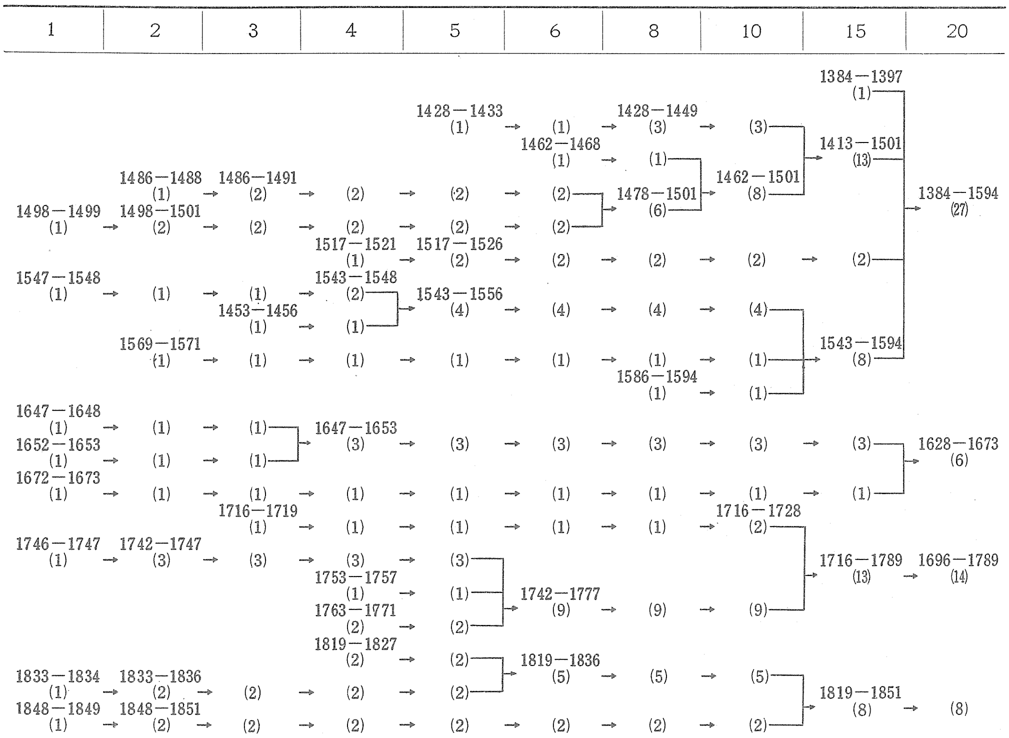
Notes (common to Figs. 50~61):

The solid circles show the numbers of the apparent clusters, while the open ones do the theoretical numbers of the false ones. "k" is the key-length in hook-interval. $(W+1)$ is the population size of clusters.

because the strong contagiousness extending to two hook-intervals is suggested from the interval analysis. But even if all individuals are distributed by chance, there are some lots constituted of single or successively arranged intervals of such a length, and the expectant number in the occurrence of the lots of W successive intervals (including single ones) constituted of the intervals as long as or shorter than k, when all individuals are distributed by chance, is computed from Formula (29). Ac-

Table 11. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 1).

1	2	3	4	5	6	8	10	15	20
	2—4 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
	174—178 (2)	(2)	(2)	(2)	(2)	(2)	(2)	163—178 (3)	163—198 (6)
196—198 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	
	277—279 (1)	(1)	273—279 (2)	(2)	(2)	(2)	264—279 (3)	264—308 (9)	(9)
298—299 (1)	(1)	298—303 (3)	(3)	298—308 (4)	292—308 (5)	(5)	(5)		
302—303 (1)	(1)								
						372—387 (2)	363—387 (3)	348—387 (4)	
					406—412 (1)	(1)	(1)	(1)	348—509 (20)
432—433 (1)	(1)	(1)	(1)	432—442 (3)	432—448 (4)	(4)	(4)		
			438—442 (1)						
463—464 (1)	(1)	(1)	(1)	463—469 (2)	(2)	(2)	(2)	432—509 (13)	
482—483 (1)	(1)	482—486 (2)	(2)	(2)	(2)	(2)	(2)		
	507—509 (1)	(1)	(1)	(1)	(1)	(1)	497—509 (2)		
					572—578 (1)	(1)	(1)	572—592 (2)	556—592 (3)
638—639 (1)	638—643 (3)	(3)	(3)	638—648 (4)	(4)	(4)	(4)	624—648 (5)	624—703 (9)
702—703 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
			748—752 (1)	(1)	(1)	741—752 (2)	(2)	(2)	(2)
						792—799 (1)	(1)	(1)	792—847 (5)
817—818 (1)	(1)	(1)	(1)	(1)	(1)	(1)	817—827 (2)	(2)	
		878—881 (1)	(1)	(1)	(1)	(1)	(1)		
896—897 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
916—917 (1)	912—919 (4)	(4)	(4)	(4)	(4)	(4)	912—933 (8)	878—968 (16)	
928—929 (1)	(1)	928—933 (3)	(3)	(3)	(3)	(3)			
932—933 (1)	(1)								
		948—951 (1)	(1)	(1)	(1)	(1)	(1)		878—1092 (33)
	966—968 (1)	(1)	(1)	(1)	(1)	(1)	(1)		
1012—1013 (1)	(1)	(1)	1008—1013 (2)	(2)	(2)	1001—1013 (3)	1001—1048 (7)		
						1032—1039 (1)			
1063—1064 (1)	(1)	(1)	(1)	(1)	(1)			987—1092 (16)	
1072—1073 (1)	(1)	(1)	1072—1078 (3)	(3)	(3)	1063—1078 (5)			
1077—1078 (1)	(1)	(1)					1063—1092 (7)		
				1087—1092 (1)	(1)	(1)			
1122—1124 (2)	(2)	1119—1128 (5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
1127—1128 (1)	(1)								
1172—1173 (1)	(1)	1172—1179 (3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
	1207—1209 (1)	(1)	(1)	1202—1209 (2)	(2)	(2)	(2)	(2)	(2)
				1231—1236 (1)	(1)	(1)	(1)	(1)	(1)
		1283—1286 (1)	(1)	(1)	(1)	(1)	(1)	(1)	1283—1302 (2)
			1358—1362 (1)	(1)	(1)	(1)	(1)	(1)	1339—1362 (2)



Note for Tables 11～22 ;

1) Number not enclosed in brackets indicates "Hook Number". While that of enclosed indicates the number of intervals constituting the lot. Accordingly, the value which is as large as this number plus 1 becomes number of individuals forming the lot.

2) All hooks and buoy-lines, excepting the buoy-lines of terminals of a row, are numbered from beginning to hauling. And this number is called as Hook Number. Consequently, the *Ath* hook in the *Bth* basket is named as a hook of "Hook Number 5(B－1)＋A".

cordingly, among the apparent-clusters of respective population-sizes, the numbers of which are represented as the observed-values in Fig. 50 — (2), those caused by the schooling tendency are illustrated as the difference in the observed-values from the estimated ones. When discussed the schooling tendency, the individuals, falsely forming the lots constituted of single or successively arranged intervals expected to be caused even if all the individuals are distributed by chance, should be also regarded as the single individuals, although they seem, in appearance, as if to form clusters. Therefore, the structure at the elemental step is guessed as follows : the population is constituted of 11 true-clusters, which are six pairs of individuals, two clusters constituted of each three individuals, two clusters of each four individuals and a cluster of five individuals, mingling with about 150 single individuals. And the hooked positions of the elemental-clusters constituted of four or one more hooked-individuals are easily estimative from Table 11; while for the rests of them, it is very hard to estimate the hooked positions, because we can hardly distinguish the true elemental-clusters due to the schooling tendency from the false ones caused by the chance distribution.

Structure at the second order ($k = 15$): Then the feature of the cluster-formation at the next order can be deduced from Fig. 50 — (15), in which k is elongated into as long as 15 hook-intervals, because the second peak of the observed-values in the interval analysis is found around $k=15$. But, for the attempt not only to use as one of the auxial proofs to distinguish the clusters due to the schooling tendency from those caused by the chance distribution but also to represent the feature of the appearance, disappearance and fusion of the clusters at respective steps of increase in k, the results of the analyses in which k is increased step by step are also represented in Table 11 and Figs. 50—(3), (4), (5), (6), (8), and (10). The observed numbers of the apparent-clusters constituted of as equal as or less than 10 hooked-individuals are not so far from the corresponding theoretical ones, as represented in Fig. 50; therefore, there is no need to consider that any of them is the true-cluster caused by the schooling tendency. But among three apparent-clusters constituted of each 14 hooked-individuals and two apparent ones of each 17 hooked-individuals, at least three or one more clusters are thought to be due to the schooling tendency and are regarded as the true-clusters. And the results at lower steps of the analyses considered together, they are thought to be hooked in the ranges, respectively from the third hook in the 176th basket (Hook Number 878) to the hook of the same order spaced by 18 baskets (H. N. 968) (constituted of 17 hooked-individuals), from the second hook in the 198th basket (H. N. 987) to the hook of the same order spaced by 21 baskets (H. N. 1092) (also 17 individuals), from the third hook in the 283th basket (H. N. 1413) to the first hook in the 301th basket (H. N. 1501) (14 hooked-individuals) and from the first hook in the 344th basket (H. N. 1716) to the last hook in the 358th basket (H. N. 1789) (also 14 hooked-individuals), and their structures at the subordinate orders can also be assumed from this table. Here, the word "Hook Number X" which is abbreviated to *H.N.X*, is introduced; this indicates the position where the *xth* hook including the buoy-lines counting from the beginning of hauling of the gears is located, for the purpose of representing the hooked positions. Besides, another apparent aggregation of such a population-size is observable, but it can not be regarded as the true cluster, not only because one or more apparent-clusters of such a population-size have to occur even if all individuals are distributed by chance but also because no proof with it supported a true one can be found in the structure at the subordinate orders. Accordingly, the distribution pattern at this order is assumed as follows: the population is constituted chiefly of many single individuals and elemental-clusters, and mingling with them, four clusters are contained; and the individuals derived from the former group occupy $\frac{2}{3}$ of total catch, while catch from the true-clusters occupies half as many as that from the former group.

Structure at the highest order ($k=20$): The third peak of the observed-values in the interval analysis is found about $k=20$. Accordingly, the distribution pattern deducible from Fig. 50 — (20), in which a width of 20 hook-intervals is adopted as the key-length, may be that of the highest order observable within a row, because the intervals longer than 20 hook-intervals are only as many as $\frac{1}{10}$ of total ones moreover the observed-values and the estimated ones in the interval analysis in the range $k>20$ are extremely scarce, which makes it impossible to give any significance to the difference in the observed-values from the estimated ones. Here, if the individuals are distributed showing gradient, the hooked positions of the true-schools should be determined by considering the influence of the gradient of the distribution together with the structure at the subordinate orders, because the gradient influences the apparent-schools as if the more frequently hooked at the latter parts of the hauling in a row. But there is no need to pay any attention to the influence of the gradient, because not so strong gradient is alluded to. If neglecting the small deviations, Fig. 50 — (20) shows that the observed numbers of the clusters each constituted of from two to 11 hooked-individuals are not so far from the corresponding estimated ones which represent the numbers caused by the chance distribution; accordingly, none of the apparent-schools of such population-sizes are regarded as the true one caused by the schooling tendency. And concerning an apparent-cluster constituted of 15 hooked-individuals, no fact suggesting us whether it can be regarded as the true one or the false one is found out from this figure, but the structure at the subordinate order suggests us that it is more reasonable to regard this as the true-cluster caused by the schooling tendency. It may safely be considered that three apparent-schools constituted of 21, 28 and 34 hooked-individuals respectively are due to the schooling tendency; and they are thought to cover the ranges from the third hook in the 70th basket (H.N. 348) to the last hook in the 102th basket (H.N. 509) (constituted of 21 hooked-individuals), from the third hook in the 176th basket (H. N. 878) to the second hook in the 219th basket (H.N. 1092) (34 hooked-individuals) and from the last hook in the 277th basket (H.N. 1384) to the hook of the same order spaced by 42 baskets (H.N. 1594) (28 hooked-individuals), and the probable one constituted of 15 hooked-individuals is assumed to be hooked in the range from the first hook in the 340th basket (H.N. 1696) to the last hook in the 358th basket (H.N. 1789). And their structures at the subordinate order can also be easily deduced from this table. Thus, about 46 % of total catch are occupied by the individuals forming four true-schools, while the rests of it are by the individuals swimming solitarily or forming the aggregations at respective steps of the subordinate orders.

But lastly, I have to describe clearly the fact that even the average occupied-rates of the hooks in the parts, where these true schools are hooked, are not so high as impressed superficially from the word "school", but are from 0.16 to 0.20, which are from 35 % to 65 % higher than that computed from throughout a row. Accordingly, the distribution pattern is thought to be not so different from the chance distribution as superficially impressed, because the chance distribution does not mean that the occupied-rate is throughout the same, but some dense and diverse are naturally expectable.

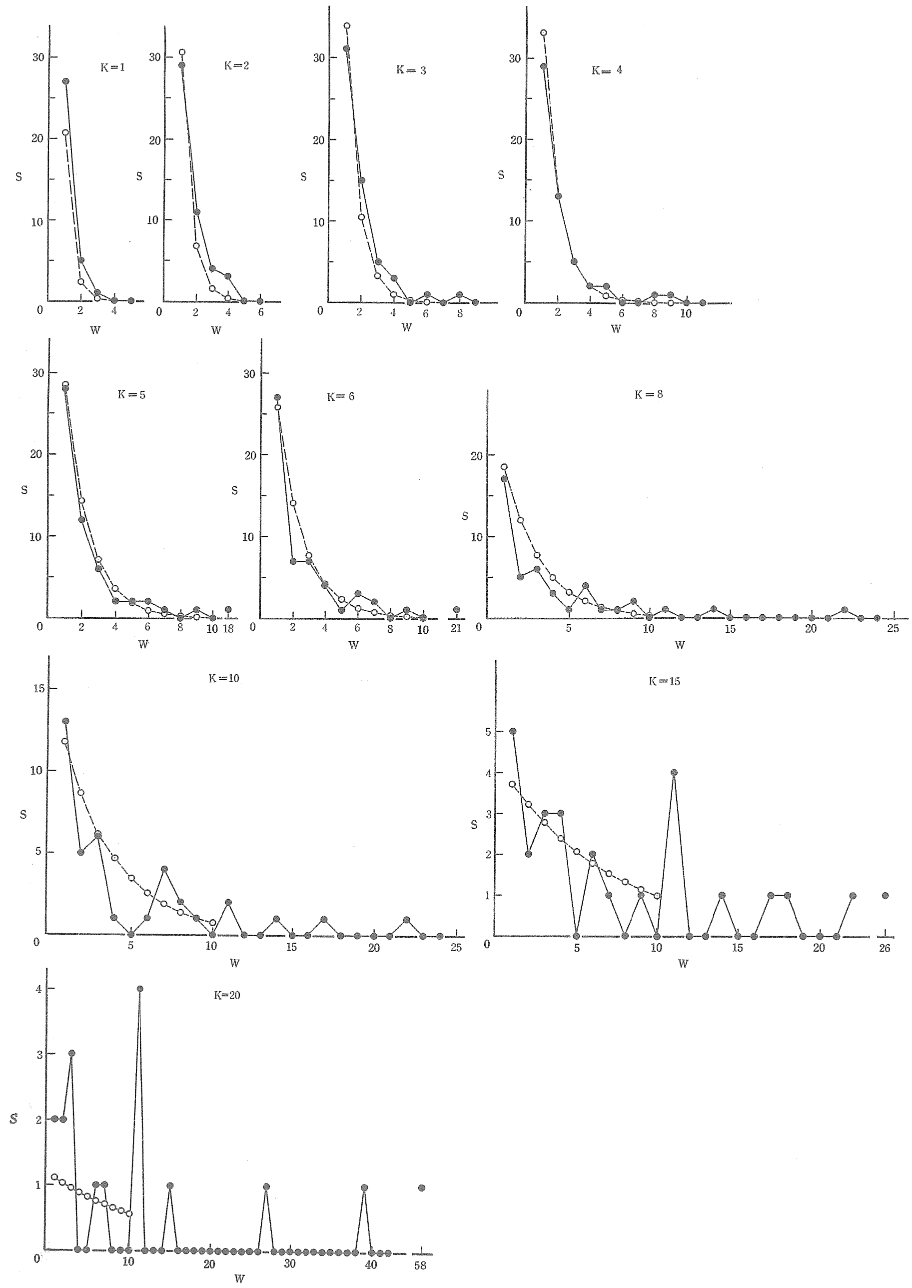


Fig. 51. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 2).

Example Y 2

Structure at the elemental step ($k = 3$) : The observed-values in the range from $k = 1$ to 3 hook-intervals in the interval analysis are continuously higher than the estimated ones; this means that the lots of single or successively arranged intervals constituted of the intervals each covering as long as or shorter than three hook-intervals, are regarded as the apparent elemental-clusters. But Fig. 51—(3), in which the result of the arrangement analysis (key-length : $k = 3$) is represented, tells us that only eight clusters —— which are four clusters constituted of each three hooked-individuals among 15 apparent ones, two clusters each constituted of four hooked-individuals among five and two of the five hooked-individual clusters among

Table 12 a. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 2).

1	2	3	4	5	6	8	10	15	20
31−32	29−32							18−32	
(1)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(3)	(3)
98−99	94−99								
(1)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
					161−167				161−184
					(1)	(1)	(1)	(1)	(2)
								213−227	
								(1)	(1)
			253−257						
			(1)	(1)	(1)	(1)	(1)	253−307	
268−269	268−273								
(1)	(3)	(3)	(3)	268−286		268−293		(11)	(11)
	281−283	278−286		(7)	(7)	(8)	(8)		
	(1)	(3)	(3)						
				411−416					
				(1)	(1)	(1)	(1)	(1)	(1)
				462−467					
				(1)	(1)	(1)	(1)	462−487	
				482−487				(3)	(3)
				(1)	(1)	(1)	(1)		
		528−531							
		(1)	(1)	(1)	(1)	528−551			
				546−551		(4)			
				(1)	(1)		528−562		528−579
561−562							(6)	(6)	(7)
(1)	(1)	(1)	(1)	(1)	(1)	(1)			
611−614	609−614								
(3)	(4)	(4)	(4)	(4)	(4)	609−624	609−634		
		621→624				(6)	(7)	(7)	
		(1)	(1)	(1)	(1)				
			653−657						609−714
			(1)	(1)	(1)	(1)	(1)	(1)	(15)
			702−706	697−706	691−706	691− 714			
			(1)	(2)	(3)	(4)	(4)	(4)	
757−758									
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
	772−774								
	(1)	(1)	(1)	(1)	(1)	(1)	(1)	757−818	
791−792								(11)	(11)
(1)	(1)	(1)	(1)	786−808			786−818		
	802−804		802−808	(6)	(6)	(6)	(7)		
	(1)	(1)	(2)						
							853−863	839−863	
							(1)	(2)	(2)
	901−903	901−906							
	(1)	(2)	(2)	(2)	(2)				
		913−916							
		(1)	(1)	(1)	913−926	901−941			
	922−926				(4)	(11)	(11)	(11)	(11)
	(2)	(2)	(2)	(2)					
938−939	938−941		934− 941						
(1)	(2)	(2)	(3)	(3)	(3)				
	987−989		987−993		981−993				
	(1)	(1)	(2)	(2)	(3)	(3)	(3)	967−1008	
1007−1008								(6)	(6)
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		

1	2	3	4	5	6	8	10	15	20
1037−1038 (1)	(1)	1034−1038 (2)	1034−1042 (3)	(3)	(3)	(3)	(3)		
	1056−1058 (1)	(1)	(1)						
		1063−1066 (1)	(1)					1034−1122 (26)	
1076−1077 (1)	1074−1077 (2)	1071−1077 (3)	(3)						
1082−1083 (1)	(1)	(1)	(1)	1056−1103 (18)	1056−1114 (21)	1056−1122 (22)	(22)		
1093−1094 (1)	1091−1094 (2)								
1097−1099 (2)	1097−1103 (4)	1088−1103 (8)	(8)						1034−1334 (58)
	1112−1114 (1)	1109−1114 (2)	(2)	(2)					
1138−1139 (1)	(1)	(1)	(1)	(1)	(1)				
	1146−1148 (1)	(1)	(1)	(1)	(1)	1138−1148 (3)	(3)		
1192−1193 (1)	(1)	(1)	(1)	1187−1193 (2)				1138−1242 (18)	
1201−1203 (2)	1199−1203 (3)	(3)	(3)	(3)	1187−1203 (6)	(6)	1178−1226 (11)		
	1216−1218 (1)	1213−1218 (2)	(2)	(2)	(2)	1213−1226 (3)			
		1239−1242 (1)	(1)	(1)	(1)	(1)	(1)		
		1266−1269 (1)	1262−1269 (2)	(2)	(2)	1262−1306 (9)	(9)	(9)	
	1277−1281 (2)	(2)	(2)	1277−1286 (3)	1277−1292 (4)				
	1332−1334 (1)	(1)	(1)	(1)	(1)	(1)	1322−1334 (2)	(2)	
1391−1392 (1)	1391−1394 (2)	(2)	(2)	1391−1408 (6)	(6)	(6)	1382−1408 (7)		
	1399−1401 (1)	1399−1404 (2)	1399−1408 (3)					1382−1437 (11)	(11)
			1422−1426 (1)	(1)	(1)	(1)	1422−1437 (3)		
1436−1437 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
			1467−1471 (1)	(1)	(1)	1467−1491 (7)	(7)		
1486−1488 (2)	(2)	1483−1491 (4)	1479−1491 (5)	(5)	(5)				
	1507−1509 (1)	1504−1509 (2)	(2)	(2)	(2)	(2)	(2)		
1522−1523 (1)	(1)	(1)	1522−1527 (2)	(2)	(2)	(2)	(2)	1467−1569 (22)	
1541−1542 (1)	1539−1542 (2)	(2)	1539−1546 (3)	(3)	(3)				
		1553−1556 (1)	(1)	(1)	(1)	1539−1556 (5)	1539−1569 (8)		1467−1617 (27)
1568−1569 (1)	1566−1569 (2)	(2)	(2)	(2)	(2)	(2)			
		1588−1591 (1)	(1)	(1)	(1)	1588−1599 (2)	(2)	1588−1617 (4)	
		1614−1617 (1)	(1)	(1)	(1)	(1)	(1)		
		1641−1644 (1)	(1)	(1)	(1)	(1)	(1)	(1)	
1677−1678 (1)	(1)	(1)	1669−1678 (3)	(3)	(3)				
		1686−1689 (1)	(1)	(1)	(1)				
1696−1697 (1)	(1)	(1)	(1)	(1)		1662−1714 (14)	(14)	(14)	
1707−1708 (1)	(1)	(1)	1703−1714 (5)	(5)	1696−1714 (7)				1641−1838 (39)
1712−1714 (2)	(2)	(2)							
1743−1744 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
1753−1754 (1)									
1756−1758 (2)	1753−1758 (4)	(4)	(4)	(4)	(4)	(4)	1734−1788 (17)	(17)	
	1767−1769 (1)	1767−1772 (2)							
1781−1782 (1)	1779−1784 (3)		1767−1788 (9)	(9)	(9)	(9)			
1787−1788 (1)	(1)	1776−1788 (6)							
1837−1838 (1)	(1)	(1)	(1)	(1)	(1)	1821−1838 (3)	(3)	1806−1838 (4)	

three —— are regarded as the true-clusters at the elemental step; and although the hooked positions of the apparent-clusters of such population-sizes are represented in Table 12 a, those of the true ones are not certain because it is very hard to distinguish the true ones from the false ones. But concerning two apparent-clusters constituted of each more than six hooked-individuals, there may be no doubt that they are caused by the schooling tendency, consequently they are regarded as the true ones. And they are guessed to cover the ranges respectively from the third hook in the 218th basket (H.N. 1088) to the third hook in the 221th basket (H.N. 1103) (constituted of nine hooked-individuals) and from the first hook in the 356th basket (H.N. 1776) to the third hook in the 358th basket (H.N. 1788) (seven hooked-individuals). Therefore, 46 hooked-individuals, which occupy 20 % of total catch, are thought to form 10 elemental-clusters, while the rests of it are swimming as single individuals.

Structure at the highest order (k = 15) : The second peak of the observed-values in the interval analysis is found at k = 14. And the structure at this step may be that of the highest order observable within a row, because there is no conspicuous third peak of the observed-values, although some fusion and appearance of the apparent- and the true-clusters may occur with increase in k into the range longer than 15 hook-intervals. But these two key-lengths (k = 3 and 15 hook-intervals) are too apart from each other, moreover there are two peak-like high observed-values between them; accordingly, it seems to be of interest and of necessity to examine on the feature of appearance, disappearance and fusion of the apparent-clusters and the true ones with increase in key-length, in order not only to find out the distribution pattern but also to examine whether it is acceptable to guess the key-lengths from the figures representing the results of the interval analysis or not. Accordingly, let us examine carefully on Table 12 a and Figs. 51 — (3), (4), (5), (6), (8), (10), and (15). Then we will obtain Table 12 b, in which the changes in the features of the apparent-

Table 12 b. Changes in the number of the apparent clusters and that of the true ones with increase in key-length from 3 to 15 hook-intervals (Example Y 2).

Key length	3	4	5	6	8	10	15
Apparent clusters							
Total number	56	53	55	53	43	38	26
Appearance	—	5	4	1	0	1	0
Fusion	—	12	7	7	14	9	12
True clusters							
Number	10	3	4	4	5	4	6

Notes:

1) Numerals in column "appearance" indicate the number of newly-appeared clusters. Accordingly, all the intervals constituting such a cluster are longer than k of the preceding step while as long as or shorter than k of respective steps.

2) Numerals in column "fusion" indicate the number of clusters, the population size of which is increased by fusion with single individuals or with any other apparent clusters.

clusters and the true ones with increase in key-length are summarized; and this table tells us the following facts: 1) total number of the apparent-clusters decreases rather constantly 2.5 clusters per increase in k, 2) as few as negligible number of the apparent-clusters appears newly when k is increased to the width longer than five hook-intervals, 3) the number of the apparent-clusters, the population-size of which swells by fusion with single individuals or with other clusters, decreases slightly with increase in key-length, while it keeps considerable number and their rate on total number of the apparent-clusters is almost invariable or rather slightly increased, 4) number of the true-clusters is invariable regardless of increase in key-length to the range longer than four hook-intervals, although some of them become impossible to be regarded as the true ones, because the theoretical numbers of the clusters of large population-sizes increase with key-length, while some other apparent-clusters swell their population-sizes into the values capable of being regarded as the true ones and 5) thus, the population-size of the true-clusters tends to increase with key-length.

And at last when the key-length is elongated into as long as 15 hook-intervals, the population gets to show such a distribution pattern as mentioned below: a half of the catch is constituted of single individuals which are swimming solitarily or forming the false-clusters; and mingling with them, there are six true-clusters which occupy the other half of catch. And the larger five of them are thought to be hooked in the ranges respectively from the second hook in the 333th basket (H. N. 1662) to the last hook in the 343th basket (H. N. 1714) (constituted of 15 hooked-individuals), from the last hook in the 347th basket (H. N. 1734) to the third hook in the 358th basket (H. N. 1788) (18 hooked-individuals), from the third hook in the 228th basket (H. N. 1138) to the second hook in the 249th basket (H. N. 1242) (19 hooked-individuals), from the last hook in the 207th basket (H. N. 1034) to the second hook in the 225th basket (H. N. 1122) (27 hooked-individuals) and from the second hook in the 294th basket (H. N. 1467) to the last hook in the 314th basket (H. N. 1569) (23 hooked-individuals); while the other cluster constituted of 12 hooked-individuals is thought to cover one of the following four ranges where the apparent-clusters of such a population-size are hooked —— from the third hook in the 51th basket (H. N. 253) to the second hook in the 62th basket (H. N. 307), from the second hook in the 152th basket (H. N. 757) to the third hook in the 164th basket (H. N. 818), from the first hook in the 181th basket (H. N. 901) to the hook of the same order spaced by 8 baskets (H. N. 941) or from the second hook in the 277th basket (H. N. 1382) to the hook of the same order spaced by 11 baskets (H. N. 1437) —— but the third range is the most probable.

Here, I wish to call attention to the fact that the average occupied-rates of the hooks in the parts covered by these true-clusters are at most three times as high as that computed from throughout a row while the lowest one is only $1\frac{1}{2}$ times as high as that computed from throughout a row, because I am afraid that the word "true-cluster" has much risk to impress too strongly as if to indicate the part of considerably high occupied-rate; thus the distribution pattern of this example, when to consider throughout a row as a whole, is also not so different from the chance distribution as impressed superficially, because even if all the individuals are distributed by chance a little weak deviation of partial occupied-rates is, of course, expected.

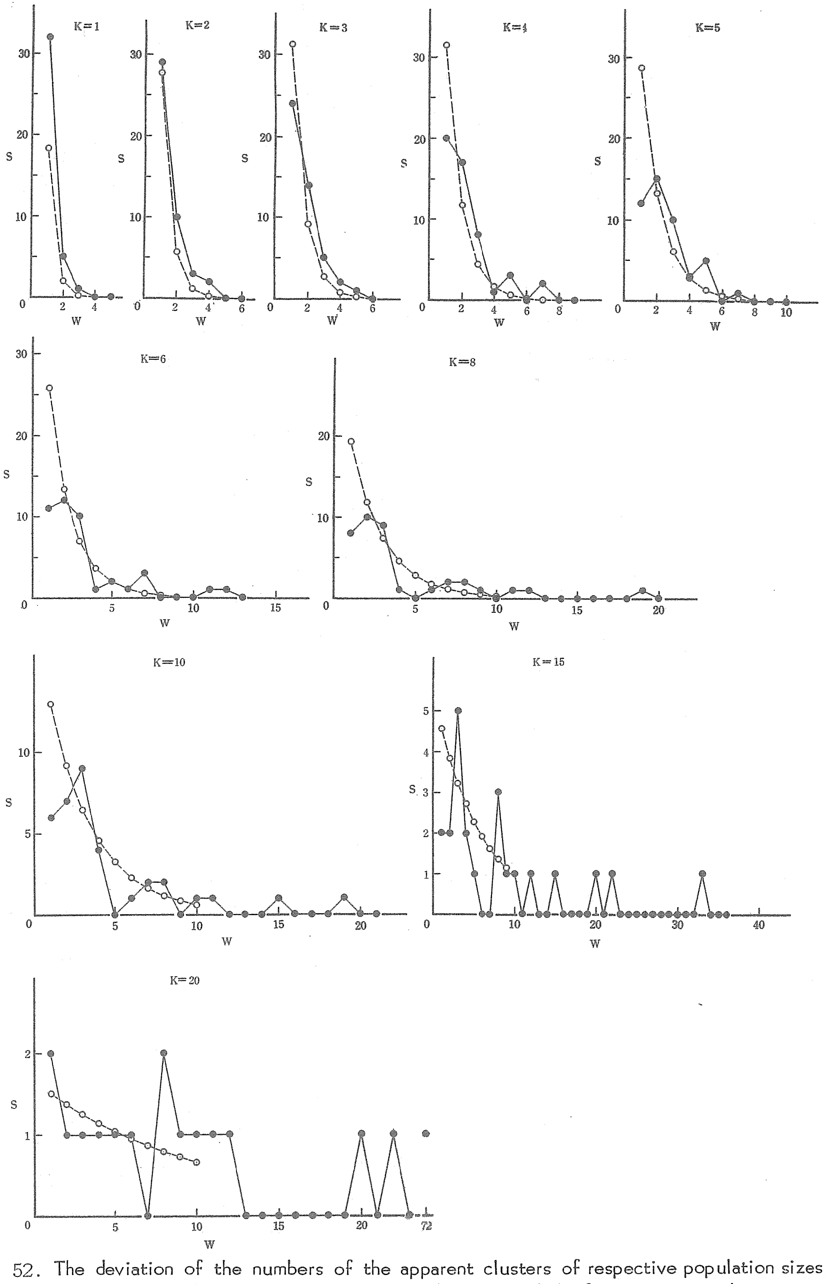


Fig. 52. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 3).

Example Y 3

Structure at the elemental step ($k = 1$) : The observed-value in the interval analysis at $k = 1$ is far higher than the estimated one, while that at $k = 2$ is nearly as equal as the estimated one. Accordingly, the apparent elemental-clusters are thought to be constituted of the individuals hooked successively. And 18 clusters, —— which are 14 pairs of the individuals hooked successively among 32 apparent ones, three clusters constituted of each three successively hooked individuals among five apparent ones and a basket fully occupied, —— are thought to be the true-clusters at the elemental step caused by the schooling tendency. And the hooked positions of these true ones, except the largest one, are uncertain because of the difficulty in distinguishing of

Table 13. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 3).

1	2	3	4	5	6	8	10	15	20
27—29 (2)	(2)	27—32 (3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
									88—107 (1)
			249—257 (2)	249—262 (3)	(3)	(3)	(3)	(3)	213—262 (5)
							403—413 (1)	379—413 (3)	379—432 (6)
431—432 (1)	429—432 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	
								474—489 (1)	(1)
	549—551 (1)	546—551 (2)	(2)	(2)	(2)	546—558 (3)	537—558 (4)	(4)	
577—578 (1)	(1)	(1)	(1)	(1)	(1)	(1)	577—588 (2)	577—603 (3)	573—629 (10)
					623—629 (1)	(1)	(1)	(1)	
693—694 (1)	(1)	(1)	(1)	(1)	(1)	693—704 (4)	(4)	(4)	(4)
702—704 (2)	(2)	(2)	(2)	(2)	(2)				
726—727 (1)	(1)	(1)	(1)	(1)	(1)	726—742 (3)	(3)	726—783 (8)	
772—773 (1)	(1)	(1)	(1)	767—773 (2)	(2)	(2)	767—783 (3)		
803—804 (1)	801—804 (2)	(2)	(2)	(2)	(2)	(2)	(2)	801—818 (3)	726—894 (22)
856—858 (2)	854—858 (3)	(3)	(3)	(3)	(3)	(3)	(3)	854—894 (8)	
877—878 (1)	(1)	877—881 (2)	873—881 (3)	(3)	(3)	(3)	(3)		
927—929 (2)									
931—932 (1)	927—932 (4)	924—932 (5)	(5)	(5)	924—949 (11)	(11)	(11)		
943—944 (1)									
948—949 (1)	943—949 (4)	(4)	(4)	938—949 (5)					
			977—981 (1)	(1)	(1)	(1)	(1)	924—1023 (20)	(20)
		994—997 (1)	(1)	(1)	(1)	(1)	994—1011 (4)		
1006—1007 (1)	(1)	(1)	1006—1011 (2)	(2)	(2)	(2)			
1046—1047 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
1073—1074 (1)	(1)	(1)	(1)	1073—1088 (4)				1046—1098 (10)	1046—1116 (11)
			1084—1088 (1)		1073—1098 (7)	(7)	(7)		
	1094—1098 (2)	(2)	(2)	(2)					
1137—1138 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	1137—1156 (5)	
1153—1154 (1)	1151—1156 (3)	(3)	(3)	(3)	(3)	(3)	(3)		1137—1196 (8)
						1176—1183 (1)	(1)	1176—1196 (2)	

1	2	3	4	5	6	8	10	15	20
					1223−1229				
					(1)				
	1244−1246	1241−1246	1237−1246						
	(1) →	(2) →	(3) →	(3) →	(3)				
			1253−1257						
			(1)	1253−1266					
			1262−1266 →	(3)		1223−1306			
			(1)			(19) →	(19)		
1272−1273			1272−1277		1253−1299				
(1) →	(1) →	(1) →	(2) →	(2) →	(12)				
1283−1284	1283−1286								
(1) →	(2) →	(2) →	(2) →	(2)					
1292−1293								1223−1384	
(1) →	(1) →	(1) →	(1) →	(1)				(33)	
1327−1328			1327−1332				1318−1332		
(1) →	(1) →	(1) →	(2) →	(2) →	(2) →	(2) →	(3)		
1343−1344		1343−1347							
(1) →	(1) →	(2) →	(2) →	(2) →	(2) →	(2) →	(2)		
	1376−1378	1376−1384	1368−1384		1362−1384				
	(1) →	(3) →	(5) →	(5) →	(6) →	(6) →	(6)		
1421−1422		1418−1422							1223−1573
(1) →	(1) →	(2)	1414−1432						(72)
1428−1429	1426−1429	1426−1432 →	(7) →	(7) →	(7) →	(7) →	(7)		
(1) →	(2) →	(3)							
			1458−1462						
			(1)	1453−1471					
	1467−1471			(5) →	(5)				
	(2) →	(2) →	(2)			1453−1489	1443−1489	1403−1503	
1488−1489				1478−1489		(9) →	(10) →	(22)	
(1) →	(1) →	(1) →	(1) →	(3) →	(3)				
1501−1503									
(2) →	(2) →	(2) →	(2) →	(2) →	(2) →	(2) →	(2)		
1526−1529		1523−1529	1519−1529						
(3) →	(3) →	(4) →	(5) →	(5) →	(5)				
	1544−1546	1541−1546	1537−1546			1519−1558	1519−1573		
	(1) →	(2) →	(3) →	(3) →	(3)	(12) →	(15) →	(15)	
1553−1554			1553−1558						
(1) →	(1) →	(1) →	(2) →	(2) →	(2)				
	1571−1573		1567−1573						
	(1) →	(1) →	(2) →	(2) →	(2) →	(2)			
1613−1614									
(1) →	(1) →	(1)	1613−1621						
		1618−1621 →	(3) →	(3) →	(3)				
		(1)				1613−1643			
1642−1643			1638−1643	1628−1643		(8) →	(8) →	(8) →	(8)
(1) →	(1) →	(1) →	(2) →	(4) →	(4)				
1668−1669						1668−1676			
(1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(2) →	(2) →	(2) →	(2)
1721−1722			1717−1726	1712−1726					
(1) →	(1) →	(1) →	(3) →	(4)	1706−1734	1698−1734		1698−1746	
	1732−1734				(7) →	(8) →	(8) →	(9) →	(9)
	(1) →	(1) →	(1) →	(1)					
1793−1794									
(1) →	(1) →	(1) →	(1) →	(1) →	(1)	1793−1803	1793−1813		
1802−1803						(3) →	(4)		
(1) →	(1) →	(1) →	(1) →	(1) →	(1)			1793−1869	
1848−1849	1848−1851				1842−1851			(12) →	(12)
(1) →	(2) →	(2) →	(2) →	(2) →	(3) →	(3) →	(3)		
1868−1869				1863→1869					
(1) →	(1) →	(1) →	(1) →	(2) →	(2) →	(2) →	(2)		

the true-clusters from the false ones, although the hooked positions of all the apparent elemental-clusters are illustrated in Table 13. Accordingly single individuals, which are swimming solitarily or forming the false-clusters caused even as the results of the chance distribution, occupy 4/5 of catch, while the rests of it form 18 elemental-clusters.

Structure at the second order ($k=4$) : The features of the cluster-formation at the second order can be guessed out from Fig. 52 — (4) and Table 13, in which k is elongated into four hook-intervals, because the second peak of the observed-values in the interval analysis is found at $k = 4$. And let us consider the distribution pattern of this order, referring to the structure at the subordinate steps together.

Then we will find the following facts that 1) the theoretical number of the isolated single-intervals, each of which covers the range as long as or shorter than k hook-intervals, increases slightly with increase in k from one to four; but contrary to this, the observed number decreases, 2) consequently when $k = 4$, the observed number is 11.4 lower than the theoretical one, although the intervals as long as or shorter than four hook-intervals are observable more frequently than expected, 3) but the clusters constituted of many successively arranged intervals are observable more frequently with increase in k; and this tendency exceeds the same in the theoretical-values, and 4) these facts seem to suggest that the individuals are hooked more aggregatively than they are distributed by chance. Thus, the structure at the second order is guessed as follows : none of the apparent-clusters constituted of each two hooked-individuals are regarded as the true one; moreover, 11 or one more apparent-clusters, which are expected to be observable as single intervals when all individuals are hooked by chance, are actually observable not as the single intervals but as the lots attached to some other intervals because of the schooling tendency. And among them, five clusters are attached to each one more interval, four clusters to each two more, two clusters to each three more and the other interval is attached to six intervals arranged successively; consequently these are all able to be regarded as the true-clusters. Accordingly, about a quarter of catch is thought to be derived from 12 true-clusters, while the rests of it are brought chiefly from the single individuals and partly from the single elemental-clusters of small population-size.

Structure at the higher orders : The clear third peak of the observed-values in the interval analysis is not found out. But the structures of the higher orders have to be discussed for reference' sake, chiefly because the presence of some obscure peak-like high observed-values in the interval analysis is suggested, moreover this key-length, four hook-interval width, seems to be too short to consider as that to the highest order observable within a row. And if such obscure peaks were regarded to be significant, the structure mentioned below in short may be guessed out.

(*Structure at the third order,* $k = 15$) : The presence of three true-clusters and a doubtful one is suggested. And the clear ones are thought to occupy the parts respectively from the last hook in the 185th basket (H. N. 924) to the third hook in the 205th basket (H. N. 1023) (constituted of 21 hooked-individuals), from the third hook in the 245th basket (H. N. 1223) to the last hook in the 277th basket (H. N. 1384) (34 hooked-individuals), and from the third hook in the 281th basket (H. N. 1403) to the hook of the same order in the 301th basket (H. N. 1503) (23 hooked-individuals); while the doubtful one is guessed to cover the range from the last hook in the 304th basket (H. N. 1519) to the third hook in the 315th basket (H. N. 1573) (constituted of 16 hooked-individuals). Thus, about 43 % of catch are thought to be brought from these four true-clusters including a doubtful one, while the rests of it are from the single individuals or from the clusters of the lower orders.

(*Structure at the fourth order,* $k = 20$) : A cluster of the third order which is constituted of 21 hooked-individuals is so distinctly separated from the others that being able to be regarded as a true-school of this step, being suffered from no change in the features. But three other clusters at the third order including a doubtful one are such faintly spaced from each other as fused into a school constituted of 73 hooked-individuals, when 20 hook-interval width is adopted as the key-length, and this is thought to cover the part from the third hook in the 245th basket (H. N. 1223) to the hook of the same order spaced by 70 baskets (H. N. 1573). Besides them, the other school constituted of 23 hooked-individuals comes to be regarded as the true-school, which is thought to be hooked in the part from the first hook in the 146th basket (H. N. 726) to the last hook in the 179th basket (H. N. 894). Accordingly, about 54% of catch are thought to be distributed within $\frac{1}{3}$ of a row forming these three schools. But we should pay attention to the fact that the average occupied-rates of the hooks in the parts covered by the former two schools are a little higher than one individual per basket while that covered by the other school is only 20% higher than the average occupied-rate computed from throughout a row. Thus, the occupied-rates are not so high, although these schools cover considerably wide ranges; accordingly, even these schools are thought to be not so strongly aggregated as superficially impressed, consequently the distribution pattern to see as a whole may be not so far from the chance distribution as superficially impressed from the above-mentioned description.

Example Y 4

Before entering into the discussion on the distribution pattern of this example, I must describe here the following facts, for reference' sake. Comparing the results of the interval analysis and the arrangement one of this example with those of the preceding three examples, we will be aware of the importance and the necessity of adding of the arrangement analysis, because the results of the interval analysis of this example and the preceding ones are essentially not so different, but the differences in another new characteristic of the distribution pattern of basic importance get possible to be found out, by adding the arrangement analysis. That is to say, the aggregative tendency of the preceding examples makes it possible to be observable some true-clusters constituted of a little many hooked-individuals even if k is not so long, moreover observable some schools constituted of many hooked-individuals covering wide ranges when k is long. Contrary to these facts, it is suggested as one of the characteristics of the distribution pattern of this example that, when $k = 6$, there is no cluster constituted of more than four hooked-individuals, and when $k=10$, there is also no one constituted of more than 10 hooked-individuals, moreover even when $k = 20$, none of the true-clusters constituted of more than 20 hooked-individuals and covering wider range than 25 baskets are observable; thus these facts clearly suggest that only a few of clusters of extremely small population-size is regarded as the true ones, moreover they are rather somewhat evenly distributed throughout a row, consequently the population does not contain any school of large population-size and covering wide range, against the fact that more clusters including those of a little large population-size are recognized in other examples as the true ones. And keeping these facts in mind, let us examine on the distribution patterns at respective steps.

Structure at the elemental step (k = 1 *or* 2) : The observed-values in the interval analysis in the range from k = 1 to 4 are continuously higher than the estimated ones, but the key-length to the elemental structure is regarded to be 1 or 2 hook-intervals, because the observed-value in the interval analysis at k=2 is far lower than those at k=1 and 3, although it is still higher than the estimated one; and the key-length to the structure at the second order is thought to be 3 or 4 hook-intervals.

When we set that the key-length to the structure at the elemental step is one hook-interval, six clusters constituted of each two hooked-individuals among 16 apparent

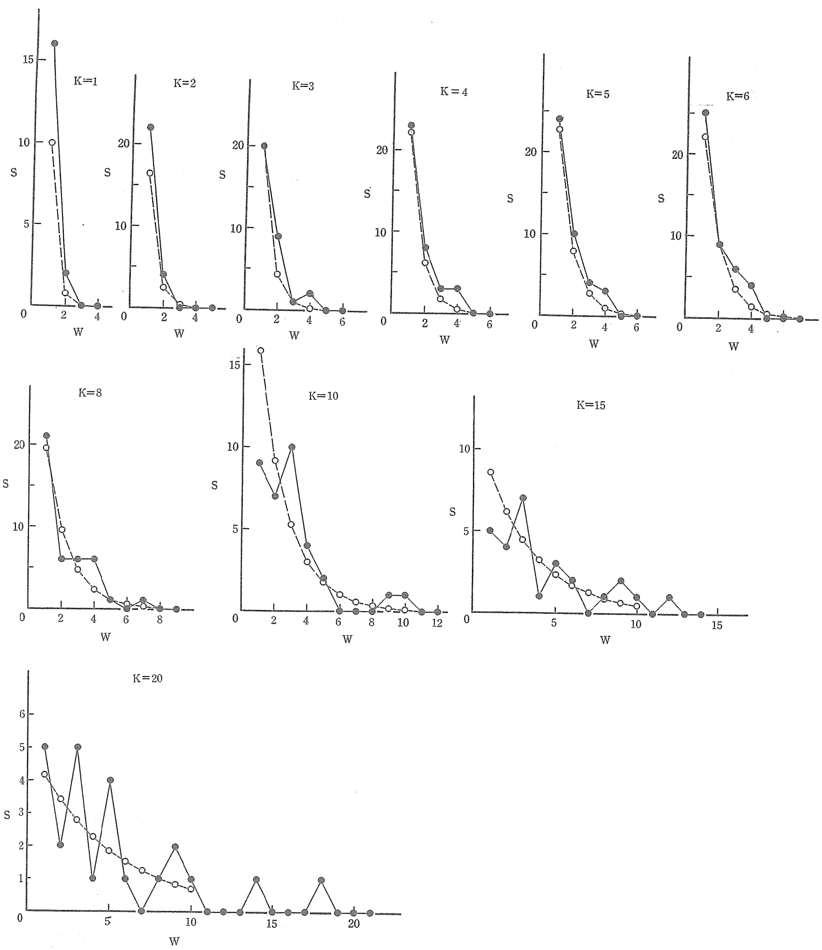
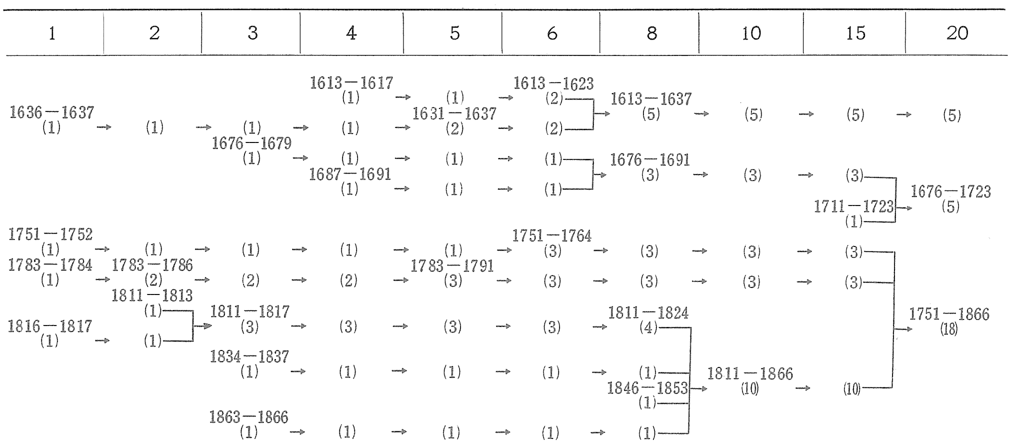


Fig. 53. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 4).

Table 14. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 4).

1	2	3	4	5	6	8	10	15	20
					43−49 (1)	43−62 (3)	(3)	(3)	(3)
					56−62 (1)				
	111−113 (1)	108−113 (2)	104−113 (3)	(3)	(3)	96−113 (4)	87−113 (5)	(5)	(5)
	226−228 (1)	223−228 (2)	223−232 (3)	(3)	217−232 (4)	(4)	(4)	217−246 (5)	(5)
348−349 (1)	(1)	(1)	348−356 (4)	(4)	(4)	(4)	(4)	(4)	(4)
353−354 (1)	353−356 (2)	(2)							
									388−408 (1)
								513−527 (1)	(1)
	561−563 (1)	558−563 (2)	(2)	(2)	552−563 (3)	552−583 (7)	552−593 (9)	(9)	(9)
	581−583 (1)	578−583 (2)	(2)	(2)	(2)				
592−593 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
			629−633 (1)	(1)	(1)	(1)	629−647 (3)	(3)	(3)
			643−647 (1)	(1)	(1)	(1)			
		743−746 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
773−774 (1)	(1)	(1)	(1)	(1)	(1)	(1)	773−783 (2)	(2)	(2)
836−873 (1)	(1)	(1)	832−837 (2)	(2)	(2)	(2)	(2)	(2)	816−837 (3)
		863−866 (1)	(1)	858−866 (2)	(2)	(2)	(2)	(2)	(2)
	972−974 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	972−1081 (14)
	1002−1004 (1)	(1)	1002−1008 (2)	(2)	(2)	994−1008 (3)	(3)	994−1081 (12)	
							1022−1032 (1)		
				1047−1052 (1)	(1)	(1)	1047−1062 (3)		
1061−1062 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
	1079−1081 (1)	1076−1081 (2)	(2)	(2)	(2)	(2)	(2)		
			1103−1107 (1)	1103−1112 (2)	(2)	(2)	(2)	(2)	1103−1131 (3)
1166−1168 (2)	(2)	1166−1174 (4)	(4)	(4)	(4)	(4)	(4)	1166−1213 (9)	(9)
				1186−1191 (1)	(1)	(1)	(1)		
			1209−1213 (1)	(1)	(1)	1202−1213 (2)	(2)		
1243−1244 (1)	(1)	1243−1247 (2)	(2)	(2)	(2)	(2)	(2)	1243−1259 (3)	(3)
1308−1309 (1)	(1)	1308−1312 (2)	(2)	(2)	1308−1318 (3)	(3)	(3)	1308−1342 (6)	1308−1388 (10)
	1329−1331 (1)	(1)	(1)	(1)	(1)	(1)	(1)		
					1362−1368 (1)	(1)	(1)	1362−1388 (3)	
				1383−1388 (1)	(1)	(1)	(1)		
1416−1418 (2)	(2)	1413−1421 (4)	(4)	(4)	(4)	(4)	(4)	1413−1447 (8)	(8)
				1432−1437 (1)	(1)	(1)	1432−1447 (3)		
1446−1447 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
		1469−1472 (1)	(1)	(1)	(1)	(1)	(1)	1469−1514 (6)	(6)
1502−1503 (1)	(1)	(1)	(1)	(1)	(1)	(1)	1502−1514 (3)		
1513−1514 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
1546−1547 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
									1571−1587 (1)



ones and a cluster constituted of three hooked-individuals are regarded as the true ones caused by the schooling tendency. But assume that the key-length is two hook-intervals, and six clusters constituted of each two hooked-individuals and two clusters constituted of each one more hooked-individuals are regarded to be the true ones among 22 apparent ones. And four apparent-clusters of large population-size are observable, but they can not be regarded as the true ones, because even if all the individuals are hooked by chance as many as apparent-clusters of such a population-size as this are expected to be observable. And even if two hook-interval width is recognized as the key-length to the elemental-clusters, the individuals derived from the true elemental-clusters reach merely a little more than 1/10 of total catch while the rests of it are the single individuals swimming solitarily or forming the false-clusters expected to occur even if all the individuals are hooked by chance.

Structure at the second order ($k = 4$) : Even if the key-length is set to be four hook-intervals, one cluster constituted of two hooked-individuals among 23 apparent ones, two clusters of each three hooked-individuals among eight apparent ones, one or two clusters of each four hooked-individuals among three and all or one less cluster of each five hooked-individuals among three apparent ones are recognized as the true ones, which occupy about 18 % of total catch.

Structure at the third order ($k = 15$) : It seems to be better to regard 15 hook-intervals as the key-length to the structure at the third order. But the observed-value in the interval analysis at $k = 15$ is higher than the neighbouring ones, although it does not exceed corresponding theoretical one, moreover, observed-value at $k = 9$ is a little higher than the neighbouring ones and this bears some characteristics of peak, and also these two key-lengths, four and 15 hook-intervals, are too apart from each other; therefore, it is necessary to examine on the change in the features of the cluster-formation with increase in key-length from four to 15 hook-intervals. But I found that no conspicuous change in the features of the cluster-formation was observable around $k = 9$ except a sudden decrease in the observed number of the clusters constituted of two hooked-individuals against the gradual decrease in the theoretical-value, although the clusters constituted of more than six hooked-individuals come to appear when k exceeds six hook-intervals.

And at last when key-length is elongated into 15 hook-intervals, the population gets to show such a pattern as mentioned below: the aggregative tendency of the shorter intervals —— *i. e.*, the schooling tendency —— decreases the actually observed numbers of the clusters constituted of a single or one more interval till they do not reach the numbers expected in the chance distribution, meanwhile increases the actually observed numbers of the clusters constituted of more than seven hooked-individuals till they exceed the theoretical numbers representing the expectant numbers from the chance distribution. Consequently, some clusters capable of being regarded as the true ones come to be observable; they are two clusters constituted of each 10 or one more hooked-individuals among three apparent ones and a cluster of 13 hooked-individuals. Thus, about 1/5 of total catch distributed within 1/10 of a row is thought to form three clusters.

Structure at the highest order ($k = 20$) : It may well be said that the fourth peak of the observed-values in the interval analysis is found at $k = 20$, although both the observed-values and the estimated ones in the interval analysis in the range $k > 11$ do not reach five, therefore, I am afraid that the guessing of the key-length is severely suffered from the influence of accidental error. And the structure at this step is, for convenience' sake, called the structure at the highest order observable within a row, the details of which will be described below.

The low observed-values and the estimated ones do not allow me to describe no fact else than that at least three clusters constituted of as many as or more than 10 hooked-individuals among five apparent ones are able to be regarded as the true-clusters due to the schooling tendency. And that constituted of 19 hooked-individuals covering the part from the first hook in the 351th basket (H. N. 1751) to the hook of the same order spaced by 23 baskets (H. N. 1866), that of 15 hooked-individuals covering the part from the second hook in the 195th basket (H. N. 972) to the first hook in the 217 th basket (H. N. 1081) and that of 10 hooked-individuals covering the part from the second hook in the 111th basket (H. N. 552) to the third hook in the 119th basket (H. N. 593) are the most probable to be the true ones. Accordingly, about 1/3 of catch distributed within 1/7 of a row is thought to form three small schools.

Example Y 5

For decoding of such an example showing a strong gradient as this, we must keep in mind the fact that the influence of the gradient is not yet excluded from the theoretical-values in the arrangement analysis and also the exclusion of this influence from the theoretical-values in the interval analysis is very hard, consequently the strong gradient is inclined to decrease slightly the theoretical numbers of the clusters of small population-size, meanwhile to increase slightly those constituted of many hooked-individuals, moreover it is also inclined to biase the hooked positions of the larger

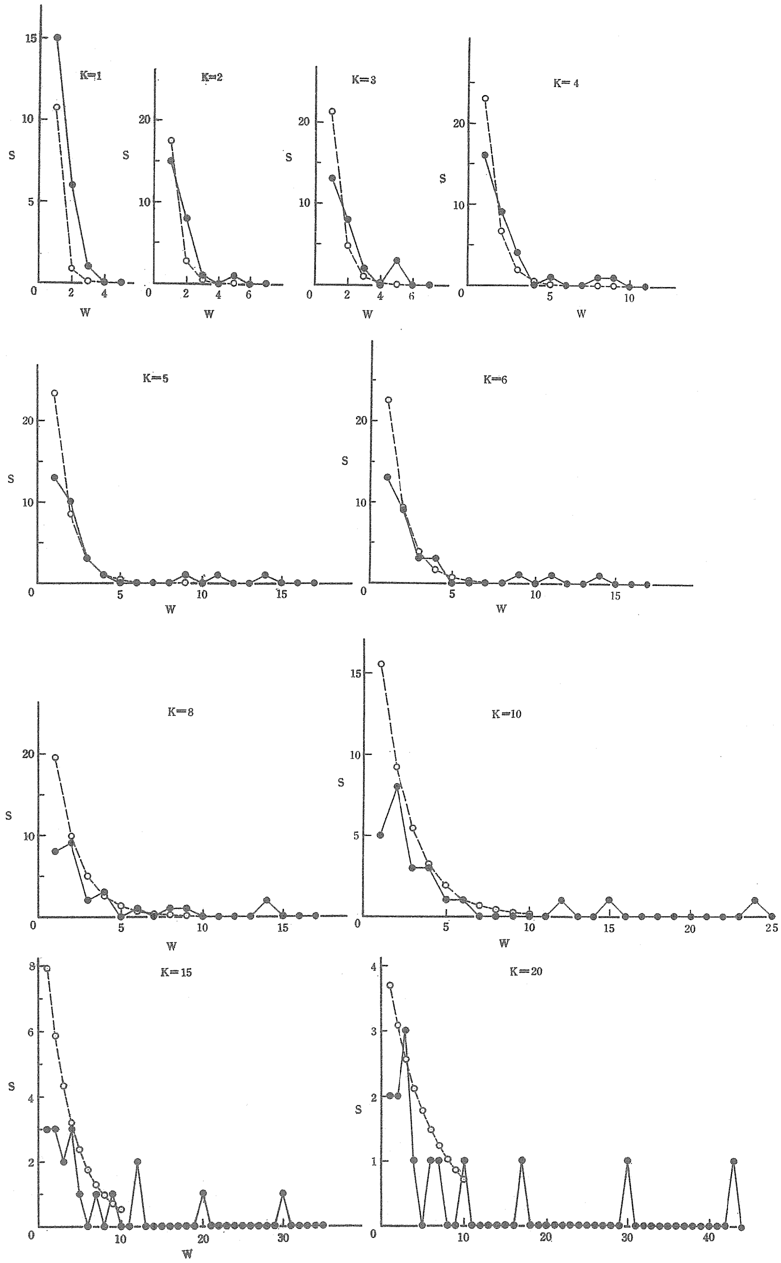


Fig. 54. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-length to decoding the distribution patterns (Example Y 5).

Table 15. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 5).

1	2	3	4	5	6	8	10	15	20
								263—276 (1)	263—312 (3)
481—483 (2)	(2)	(2)	477—483 (3)	472—483 (4)	(4)	(4)	472—493 (5)	(5)	472—512 (6)
			592—596 (1)	(1)	(1)	(1)	582—596 (2)	(2)	(2)
				617—622 (1)	(1)	(1)	(1)	(1)	(1)
848—849 (1)	(1)	(1)	(1)	(1)	(1)	833—849 (3)	(3)	(3)	(3)
								912—923 (1)	(1)
951—952 (1)	(1)	(1)	947—952 (2)	(2)	(2)	(2)	(2)	(2)	947—1021 (10)
							968—977 (1)	968—1021 (7)	
			988—992 (1)	(1)	988—998 (2)	(2)	(2)		
	1019—1021 (1)	(1)	(1)	(1)	(1)	1011—1021 (2)	(2)		
1136—1137 (1)	(1)	1133—1137 (2)	1133—1141 (3)	(3)	1127—1141 (4)	(4)	(4)	(4)	1077—1141 (7)
								1171—1222 (4)	(4)
1252—1253 (1)	(1)	1252—1256 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
			1278—1282 (1)	(1)	(1)	(1)	1278—1294 (3)	(3)	(3)
		1291—1294 (1)	(1)	(1)	(1)	(1)			
1323—1324 (1)	1323—1326 (2)	(2)	(2)	(2)	1323—1332 (3)	1323—1359 (8)	1323—1377 (12)	(12)	1323—1411 (17)
			1339—1343 (1)	(1)	(1)				
1351—1352 (1)	(1)	(1)	(1)	(1)	(1)				
1368—1369 (1)	1368—1371 (2)	(2)	(2)	(2)	1368—1377 (3)	(3)			
1393—1394 (1)	(1)	(1)	(1)	(1)	(1)	(1)	1393—1411 (4)	(4)	
			1403—1411 (2)	(2)	(2)	(2)			
1478—1479 (1)	(1)	(1)	1478—1483 (2)	1473—1483 (3)	1467—1483 (4)	1467—1497 (6)	(6)	1454—1513 (9)	1454—1616 (30)
					1491—1497 (1)				
	1511—1513 (1)	(1)	(1)	(1)	(1)	(1)	(1)		
1557—1558 (1)	(1)	(1)	1557—1563 (3)	1552—1584 (14)	(14)	(14)	1543—1584 (15)	1532—1616 (20)	
1562—1563 (1)	(1)	(1)							
1571—1573 (2)	(2)	1568—1573 (3)	1568—1584 (9)						
1581—1584 (3)	1577—1584 (5)	(5)							
	1611—1613 (1)	1611—1616 (2)	(2)	(2)	(2)	(2)	(2)		
			1638—1642 (1)	(1)	(1)	(1)	(1)	1638—1758 (30)	1638—1847 (43)
			1657—1661 (1)	1657—1666 (2)	(2)	1657—1698 (14)	1657—1736 (24)		
1673—1674 (1)	(1)	(1)	1673—1678 (2)	1673—1698 (11)	(11)				
1683—1684 (1)	(1)	1683—1687 (2)	1683—1698 (8)						
1691—1693 (2)	(2)	1691—1698 (5)							
1696—1698 (2)	(2)								
			1708—1712 (1)	1708—1736 (9)	(9)	(9)			
1727—1729 (2)	(2)	1727—1736 (5)	(5)						
1732—1733 (1)	(1)								
1747—1749 (2)	(2)	(2)	(2)	(2)	(2)	(2)	1747—1758 (3)		
		1778—1781 (1)	(1)	(1)	(1)	(1)	(1)	1778—1847 (12)	
1801—1802 (1)	1799—1804 (3)	(3)	(3)	(3)	(3)	1792—1804 (4)	(4)		
		1823—1826 (1)	(1)	1818—1826 (2)	(2)	(2)	(2)		
			1838—1842 (1)	1838—1847 (2)	(2)	(2)	(2)		

apparent-clusters observable the more frequently with approach to the end of hauling. In company with these, the low observed-values and the estimated ones in the interval analysis do not allow me to find out any key-length longer than six hook-intervals somewhat rid of the severe influence of accidental error. Accordingly, I do not wish to describe any further pattern but that represented below.

Structure at the elemental step ($k = 1$) : Even if putting the influence of the strong gradient out of consideration, I can not find out any fact but that 10 clusters——which are four clusters constituted of each two hooked-individuals among 15 apparent ones, five clusters of each three hooked-individuals among six apparent ones and a basket fully occupied——may be as if the true ones. But, for the purpose of guessing out which apparent-clusters are the true ones, we must consider together with their hooked positions. But no fact is deducible other than that the influence of the gradient is very strong, because all the apparent-clusters, except two constituted of not so many hooked-individuals, are caught in the latter half of hauling of a row, especially densely in the last quarter.

Structure at the second order ($k = 4$) : To the distribution pattern at this step, generally speaking, no fact can be deduced other than that the individuals are hooked showing a strong gradient. That is to say, the deviation of the observed-values in the arrangement analysis seems to show as if there are three true cluster-like aggregations constituted of 6 , 9 and 10 hooked-individuals respectively, besides two of those constituted of each three hooked-individuals and the same number of those of four hooked-individuals; but when we take the influence of the strong gradient into consideration, whether each of them is recognizable as the true one or not becomes highly doubtful, because all of these larger clusters are hooked in the last 1/7 of hauling of a row; moreover, even all other apparent-clusters, except three, are also hooked in the latter half of hauling of a row, which suggest that the presence of even the smaller clusters is also doubtful.

Structure at the higher orders : The low observed-values and the estimated ones in the interval analysis make it impossible to guess out any key-length to the higher orders; accordingly, it is impossible to continue discussing the structures at the higher orders somewhat rid of the influence of accidental error introduced into the guessing of the key-length. Accordingly, the key-length increased step by step, the changes in the features of the true cluster-like aggregations are discussed; then the influence of the strong gradient considered together with their hooked positions, whether they can be regarded as the true ones or not is examined. But, here, none of the apparent-clusters, except those mentioned in the preceding step as the larger ones, can be regarded as the true cluster-like aggregation, consequently there is no need to give any further description.

And we will easily notice that, when k does not exceed six hook-intervals, there is no true cluster-like aggregation hooked in the other part in a row than the last 1/7 of hauling; and even if the key-length is elongated into as long as 20 hook-intervals, all the true cluster-like aggregations are hooked successively from the last hook of the hauling of a row to the third hook in the 265th basket (H. N. 1323).

Accordingly, no fact is deducible from the results except that the individuals are distributed showing a strong gradient.

But before closing the discussion on the pattern observable in such a example as this in which a strong gradient is suspected, further attention should be paid to another factor newly closed up——the hooked positions of respective lots relating to their population-size, because it is more probable that the apparent-clusters constituted of a little many hooked-individuals and found in the earlier part of hauling have to be regarded as the true-clusters due to the schooling tendency, even if the observed numbers in the arrangement analysis do not reach corresponding theoretical ones. Therefore, it seems to be better to regard that the following four apparent-clusters may be caused by the schooling tendency and should be regarded as the true-schools; they are respectively the cluster constituted of seven hooked-individuals and covering the part from the second hook in the 95th basket (H. N. 472) to the hook of the same order spaced by eight baskets (H. N. 512), that of 11 hooked-individuals and covering the part from the second hook in the 190th basket (H. N. 947) to the first hook in the 205th one (H. N. 1021) and that of eight hooked-individuals and covering the part from the second hook in the 216th basket (H. N. 1077) to the first hook in the 229th basket (H. N. 1141).

Example Y 6

In contrast with the preceding example, the influence of the gradient of distribution seems to be as weak as negligible.

Structure at the elemental step ($k = 1$) : The following pattern is deducible from Fig. 55 — (1) as the structure at the elemental step, in which one hook-interval is adopted as the key-length: nineteen clusters —— which are 10 clusters constituted of each two individuals hooked successively among 35 apparent ones and nine ones constituted of one more individuals among 12 apparent ones——are recognized as the true-clusters; and, of course, a basket fully occupied is also thought to be the true one. Therefore, one fifth of catch is thought to be derived from 20 elemental-clusters mingling with single individuals which occupy 4/5 of catch; but the hooked positions of the clusters, except the largest one, are uncertain because of the difficulty in distinguishing the true-clusters from the false ones, although all the hooked positions of the apparent-clusters are illustrated in Table 16.

Structure at the second order ($k=3$) : The second peak of the observed-values in the interval analysis is found at $k = 3$. Accordingly, the following structure is found out, when we adopt three hook-intervals as the key-length. The schooling tendency of the individuals lets decrease the number of the lots of small population-size meanwhile increase those of the large population-size; thus the single isolated-intervals do not so frequently observable as the expectant number from the chance distribution, against the fact the intervals as long as or shorter than three hook-intervals are more frequently observable than expected from the chance distribution; while three more lots each of which is constituted of two intervals arranged successively, two more lots of three intervals and one more lot of four intervals and each two more lots

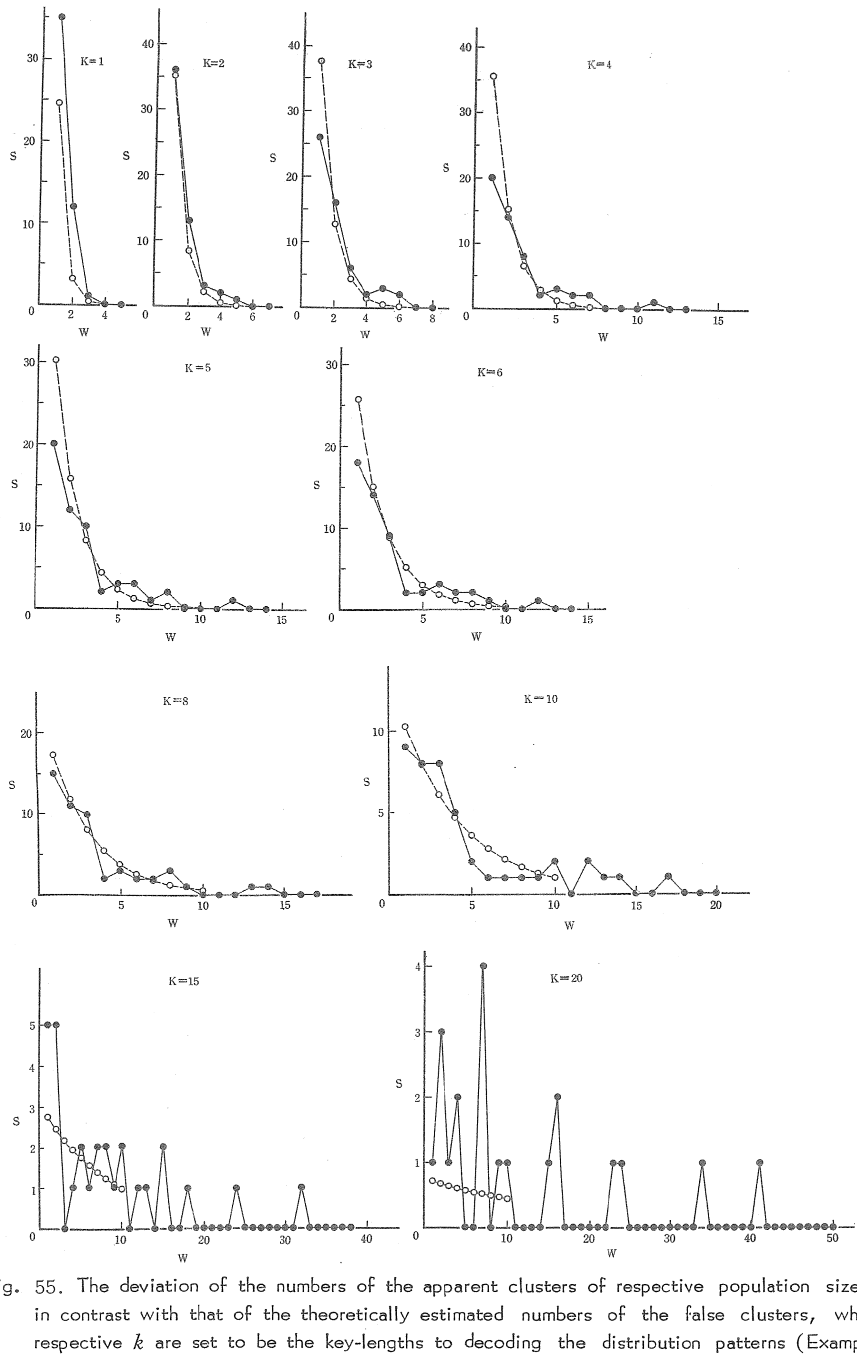


Fig. 55. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 6).

Table 16. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 6).

1	2	3	4	5	6	8	10	15	20
			14—18 (1)	14—23 (2)	(2)	14—46 (7)	(7)	(7)	14—111 (16)
36—38 (2)	(2)	(2)	(2)	31—38 (3)	(3)				
66—67 (1)	(1)	(1)	62—67 (2)	62—72 (3)	(3)	(3)	62—81 (4)	62—111 (8)	
				106—111 (1)	(1)	92—111 (3)	(3)		
137—138 (1)	(1)	137—141 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
	187—189 (1)	(1)	(1)	(1)	(1)	(1)	168—189 (3)	168—237 (9)	(9)
							201—211 (1)		
231—232 (1)	(1)	(1)	(1)	226—237 (3)	(3)	(3)	(3)		
				258—263 (1)	(1)	(1)	(1)	(1)	258—303 (7)
288—289 (1)	(1)	(1)	(1)	(1)	282—289 (2)	(2)	282—303 (5)	(5)	
	299—303 (2)	(2)	(2)	(2)	(2)	(2)			
		241—247 (2)	(2)	(2)	(2)	(2)	(2)	(2)	341—374 (4)
								363—374 (1)	
		414—417 (1)	(1)	(1)	(1)	(1)	414—447 (10)	(10)	(10)
436—438 (2)	(2)								
	441—443 (1)	436—447 (6)	432—447 (7)	427—447 (8)	(8)	(8)			
446—447 (1)	(1)								
511—512 (1)	511—514 (2)	508—514 (3)	(3)	(3)	(3)	508—533 (8)			
521—523 (2)	(2)	(2)	521—527 (3)	(3)	521—533 (4)				
551—552 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
562—563 (1)	(1)	562—568 (3)					508—573 (17)	483—617 (24)	(24)
	566—568 (1)								
572—573 (1)	(1)	(1)	562—573 (5)	(5)	(5)	(5)			
				586—591 (1)	586—602 (3)	(3)	(3)		
				597—602 (1)					
658—659 (1)	654—659 (3)	648—659 (5)							
663—664 (1)	663—668 (4)	663—671 (5)	648—671 (11)	648—676 (12)	(12)	641—676 (13)	(13)	(13)	641—697 (16)
666—668 (2)									
696—697 (1)	(1)	693—697 (2)	(2)	(2)	(2)	(2)	(2)	(2)	
									728—747 (1)
787—788 (1)	(1)	(1)	(1)	787—793 (2)	(2)	(2)	(2)	773—818 (7)	(7)
817—818 (1)	(1)	814—818 (2)	(2)	(2)	(2)	806—818 (3)	(3)		
866—867 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	866—901 (6)	849—901 (7)
887—888 (1)	(1)	(1)	(1)	(1)	(1)	879—888 (2)	879—901 (4)		
			897—901 (1)	(1)	(1)	(1)			
		941—944 (1)	(1)	(1)	(1)	941—951 (2)	931—951 (3)		
966—968 (2)	964—968 (3)	(3)	(3)	(3)	(3)	(3)			
977—978 (1)	(1)	977—984 (3)	(3)	(3)	(3)	977—997 (5)	964—997 (9)	931—1013 (15)	(15)
				992—997 (1)	(1)				
			1009—1013 (1)	(1)	(1)	(1)	(1)		

1	2	3	4	5	6	8	10	15	20
					1092—1098 (1)	(1)	(1)	(1)	1092—1121 (3)
		1118—1121 (1)	(1)	(1)	(1)	(1)	(1)	(1)	
1151—1152 (1)	(1)	(1)	1143—1156 (4)	(4)	(4)	(4)	(4)	(4)	(4)
1188—1189 (1)	(1)	(1)	(1)	(1)	1182—1189 (2)	1182—1197 (3)	1182—1216 (5)	(5)	
								1233—1246 (1)	1182—1246 (7)
				1272—1277 (1)	(1)	(1)	1272—1287 (2)	(2)	(2)
1317—1318 (1)	(1)	1317—1321 (2)	(2)	(2)	(2)	1317—1329 (3)	(3)		
1341—1343 (2)	(2)	(2)	(2)	1341—1348 (3)	(3)	(3)	(3)	1317—1413 (15)	
1372—1374 (2)	(2)	(2)	1372—1378 (3)	(3)	(3)	(3)	1362—1378 (4)		
						1391—1398 (1)	(1)		1317—1507 (34)
	1446—1448 (1)	(1)	(1)	1446—1461 (4)					
		1458—1461 (1)	(1)		1446—1469 (7)				
1467—1469 (2)	(2)	(2)	(2)	(2)		1446—1486 (14)	(14)		
1476—1479 (3)									
1481—1482 (1)	1476—1482 (5)	(5)	1476—1486 (6)	(6)	(6)			1433—1507 (18)	
1497—1498 (1)	(1)	(1)	(1)	(1)	(1)	(1)	1497—1507 (2)		
1537—1538 (1)	(1)	1537—1541 (2)	1533—1541 (3)	(3)					
1553—1554 (1)					1533—1557 (9)	(9)	1533—1567 (10)	(10)	
1556—1557 (1)	1551—1557 (4)	(4)	1547—1557 (5)	(5)					
1586—1588 (2)	(2)	(2)							1533—1627 (23)
1592—1593 (1)	(1)	(1)							
	1597—1599 (1)	1597—1602 (2)	1586—1602 (7)	(7)	(7)	(7)			
	1612—1614 (1)	(1)	(1)	(1)	(1)	(1)	1586—1627 (12)	(12)	
1626—1627 (1)	1624—1627 (2)	(2)	(2)	(2)	(2)	(2)			
1648—1649 (1)									
1651—1652 (1)	1648—1652 (3)	(3)	(3)						
1657—1659 (2)	(2)			1648—1664 (8)	(8)	(8)	(8)	(8)	
	1662—1664 (1)	1657—1664 (4)	(4)						
1687—1688 (1)	(1)	(1)	(1)	(1)	1681—1688 (2)	(2)	(2)		1648—1829 (41)
1703—1704 (1)	(1)	(1)	(1)	(1)	(1)	1703—1713 (4)	(4)		
1711—1713 (2)	(2)	(2)	(2)	(2)	(2)				
1726—1727 (1)	(1)	(1)	1726—1731 (2)	(2)	(2)	(2)	(2)		
1746—1748 (2)	(2)	1743—1748 (3)	(3)						
	1757—1759 (1)	(1)	1753—1759 (2)	1743—1759 (6)	(6)	(6)	(6)	1681—1829 (32)	
					1772—1778 (1)	(1)	(1)		
	1792—1794 (1)								
1797—1798 (1)	(1)	1792—1806 (6)	(6)	(6)	(6)	(6)			
	1801—1803 (1)						1792—1829 (12)		
1816—1817 (1)	(1)	(1)							
		1821—1824 (1)	1816—1829 (5)	(5)	(5)	(5)			
1828—1829 (1)	(1)	(1)							
						1864—1872 (1)	(1)	1853—1872 (2)	(2)

of 5 and 6 successively arranged intervals are observable; these are all thought to reflect on the schooling tendency and should be regarded as the true-clusters. But their hooked positions are uncertain because of the same reason as mentioned above. And the catch from these 10 clusters occupies 1/5 of total catch.

Structure at the higher orders : The observed-values in the interval analysis at k = 10, 13, 17 and 19 hook-intervals seem to exceed the theoretical ones; this fact suggests that these may be the key-lengths to the higher orders. But all the observed-values and the estimated ones in the interval analysis in the range $k > 15$ hook-intervals do not reach five. Therefore, if we want to find out the pattern somewhat rid of the influence of accidental error introduced into the key-length, we can not give any further consideration to the structure of the higher orders than the third. Accordingly, the distribution pattern, when 10 hook-interval width is adopted as the hypothetical key-length, will be explained; then a short description of the structure, in which the hypothetical key-length is set to be 15 hook-intervals, and appendantly with that at 20 hook-intervals, will be added, for reference' sake.

(*Structure at the third order*)——Among many apparent-clusters of small population-size, only two clusters constituted of each four hooked-individuals are capable of being regarded as the true-clusters due to the schooling tendency. Besides them, it is also suggested that, among eight apparent-clusters constituted of each as many as or more than 10 hooked-individuals, at least some of them may be the true ones. But the hooked positions, moreover even the number, of these true-clusters are uncertain.

(*Structure at the higher orders*)——When the key-length is elongated into as long as 15 hook-intervals, total number of the lots can not be more than 30, which is thought to be not so many enough, because the intervals longer than 15 hook-intervals are only as many as 28 among 253 intervals. Moreover, these 30 or less lots are classified into the groups according to their population-size showing a slight decrease with increase in their population-size; accordingly, not only the theoretical numbers of the lots of respective population-size but also the observed ones become very few. And these facts make it difficult to deduce any fact but that the presence of some clusters of large population-size is suspected; and their hooked positions and the population-sizes are easily estimative from Table 16. But even if dare to say committing against the presupposable severe-influence of accidental error, no further fact is guessed out except that these probable schools are rather dispersively distributed. These tendencies become far influential when the key-length is elongated into as long as 20 hook-intervals.

Example Y 7

It is one of the characteristics of the distribution pattern of this example that the lots constituted of many intervals arranged successively are rather frequently observable, although this fact seems to be partly indebted to the gradient of the distribution. When we regard two hook-intervals as the key-length to the elemental step, four as that to the second order, six or eight as that to the third order, 15 as that to the fourth order and 20 as that to the fifth order respectively, the following

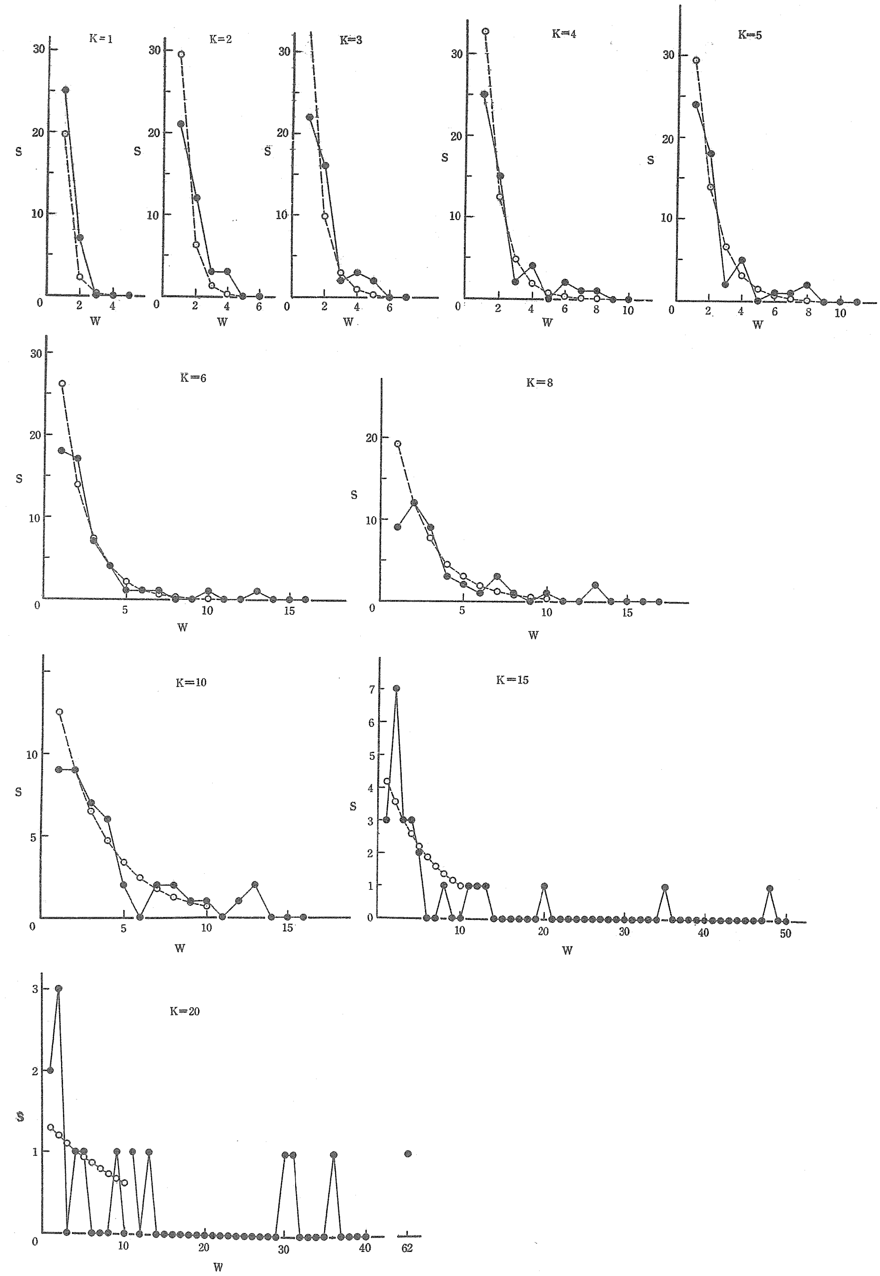
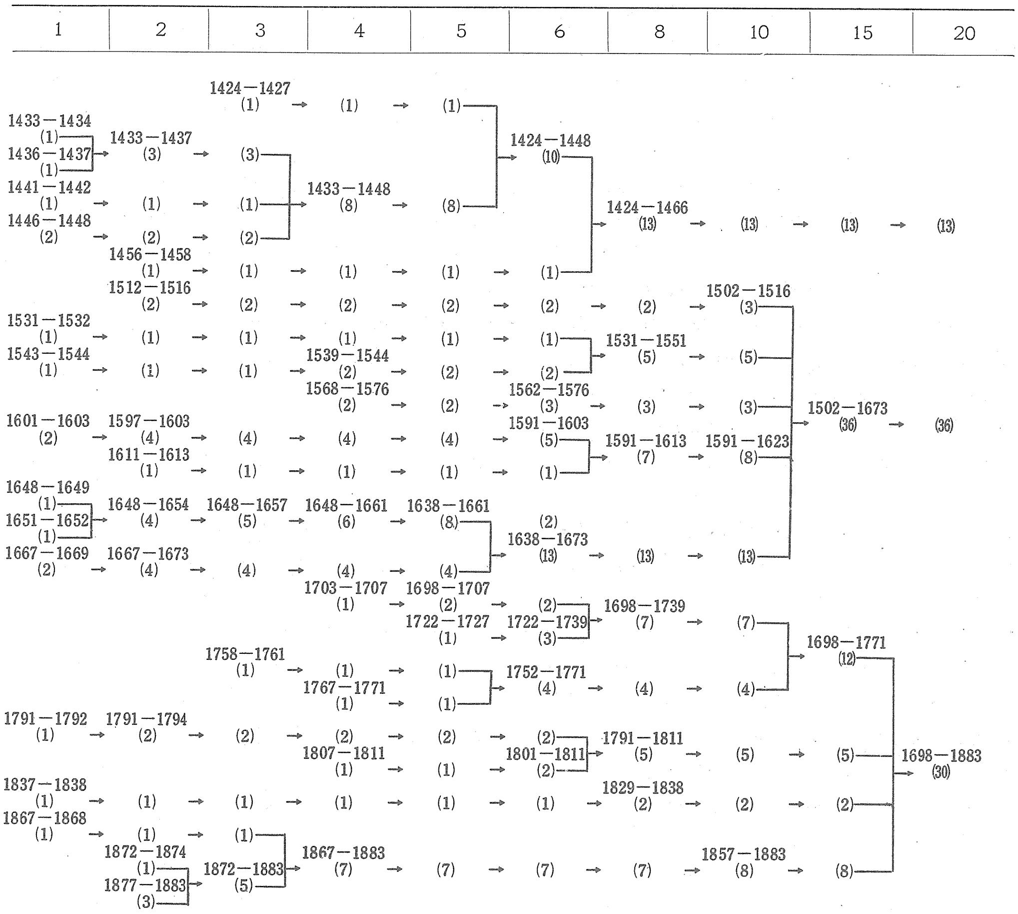


Fig. 56. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 7).

Table 17. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 7).

1	2	3	4	5	6	8	10	15	20
						63−71 (1)	(1)	(1)	(1)
					127−139 (2)	(2)	(2)	112−139 (3)	92−178 (9)
	169−173 (2)	(2)	(2)	169−178 (3)	(3)	(3)	159−178 (4)	(4)	
			237−241 (1)	(1)	(1)	(1)	(1)	222−241 (2)	222−262 (5)
261−262 (1)	259−262 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	
293−294 (1)	(1)	(1)	(1)	288−294 (2)	(2)	(2)	(2)	288−312 (4)	(4)
			308−312 (1)	(1)	(1)	(1)	(1)		
		398−401 (1)	(1)	(1)	(1)	(1)	(1)	383−401 (2)	(2)
426−427 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
		481−484 (1)	481−488 (2)	(2)	(2)	(2)	(2)	(2)	(2)
581−582 (1)	(1)	(1)	(1)	(1)	(1)	(1)	572−582 (2)	(2)	(2)
				638−643 (1)	(1)	631−643 (2)	(2)	631−654 (3)	
							687−696 (1)	673−696 (2)	
								714−729 (1)	
			759−767 (2)	(2)	(2)	(2)	(2)	747−781 (4)	
806−808 (2)	(2)	806−811 (3)	(3)	801−811 (4)	(4)	(4)	(4)		
832−834 (2)	(2)	(2)	(2)	(2)	(2)	832−842 (3)	823−842 (4)		631−1081 (62)
		853−856 (1)	(1)	(1)	(1)	(1)	(1)		
876−877 (1)	874−877 (2)	(2)	(2)	(2)	868−877 (3)	(3)	868−924 (12)		
893−894 (1)	(1)	(1)	(1)	(1)	887−894 (2)	887−924 (8)			
901−902 (1)	(1)	(1)	(1)	(1)	(1)				
923−924 (1)	(1)	(1)	(1)	(1)	(1)				
		946−949 (1)	(1)	946−954 (2)	(2)	946−961 (3)	937−961 (4)	801−1081 (48)	
993−994 (1)	(1)	993−997 (2)	(2)	(2)	(2)	(2)	974−1022 (9)		
1007−1008 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
	1017−1019 (1)	1017−1022 (2)	(2)	(2)	(2)	(2)			
1037−1038 (1)	(1)	1037−1041 (2)	(2)	(2)	1037−1047 (3)	(3)	(3)		
	1061−1063 (1)	(1)	(1)	(1)	(1)	(1)	(1)		
1078−1079 (1)	1078−1081 (2)	(2)	(2)	(2)	(2)	(2)	(2)		
1112−1113 (1)	(1)	1109−1113 (2)	(2)	(2)	1103−1113 (3)	(3)	(3)	(3)	
1162−1164 (2)	(2)	(2)	1162−1169 (4)	(4)	(4)	(4)	(4)	1151−1169 (5)	
1168−1169 (1)	(1)	(1)							1103−1306 (31)
1187−1189 (2)	(2)	(2)	1187−1201 (6)	(6)	(6)	1187−1229 (10)	(10)		
	1197−1201 (2)	(2)							
			1209−1213 (1)	(1)	(1)				
		1241−1247 (2)	1241−1251 (3)	(3)	(3)	(3)	(3)	1187−1306 (20)	
							1263−1272 (1)		
				1287−1297 (2)	(2)	(2)	1287−1306 (3)		
			1328−1332 (1)	(1)	(1)	1328−1346 (3)	(3)	1328−1388 (11)	(11)
1373−1374 (1)	1369−1374 (3)	1369−1377 (4)	(4)	(4)	(4)	1369−1388 (6)	1359−1388 (7)		
			1384−1388 (1)	(1)	(1)				



structures at respective steps will be guessed out.

Structure at the elemental step ($k=2$) : From Fig. 56 —(2), it becomes clear that, on account of the schooling tendency and of the gradient, some of the lots expected to be observable as single or not so many intervals arranged successively are attached to some other intervals; consequently, the single isolated-intervals are actually observable only 2/3 times as frequently as expected from the chance distribution, in contrast with the fact that the lots constituted of two or three intervals arranged successively are observable two times as frequently as expected, moreover three lots of each four intervals are observable. And even if a part of them may be indebted to the gradient, most of them are well thought to be the true-clusters at the elemental step due to the schooling tendency. Therefore, a little more than 4/5 of total catch are thought to be brought from single individuals hooked solitarily or forming the false-clusters caused even by the chance distribution.

Structure at the second order ($k = 4$) : Besides some clusters of small population-size —— significance of which is somewhat doubtful and they may be probable to be due to accidental error in the chance distribution ——, there are four true cluster-like aggregations constituted of from seven to nine hooked-individuals and each aggregation is thought to be chiefly constituted of some elemental-clusters to which some single-individuals are attached. But their hooked positions suggest that it seems to be more probable to consider some of even these clusters are not the true ones due to the schooling tendency, but are the false ones indebted to the gradient; while among the apparent-clusters of small population-size, some of those at least hooked in the beginning half of hauling of a row may be neither due to the chance distribution nor to the gradient, but are well thought to be caused by the schooling tendency and have to be regarded as the true-clusters.

Consideration upon the structure, in which eight hook-interval width is set to be the key-length : The fact, whether this length can be regarded as one of the key-lengths or not, is somewhat doubtful. Moreover even if we examine on the structure at this step in detail, no fact other than the same one described in the preceding step can be deduced, which seems to mean that this length can not be one of the key-lengths.

Structure at the third order ($k = 15$) : The number of the intervals longer than 15 hook-intervals is no more than 30 among 223 total ones; thus total number of the lots is not so many; moreover the scarcity of the lots of each population-size is emphasized by the gradual decrease in both the observed numbers and the estimated ones of the lots with increase in their population-size. Accordingly, I am afraid that the arrangement analysis is severely suffered from the influence of accidental error. But, in any case, the presence of three clusters constituted of 21, 36 and 49 hooked-individuals respectively may well be regarded to be caused by the schooling tendency, because of the fact that their hooked positions are not so strongly restricted to the latter half of the hauling of a row. But their schooling tendency is thought to be not so strong, because, in contrast with the fact that they cover 1/3 as wide as total length of a row, catch does not attain to as many as a half of total one.

Structure at the highest order ($k = 20$) : The intervals longer than 20 hook-intervals are no more than 1/10 of total one; accordingly, the structure at this step may be thought to be that of the highest order observable within a row. The observed numbers of the lots of respective population-sizes and the estimated ones become far less than those in the preceding step; this makes it far more difficult to decode the pattern rid of the severe influence of accidental error. But it may well be considered that at least two, frequently all three schools constituted of each a little more than 30 hooked-individuals among three apparent ones are regarded to be the true-schools caused by the schooling tendency and, of course, that constituted of 63 hooked-individuals is also the true one. Thus, the same but clearer pattern as that of the preceding step can be deduced. And even if one were result of the chance distribution or accidental error in the arrangement analysis, about a little more than a half of total catch distributed within a little narrower width than a half of a row forms three schools of weak contagiousness, the adjacent centers of which are spaced by a width as long as 80 baskets from each other.

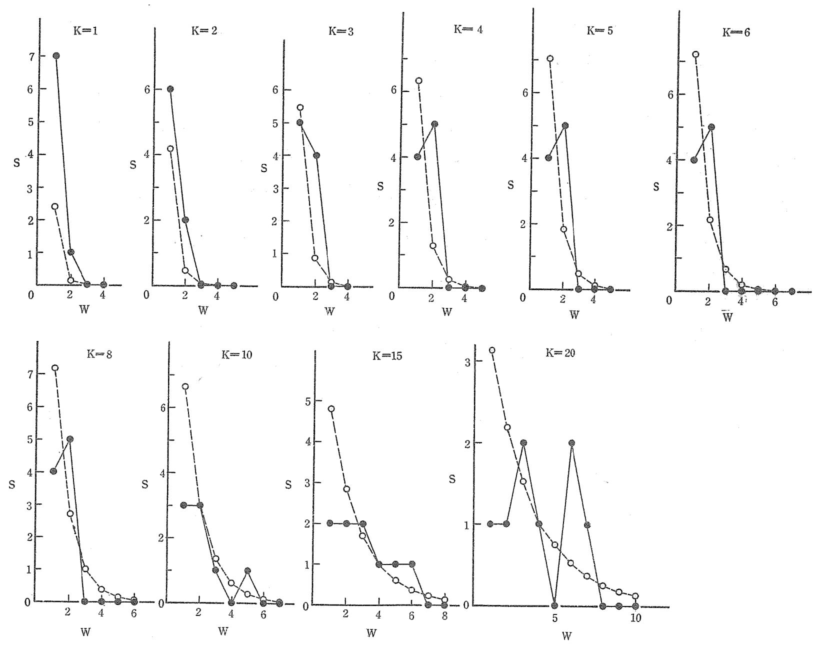


Fig. 57. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective *k* are set to be the key-lengths to decoding the distribution patterns (Example Y 8).

Table 18. The positions of the apparent clusters and the changes in their features with increase in *k* (Example Y 8).

1	2	3	4	5	6	8	10	15	20
98—99 (1)	(1)	98—102 (2)	(2)	(2)	(2)	(2)	98—112 (3)	(3)	(3)
181—183 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	181—203 (3)
		358—361 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
398—399 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	384—432 (6)	(6)
416—417 (1)	(1)	413—417 (2)	(2)	(2)	(2)	(2)	(2)		
								528—563 (3)	509—608 (7)
								583—608 (2)	
666—667 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	666—684 (4)	(4)
683—684 (1)	681—684 (2)	(2)	(2)	(2)	(2)	(2)	(2)		
742—743 (1)	(1)	(1)	(1)	(1)	(1)	(1)	733—757 (5)	(5)	733—777 (6)
752—753 (1)	(1)	(1)	752—757 (2)	(2)	(2)	(2)			
								803—814 (1)	803—833 (2)

Example Y 8

Short gears are poorly occupied; therefore, the catch is too scarce to get both the observed-values and the estimated ones in both the interval analysis and the arrangement one high enough to be free from severe influence of accidental error; consequently it is difficult to deduce any structure of significance. Accordingly, I do not wish to give any further interpretation than those briefly described in the below.

1) The first peak of the observed-values in the interval analysis is assumed to be at one hook-interval. Therefore, set this width as the key-length to the elemental step, and the strong schooling-tendency is suggested from the fact that as many as eight clusters are observed apparently, against the fact that no more than $2\frac{1}{2}$ clusters are expected to be observable from the chance distribution.

2) The schooling tendency is also suggested from such results at respective steps of analyses as the high observed-values of the lots of large population-size and *vice versa*.

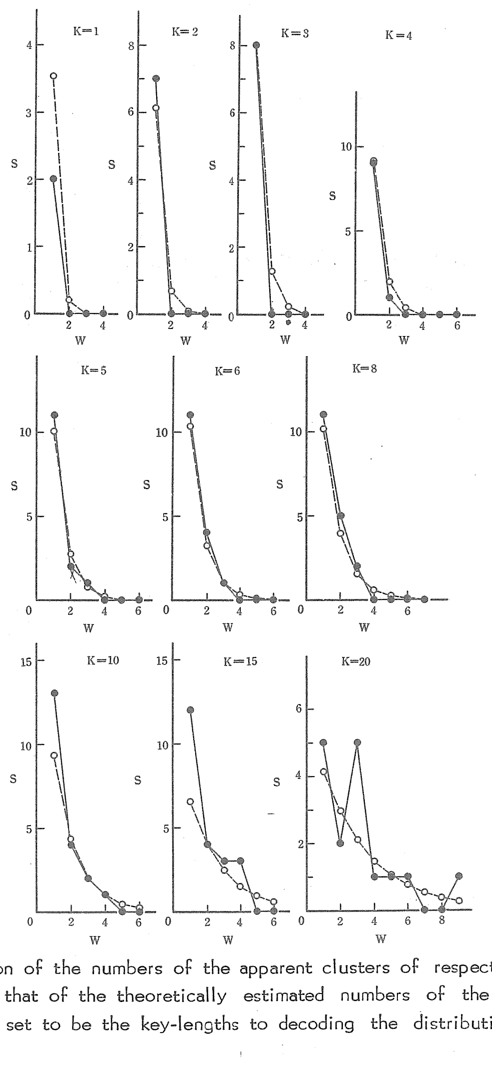


Fig. 58. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 9).

Table 19. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 9).

1	2	3	4	5	6	8	10	15	20
						89—97 (1)	(1)	(1)	(1)
			147—151 (1)	(1)	(1)	(1)	(1)	(1)	(1)
								189—203 (1)	(1)
	276—278 (1)	(1)	(1)	271—283 (3)	(3)	(3)	261—283 (4)	(4)	261—317 (6)
								302—317 (1)	
		339—342 (1)	(1)	(1)	(1)	(1)	(1)	339—354 (2)	339—372 (3)
	414—416 (1)	(1)	(1)	(1)	408—416 (2)	408—424 (3)	(3)	(3)	(3)
	469—471 (1)	(1)	(1)	(1)	(1)	461—471 (2)	(2)	446—471 (3)	(3)
							496—506 (1)	(1)	496—583 (9)
				522—527 (1)	(1)	(1)	(1)	522—546 (4)	
	544—546 (1)	(1)	(1)	(1)	538—546 (2)	(2)	(2)		
				578—583 (1)	(1)	(1)	(1)	563—583 (2)	
641—642 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	641—682 (4)
					658—664 (1)	658—682 (2)	(2)	(2)	
				708—713 (1)	(1)	(1)	(1)	(1)	(1)
							743—752 (1)	(1)	743—781 (3)
								769—781 (1)	
				841—846 (1)	(1)	(1)	(1)	(1)	841—863 (2)
					887—893 (1)	(1)	(1)	887—916 (3)	(3)
						908—916 (1)	(1)		
963—964 (1)	(1)	(1)	(1)	958—964 (2)	(2)	(2)	(2)	(2)	(2)
	1007—1009 (1)	(1)	1007—1013 (2)	(2)	(2)	(2)	1007—1023 (3)	1007—1038 (4)	991—1062 (7)
			1058—1062 (1)	(1)	(1)	(1)	(1)	(1)	
								1131—1143 (1)	(1)

Example Y 9

No further fact than those described in the below can be deduced, because of the low observed-values and the estimated ones due to poor total-catch.

1) When a length shorter than five hook-intervals is set to be the key-length, the apparently observed number of the clusters of any population-size can not reach the theoretical one; this suggests that individuals seem to be hooked rather self-spacingly.

2) Moreover, when the key-length is neither shorter than five hook-intervals nor longer than 10, none of the apparently observed clusters are constituted of more than five or six hooked-individuals, while the deviation of the observed-values shows that the clusters of small population-size are more frequently observable than expected from the chance distribution. And these facts also seem to support the self-spacing pattern.

3) And even when the key-length is elongated into as long as 15 hook-intervals, none of the deviation are incapable of being negligible, except the higher observed-value at $W=1$; this means that the clusters being able to be regarded as the true

ones are only five ones constituted of each two hooked-individuals.

4) Furthermore, if the key-length is increased to the width as long as 20 hook-intervals, the estimated numbers of the lots still keep a sharp decrease with increase in their population-size. And even if to say committing against the presupposable severe-influence of accidental error, we can not find out any true-cluster other than no or one cluster constituted of two hooked-individuals, three or one less clusters of each four hooked-individuals and perhaps including a cluster constituted of 10 hooked-individuals and covering the part from the first hook in the 100th basket (H. N. 496) to the third hook in the 117th basket (H. N. 583).

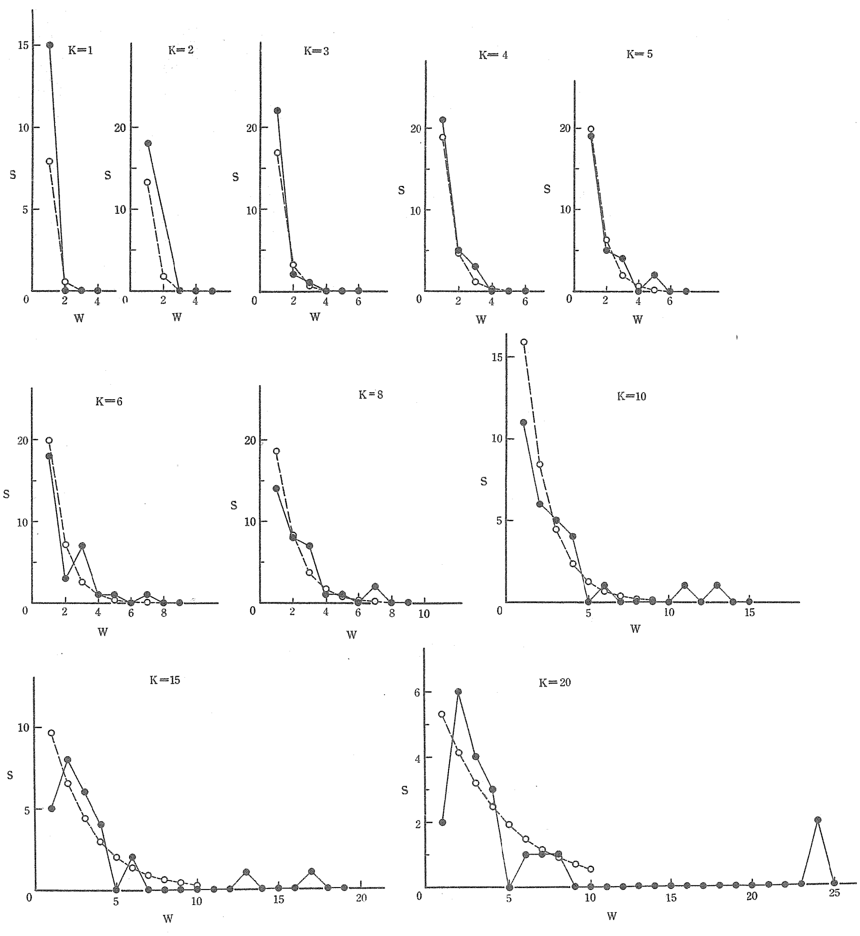


Fig. 59. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 10).

Table 20. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 10).

1	2	3	4	5	6	8	10	15	20
			119–123 (1)	(1)	(1)	119–131 (2)	(2)	(2)	(2)
181–182 (1)	(1)	(1)	(1)	181–187 (2)	181–193 (3)	(3)	(3)	(3)	(3)
263–264 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	243–264 (2)
					302–308 (1)	302–316 (2)	(2)	(2)	(2)
			347–351 (1)	(1)	(1)	(1)	(1)	(1)	347–372 (3)
371–372 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
								433–448 (1)	(1)
	512–514 (1)	(1)	(1)	(1)	(1)	(1)	(1)	512–527 (2)	(2)
597–598 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	597–622 (3)	578–661 (7)
						653–661 (1)	(1)	642–661 (2)	
						754–761 (1)	754–781 (4)	(4)	(4)
	771–773 (1)	(1)	(1)	(1)	(1)	771–781 (2)			
				963–968 (1)	(1)	956–968 (2)	(2)	942–968 (3)	(3)
1008–1009 (1)	1006–1009 (2)	(2)	(2)	1001–1009 (3)	(3)	(3)	(3)	(3)	1001–1159 (24)
1032–1033 (1)	(1)	1029–1033 (2)	(2)	(2)	(2)	(2)	(2)	(2)	
1061–1062 (1)	(1)	(1)	(1)	(1)	(1)	(1)	1052–1123 (13)		
		1084–1087 (1)	(1)	1084–1103 (5)	1072–1103 (7)	(7)			
	1101–1103 (1)	(1)	1097–1103 (2)						
			1119–1123 (1)	(1)	(1)	1112–1123 (2)		1052–1159 (17)	
1138–1139 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
						1151–1159 (1)	(1)		
1267–1268 (1)	(1)	(1)	1259–1268 (3)	(3)	(3)	1252–1268 (4)	(4)	1222–1268 (6)	
			1297–1301 (1)	(1)	(1)	(1)	1288–1301 (2)	(2)	
		1343–1346 (1)	(1)	1338–1346 (2)	(2)				1222–1413 (24)
		1359–1362 (1)	1359–1369 (3)	(3)	1353–1369 (4)	1338–1369 (7)	1338–1401 (11)		
		1366–1369 (1)							
			1387–1391 (1)	(1)	(1)	1379–1391 (2)		1338–1413 (13)	
1412–1413 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
	1437–1441 (2)	1437–1444 (3)	(3)	(3)	(3)	(3)	(3)	1437–1457 (4)	(4)
1491–1492 (1)	(1)	(1)	(1)	(1)	(1)	1484–1499 (3)	1484–1509 (4)	(4)	(4)
1541–1542 (1)	(1)	(1)	(1)	1541–1557 (5)	(5)	(5)	1541–1567 (6)	(6)	(6)
1556–1557 (1)	(1)	(1)	1552–1557 (2)						
				1633–1638 (1)	(1)	(1)	(1)	(1)	(1)
				1676–1681 (1)	(1)	(1)	(1)	1662–1681 (2)	(2)
1727–1728 (1)	(1)	(1)	(1)	1722–1728 (2)	1716–1728 (3)	(3)	1716–1737 (4)	(4)	1716–1794 (8)
					1756–1794 (3)	(3)	(3)	(3)	
	1836–1838 (1)	(1)	1832–1838 (2)	(2)	(2)	(2)	(2)	(2)	(2)
		1868–1871 (1)	(1)	(1)	1868–1878 (3)	(3)	(3)	(3)	(3)
1877–1878 (1)	(1)	(1)	(1)	(1)					

Example Y 10

It is one of the characteristics of the distribution pattern of this example that, when we neglect slight deviations of the observed-values in the interval analysis at $k=2$ and 3, the observed-values within eight hook-intervals are continuously higher than the estimated ones; this seems to mean that the intervals forming the elemental-clusters in this example are far longer than those of the other examples, in other words, the contagiousness at the elemental step reaches the wider range than those of the other examples and is as long as eight hook-intervals. And when we consider this fact together with a little lower occupied-rate, it is suggested that the population seems to be more dispersing than in the other examples, but it still keeps a contagious pattern. Keeping the above-mentioned facts in mind, let us analyze the distribution pattern of this example; then the following results will be obtained.

Structure at the elemental step ($k=1$ *or* 8) : As mentioned above, the key-length to this step is thought to be eight hook-intervals; but when we regard the slight deviations of the observed-values in the interval analysis at 2 and 3 hook-intervals as significant, one hook-interval can be regarded as the key-length; then the distribution pattern is decoded as follows: the population seems to contain seven true-clusters constituted of each two individuals hooked adjoiningly, which occupy about 1/10 of total catch. But when the deviations at 2 and 3 hook-intervals are regarded to be insignificant, the key-length becomes as long as eight hook-intervals and the following pattern is deducible. Because of the schooling tendency, the single isolated-intervals are not so frequently observable as expected from the chance distribution; while three more clusters constituted of each four hooked-individuals and two more clusters of each eight hooked-individuals than expected from the chance distribution are observable, complementing the insufficiency of the number of the single intervals observed actually; and these clusters are thought to be the true ones at the elemental step. And the hooked positions of the clusters of small population-size are uncertain because of the difficulties of distinguishing the true ones constituted of each three hooked-individuals from the false ones of the same population-size observable even as the results of the chance distribution. And a little less than 20 % of total catch is thought to be derived from these true-clusters. Here, for reference' sake, I must describe the fact that the elemental-clusters of such a large population-size as eight individuals seem to be as if to indicate where the occupied-rate of the hooks located there is extremely high, but actually, the average occupied-rate of the hooks is not so high, and is only about a little higher than one individual per basket, because of long key-length in company with the low occupied-rate.

Structure at the second order ($k=20$) : All the observed-values and the estimated ones in the interval analysis in the range $k>10$ do not reach five. Accordingly, whether the obscurely high observed-values at $k=10$, 13 and 15 can be regarded as significant or not is doubtful, because the interval analysis may be severely suffered from the influence of accidental error; but it has little less risk to be suffered from the influence of accidental error to consider that the observed-value in the interval analysis at 20 hook-intervals may, perhaps, be significantly higher than the estimated one and is regarded as the key-length to the second order. Accordingly, when we set 20 hook-intervals as the key-length, the distribution pattern of the probable second order, which may be the highest order observable within a row, is decoded as follows: the deviation of the observed-values from the estimated ones seems to allude to the presence of some true-clusters of small population-size; but it seems to be better to regard that there is no true-cluster of small population-size, because the low observed-values and the estimated ones have much risk to introduce severe influence of accidental error into the decoding of the pattern, which makes it impossible to give any significance to the above-mentioned deviation. On the other hand, two clusters of large population-size pointed out at the preceding step of analysis are swelled their population-size into each 25 hooked-individuals, and they are raised to be regarded as the true-clusters at this step. And they seem to be situated side by side at the parts respectively from the first hook in the 201th basket (H. N. 1001) to the last hook in the 232th basket (H. N. 1159) and from the second hook in the 245th basket (H. N. 1222) to the third hook in the 283th basket (H. N. 1413). Thus, the population seems to contain two schools, each of which is constituted of 1/5 of total catch and covering 9 and 11 % of a whole length of a row. But examining on Table 20, we may be aware of the fact as one of the characteristics of the distribution pattern of these schools, especially of the latter one, that, in contrast with the fact that the intervals of one hook-interval width or thereabout are the principal ingredient of the schools of the similar population-size in the other examples, the schools in this example do not contain so many intervals of such a narrow width as one hook-interval; this fact seems also to reflect the dispersed pattern pointed out at the top of the description of this example.

Example Y 11

Good catch by long gears raises the observed-values in the interval analysis enough to estimate the key-lengths being suffered from scarcely any influence of accidental error. Notwithstanding, the gradient, the exclusion of the influence of which on the interval analysis is too troublesome, is expected to be strongly influential, which makes it difficult to find out the key-lengths. But, it may be said that the observed-values in the interval analysis within three hook-intervals are continuously higher than the theoretical ones, even if the influence of the gradient is taken into consideration. And the high observed-values in the interval analysis in the range from $k = 17$ to 19 may also be significant. Moreover, when we refer to the deviations, some significance may be given to the high observed-value in the interval analysis at $k = 10$, although it does not exceed the theoretical one. Accordingly, regarding these three lengths as the key-lengths to decoding of the distribution pattern, let us analyze the pattern of this example.

Structure at the elemental step ($k = 3$) : The lots of small population-size are not so frequently observable as expected from the chance distribution; complementing them, the lots of large population-size are far more frequently observable than expected, because chiefly of strong cluster-formation at the elemental step and partly of the

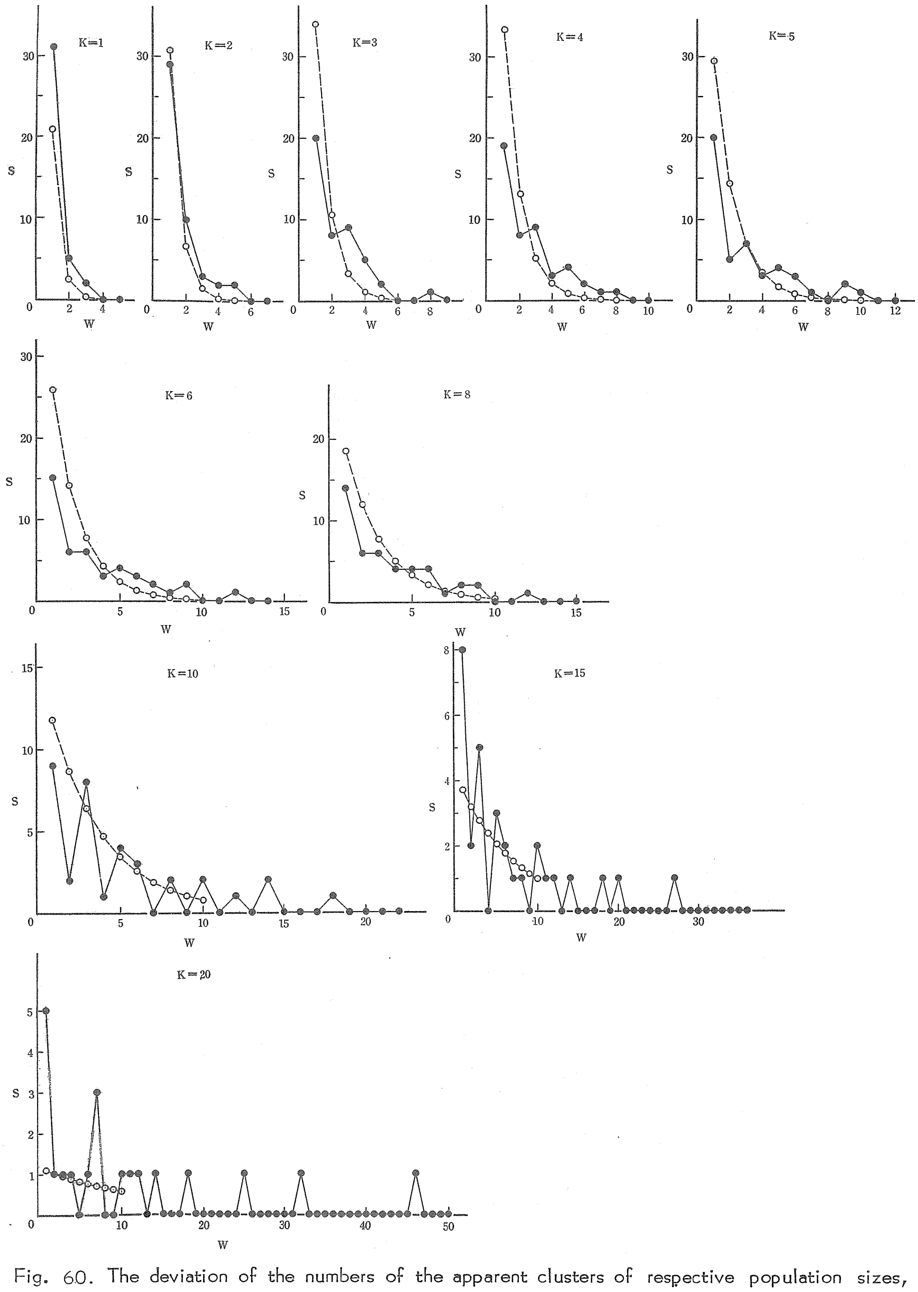
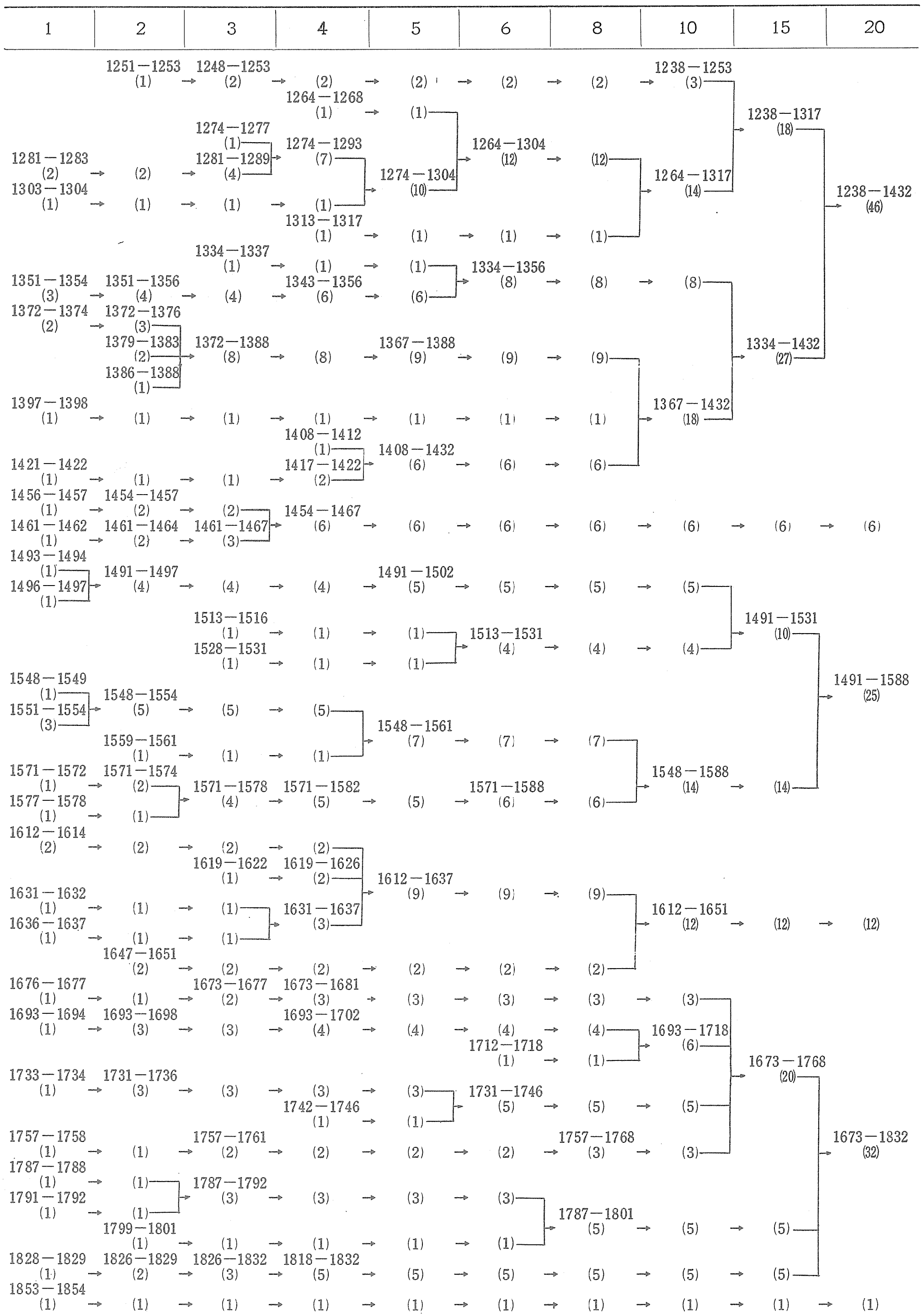


Fig. 60. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y11).

high observed-values in the interval analysis at one hook-interval and of the high occupied-rate. And the above-mentioned facts cause the gradual decrease in the observed numbers of the lots with increase in their population-size. That is to say, the apparently observed numbers of the clusters constituted of each as many as or less than three hooked-individuals can not reach the numbers expected from the chance distribution, but six more clusters constituted of each four hooked-individuals, four more ones of each five hooked-individuals and one and two more clusters of six and three more hooked-individuals than those expected from the chance distribution are

Table 21. The positions of the apparent clusters and the changes in their features with increase in k (Example Y 11).

1	2	3	4	5	6	8	10	15	20
8−9 (1)	(1)	8−13 (3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
12−13 (1)	(1)								
									61−79 (1)
			117−121 (1)	(1)	(1)	(1)	107−121 (2)	(2)	107−162 (7)
142−143 (1)	(1)	139−146 (3)	(3)	(3)	(3)	(3)	(3)	(3)	
	207−211 (2)	204−211 (3)	(3)	(3)	(3)	(3)	(3)	193−236 (7)	(7)
	234−236 (1)	(1)	(1)	(1)	(1)	(1)	(1)		
					391−397 (1)	(1)	(1)	(1)	(1)
				448−453 (1)	(1)	(1)	(1)	(1)	411−471 (4)
								501−513 (1)	(1)
						557−572 (2)	547−572 (3)	534−587 (5)	534−607 (7)
606−607 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
				654−659 (1)	(1)	(1)	(1)	(1)	(1)
								687−702 (1)	687−722 (2)
762−764 (2)	(2)	762−767 (3)	(3)	762−772 (4)	(4)	(4)	743−772 (6)	(6)	743−861 (18)
	789−791 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
826−827 (1)	826−833 (5)	(5)	(5)	(5)	(5)	826−841 (6)	826−861 (8)	(8)	
831−833 (2)									
					936−942 (1)	(1)	(1)	911−942 (3)	911−1017 (10)
	964−966 (1)	961−966 (2)	(2)	(2)	(2)	(2)	(2)	961−979 (3)	
						997−1004 (1)	(1)	997−1017 (2)	
			1059−1063 (1)	(1)	1059−1069 (2)	(2)	1059−1116 (10)	1044−1116 (11)	(11)
	1082−1084 (1)	1079−1084 (2)	(2)	(2)	(2)	(2)			
1101−1102 (1)	(1)	(1)	(1)	(1)	(1)	1093−1116 (4)			
1142−1143 (1)	(1)	(1)	1142−1148 (3)	(3)	(3)	(3)	(3)	(3)	1142−1206 (14)
1147−1148 (1)	(1)	(1)							
			1164−1168 (1)	(1)	(1)	(1)	1164−1206 (10)	(10)	
1177−1178 (1)	(1)	(1)	(1)	(1)	1177−1198 (7)	1177−1206 (8)			
1187−1188 (1)	(1)	1184−1192 (4)	(4)	(4)					
1191−1192 (1)	(1)								


1 2 3 4 5 6 8 10 15 20
1251−1253 1248−1253 1238−1253
(1) → (2) → (2) → (2) → (2) → (2) → (3)
1264−1268
(1) → (1)
1274−1277 1238−1317
(1) 1274−1293 1264−1304 (18)
1281−1283 1281−1289 (7) (12) → (12)
(2) → (2) → (4) 1274−1304 1264−1317
1303−1304 (10) (14) 1238−1432
(1) → (1) → (1) → (1) (46)
1313−1317
(1) → (1) → (1) → (1)
1334−1337
(1) → (1) → (1) 1334−1356
1351−1354 1351−1356 1343−1356 (8) → (8) → (8)
(3) → (4) → (4) → (6) → (6)
1372−1374 1372−1376
(2) → (3)
1379−1383 1372−1388 1367−1388 1334−1432
(2) (8) → (8) → (9) → (9) → (9) (27)
1386−1388
(1)
1397−1398 1367−1432
(1) → (1) → (1) → (1) → (1) → (1) → (1) (18)
1408−1412
(1) 1408−1432
1421−1422 1417−1422 (6) → (6) → (6)
(1) → (1) → (1) → (2)
1456−1457 1454−1457
(1) → (2) → (2) 1454−1467
1461−1462 1461−1464 1461−1467 (6) → (6) → (6) → (6) → (6) → (6) → (6)
(1) → (2) → (3)
1493−1494
(1) 1491−1497 1491−1502
1496−1497 (4) → (4) → (4) → (5) → (5) → (5) → (5)
(1)
1513−1516 1491−1531
(1) → (1) → (1) 1513−1531 (10)
1528−1531 (4) → (4) → (4)
(1) → (1) → (1)
1548−1549 1491−1588
(1) 1548−1554 (25)
1551−1554 (5) → (5) → (5)
(3) 1548−1561
1559−1561 (7) → (7) → (7)
(1) → (1) → (1)
1571−1572 1571−1574 1548−1588
(1) → (2) 1571−1578 1571−1582 1571−1588 (14) → (14)
1577−1578 (4) → (5) → (5) → (6) → (6)
(1) → (1)
1612−1614
(2) → (2) → (2) → (2)
1619−1622 1619−1626 1612−1637
(1) → (2) (9) → (9) → (9)
1631−1632 1612−1651
(1) → (1) → (1) 1631−1637 (12) → (12) → (12)
1636−1637 (3)
(1) → (1) → (1)
1647−1651
(2) → (2) → (2) → (2) → (2) → (2)
1676−1677 1673−1677 1673−1681
(1) → (1) → (2) → (3) → (3) → (3) → (3) → (3)
1693−1694 1693−1698 1693−1702
(1) → (3) → (3) → (4) → (4) → (4) → (4) 1693−1718
1712−1718 (6)
(1) → (1) 1673−1768
1733−1734 1731−1736 (20)
(1) → (3) → (3) → (3) → (3) 1731−1746
1742−1746 (5) → (5) → (5)
(1) → (1)
1757−1758 1757−1761 1757−1768 1673−1832
(1) → (1) → (2) → (2) → (2) → (2) → (3) → (3) (32)
1787−1788
(1) → (1) 1787−1792
1791−1792 (3) → (3) → (3) → (3) 1787−1801
(1) → (1) (5) → (5) → (5)
1799−1801
(1) → (1) → (1) → (1) → (1)
1828−1829 1826−1829 1826−1832 1818−1832
(1) → (2) → (3) → (5) → (5) → (5) → (5) → (5) → (5)
1853−1854
(1) → (1) → (1) → (1) → (1) → (1) → (1) → (1) → (1) → (1)

observable and they are thought as if to be regarded as the true-clusters due to schooling tendency. But it is probable that some of them may be not the true ones but the false ones indebted to the gradient, because the gradient expects to cause some false-clusters occurred more frequently with approach to the final end of hauling of a row. Accordingly, it may well be thought that catch from less than 13 clusters at the elemental step occupies 1/4 of total catch; while catch from single-individuals, which are swimming solitarily or falsely forming clusters due to even the chance distribution or due to the gradient, reaches three times as many as that from the former.

Structure at the second order ($k = 10$) : The high observed-values in Fig. 60-(10) at $W = 3$ and 10 seem to allude to the presence of some clusters; but when the influence of accidental error due to the low observed-values is taken into consideration, the significance of the presence of them becomes highly doubtful. But, even if the influence of the gradient is taken into consideration, there may be no doubt about the presence of a cluster constituted of 19 hooked-individuals and covering the range from the second hook in the 274th basket (H.N. 1367) to the hook of the same order spaced by 13 baskets (H.N. 1432). And also it is suspected, even if the influence of the gradient is taken into consideration, that among a cluster constituted of 13 hooked-individuals and two clusters of 15 hooked-individuals, at least one or two may well be regarded as the true ones due to the schooling tendency.

Structure at the highest order ($k = 20$) : The theoretical number of the intervals longer than 20 hook-intervals is estimated to be as many as 16 among 229 total ones; this fact results in the small number of the lots actually observed and estimated, moreover the high occupied-rate also causes a very slight decrease in the number of the lots with increase in their population-size. Accordingly, the estimated numbers of the lots of respective population-size are expected to be far lower; and this fact makes it hardly possible to guess the pattern free from the influence of accidental error. And even if dare to say committing against severe influence of accidental error and of the gradient, I can not deduce any fact but mentioned below. Four clusters constituted of each two hooked-individuals among five apparently observed ones and two of each eight hooked-individuals among three apparent ones are probably regarded as the true-schools of small population-size. But among the apparently observed clusters of respective population-size, those having the more intervals of narrow width are the more probable to be the true ones. And also, among four clusters constituted of from 11 to 15 hooked-individuals, at least two are well regarded as the true ones. Moreover, it is more probable that all or at least one less of four clusters of such a large population-size as 19, 26, 33 and 46 hooked-individuals respectively are regarded as the true ones due to the schooling tendency; and their hooked positions, widths, average occupied-rates, *etc.* are estimative from Table 21. Accordingly, at least about as many as a half of catch is thought to be derived from as many as or more than 11 schools of not so strong contagiousness.

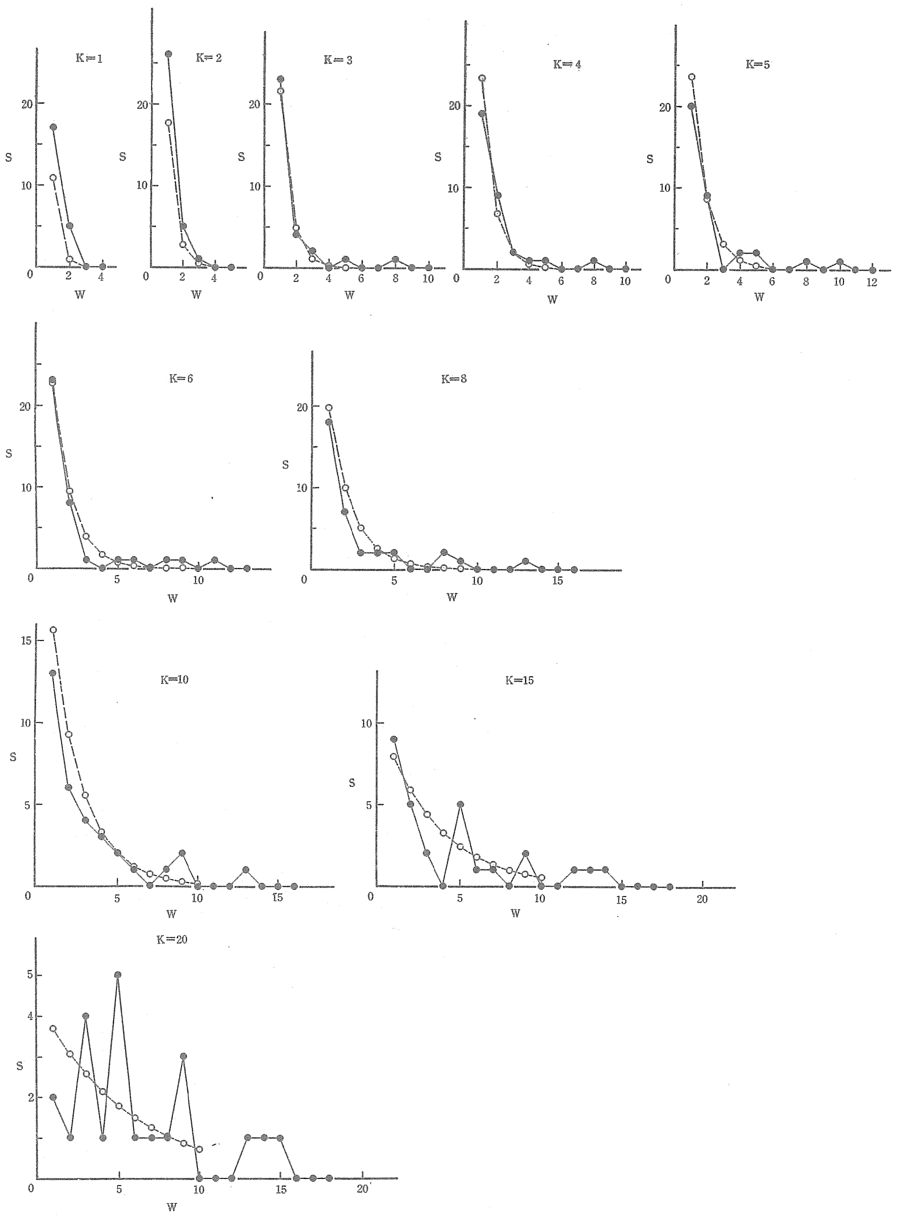


Fig. 61. The deviation of the numbers of the apparent clusters of respective population sizes, in contrast with that of the theoretically estimated numbers of the false clusters, when respective k are set to be the key-lengths to decoding the distribution patterns (Example Y 12).

Table 22. The positions of the apparent clusters and the changes in their features with increase in *k* (Example Y 12).

1	2	3	4	5	6	8	10	15	20
33−34 (1)	(1)	(1)	(1)	(1)	(1)	(1)	23−34 (2)	(2)	3−34 (3)
61−62 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	61−89 (5)	(5)
88−89 (1)	(1)	(1)	84−89 (2)	(2)	(2)	(2)	(2)		
							114−124 (1)	114−164 (7)	(7)
				136−141 (1)	(1)	136−164 (5)	(5)		
		153−156 (1)	149−156 (2)	(2)	(2)				
			199−203 (1)	194−214 (5)	188−214 (6)	188−224 (8)	188−233 (9)	(9)	(9)
208−209 (1)	(1)	(1)	(1)						
	222−224 (1)	(1)	(1)	(1)	(1)				
	272−274 (1)	(1)	(1)	(1)	(1)	272−322 (13)	(13)	(13)	(13)
	292−294 (1)	(1)	288−298 (3)	288−322 (10)	282−322 (11)				
317−319 (2)	(2)	317−322 (3)	313−322 (4)						
446−448 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	446−493 (12)	427−522 (15)
478−479 (1)	478−483 (3)								
486−488 (2)	(2)	478−493 (8)	(8)	(8)	(8)	(8)	(8)		
	491−493 (1)								
								511−522 (1)	
566−567 (1)	(1)	(1)	(1)	(1)	(1)	558−567 (2)	549−567 (3)	(3)	(3)
									601−618 (1)
647−648 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	647−706 (4)
						698−706 (1)	(1)	667−706 (2)	
				737−742 (1)	(1)	(1)	727−752 (3)	727−768 (5)	(5)
767−768 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
807−808 (1)	(1)	807−811 (2)	(2)	(2)	(2)	(2)	807−822 (4)	807−837 (5)	807−858 (8)
821−822 (1)	(1)	(1)	(1)	(1)	(1)	(1)			
856−858 (2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	
936−937 (1)	(1)	(1)	932−937 (2)	922−937 (4)	922−953 (9)	(9)	(9)	(9)	(9)
946−948 (2)	(2)	943−948 (3)	(3)	943−953 (4)					
								987−998 (1)	987−1038 (5)
					1032−1038 (1)	1017−1038 (3)	(3)	(3)	
				1082−1087 (1)	(1)	1082−1101 (3)	(3)	1082−1113 (5)	1064−1113 (6)
1112−1113 (1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
	1139−1141 (1)	(1)	(1)	(1)	(1)	(1)	1139−1156 (4)	1139−1237 (14)	(14)
	1151−1153 (1)	1151−1156 (2)	(2)	(2)	(2)	(2)			
		1179−1182 (1)	(1)	(1)	(1)	(1)	1179−1192 (2)		
1217−1218 (1)	(1)	(1)	1213−1218 (2)	(2)	1207−1218 (3)	1207−1226 (4)	(4)		
					1268−1274 (1)	(1)	1268−1302 (6)	(6)	1268−1338 (9)
			1284−1288 (1)	(1)	(1)	1284−1302 (4)			
	1296−1298 (1)	(1)	1296−1302 (2)	(2)	(2)				
				1321−1326 (1)	(1)	(1)	(1)	1321−1338 (2)	

1	2	3	4	5	6	8	10	15	20
		1409−1412 (1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) ┐	1409−1436 (3)
						1429−1436 (1) →	(1) →	(1) ┘	
1506−1507 (1) →	(1) →	(1) →	(1) →	1506−1512 (2) →	(2) →	(2) →	(2) →	(2) →	(2)
	1537−1539 (1) ┐								
	1542−1544 (1) →	1537−1548 (5) →	(5) →	(5) →	(5) →	(5) →	(5) →	(5) →	(5)
1547−1548 (1) →	(1) ┘								
					1572−1578 (1) →	(1) →	(1) →	(1) →	1572−1617 (3)
1651−1652 (1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1)
	1747−1749 (1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) ┐	1711−1767 (5)
1766−1767 (1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) →	(1) ┘	

Example Y 12

Most of the observed-values and the estimated ones in the interval analysis in the range $k > 10$ do not reach five, which has much risk to introduce severe influence of accidental error into the decoding; but it may well be acceptable to regard that 3, 5, 8, 11, 15 and 20 hook-intervals are the key-lengths to decoding of the distribution pattern. And when we regard them as key-lengths, the following results are obtained as the distribution pattern at respective steps.

Structure at the elemental step ($k = 3$) : It is rather clearly suggested from Fig. 61 - (3) that two clusters constituted of six and three more hooked-individuals are surely the true-clusters at the elemental step due to the schooling tendency; and they are thought to be hooked in the ranges respectively from the second hook in the 308th basket (H. N. 1537) to the third hook in the 310th basket (H. N. 1548) and from the third hook in the 96th basket (H. N. 478) to the hook of the same order spaced by three baskets (H. N. 493). Besides them, the presence of the other elemental-clusters constituted of two or four hooked-individuals is also suggested.

Structure at the second order ($k = 5$) : The presence of two clusters constituted of six and five more hooked-individuals is suggested from Fig. 61 - (5); and they are guessed to be hooked in the beginning $\frac{1}{6}$ of hauling of a row —— from the last hook in the 39th basket (H. N. 194) to the hook of the same order spaced by four baskets (H. N. 214) and from the third hook in the 58th basket (H. N. 288) to the second hook in the 65th basket (H. N. 322), respectively; and also two elemental-clusters of large population-size are suffered from no change in their features, and are also regarded as the true-clusters at this step. And the high observed number of the lots constituted of five hooked-individuals seems to suspect that some of the clusters of such a population-size as this are the true ones, but whether we can give any significance to this suspection or not is somewhat doubtful.

Structure at the third order ($k = 8$) : All the clusters regarded as the true ones at the preceding step of analysis, except that hooked at the latter-most part which is also regarded as an elemental-cluster, are swelled their population-size and keep the features of the true-clusters at this step. Besides them, the occurrence in another cluster is suspected; this is a boundle of a pair of the clusters arranged successively and constituted of each five hooked-individuals, although the results at the preceding step of analysis still have a doubt about the significance of regarding each of them as the true one. Accordingly, about 1/4 of total catch distributed within 7 % of whole length of a row is thought to form four clusters at this step. And, it seems to be one of the characteristics of the structures of the true-clusters at this step in this example that all of the true-clusters are narrow but densely crowded and hooked in the beginning half of a row especially in the beginning 1/4 or thereabout.

Structure at the fourth order ($k = 11$) : For convenience' sake of comparison with other examples, the figure showing the result at $k = 10$ is represented, against the fact that the key-length to this step is estimated to be 11 hook-intervals. But there are eight intervals of 11 hook-intervals wide and among them, two are observable as solitarily, one forms a lot of two intervals, while the rest five form four lots of five intervals. Accordingly, if we wish to get the figure showing the result of the arrangement analysis at $k = 11$, the observed-values in Fig. 61-(10) should be corrected for the above-mentioned influence of the intervals of 11 hook-intervals wide and the theoretical-values at smaller W must be decreased slightly while those at larger W must be increased slightly. Then, the following clusters are guessed to be the true ones.

1) Three clusters among four of those recognized as the true-ones at the preceding step: they are suffered from no change and keep the same features as those at the preceding step; they are thought to cover the parts respectively from the third hook in the 96th basket (H. N. 478) to the hook of the same order spaced by three baskets (H. N. 493) (constituted of nine hooked-individuals), from the second hook in the 185th basket (H. N. 922) to the third hook in the 191th basket (H. N. 953) (10 hooked-individuals) and from the second hook in the 55th basket (H. N. 272) to the hook of the same order spaced by 10 baskets (H. N. 322) (14 hooked-individuals).

2) The other cluster regarded to be also the true one at the preceding step: it swells its population-size by fusion with a single individual and covers the part from the third hook in the 38th basket (H. N. 188) to the hook of the same order spaced by nine baskets (H. N. 233) (constituted of 10 hooked-individuals).

3) Four clusters or thereabout among six apparent ones constituted of each hooked-individuals: they are any four of those covering the parts respectively six from the first hook in the 13th basket (H. N. 61) to the last hook in the 17th basket (H. N. 89), from the first hook in the 28th basket (H. N. 136) to the last hook in the 33th basket (H. N. 164), from the second hook in the 217th basket (H. N. 1082) to the third hook in the 223th basket (H. N. 1113), from the last hook in the 228th basket (H. N. 1139) to the second hook in the 234th basket (H. N. 1167), from the second hook in the 242 th basket (H. N. 1207) to the hook of the same order spaced by six baskets (H. N. 1237) and from the second hook in the 308th basket (H. N. 1537) to the third hook in the 310th basket (H. N. 1548).

Therefore, when we set the true-clusters constituted of six hooked-individuals are the narrower four, about a half of total catch distributed within 12% of a whole length of a row seems to form eight clusters. And it seems to be one of the characteristics of the distribution pattern of these clusters that the narrow but rather densely crowded clusters are somewhat evenly distributed throughout a row.

Structure at the fifth order ($k = 15$) : The fifth peak of the observed-values in the interval analysis can be found at $k = 15$. But the intervals neither shorter than 11 hook-intervals nor longer than 15 hook-intervals are only as many as eight; therefore, essentially not so different pattern from that at the preceding step is expected to be observable, except the fact that some true-clusters at the preceding step swell their population-size. And no further description is given, because the pattern is easily deducible from Table 22 considering together with the pattern at the preceding step.

Structure at the highest order ($k=20$) : It is very hard to deduce the pattern at this step with scarcely any influence of accidental error, because of the low observed-values and the estimated ones. And even if dare to say committing against severe influence of accidental error, any fact but the below-mentioned one is deducible: seven or one less clusters —— which are two or one more clusters among five apparently observed ones constituted of each six hooked-individuals, two or one less cluster among three constituted of each 10 hooked-individuals —— are able to be regarded as the true ones due to the schooling tendency.

2. Summarized results of the arrangement analysis

Summarizing the descriptions in the paragraph "exposition of particular example", the following facts can be admitted to describe as the general structure of the distribution pattern of the yellow-fin tuna projected along long-lines observed in this series of operations analyzed through the arrangement method:

1) Population usually has the structures of several-fold contagiousness.

2) The usual structure at the highest order observable within a whole length of a row is thought as follows: about a half of total catch constitutes several schools and the average occupied-rate of the hooks in the parts covered by them is from several tenths to several times higher than that estimated from throughout a row.

3) But there are examples showing some special structures. For instances, even if the key-length is not so long, the schooling tendency in the usual examples makes it possible to be observed some true clusters at the elemental step or at lower orders constituted of a little many hooked-individuals, moreover to be observed some schools of large population-size covering wide range, when the key-length is long; but it is suggested as one of the characteristics of the distribution pattern of the yellow-fin tuna in Example Y 4 that there is no elemental-cluster or cluster at lower orders constituted of a little large population-size moreover the clusters of small population-size are rather evenly or at least randomly distributed throughout a whole length of a row, consequently the population does not contain any school of large population-size

covering a wide range; the clusters at respective orders constituted of rather many hooked-individuals are frequently observable in the population of the yellow-fin tuna in Example Y 7; aggregations at respective steps in the population of the yellow-fin tuna in Example Y 10 are rather scattered ones in which no individual is hooked so closely one another, while rather narrowly but densely crowded clusters of relatively large population-size are observable in the population of the yellow-fin tuna in Example Y 12.

3. Comparison of the results of the arrangement analysis with those of the spacing one

The results of this arrangement analysis are rather compared to corresponding to those of the spacing one, in which various unit-lengths including one hook-interval width are adopted, against the fact that the results of the interval analysis are compared to corresponding to those of the spacing one in which one hook-interval width is adopted as the unit-length under consideration. On the other hand, the results of the arrangement analysis can tell us the number of the aggregations of respective population-size as easily noticed from the descriptions in the first paragraph of this part, in contrast with the fact that the results of the spacing analysis simply tell us the probable distances among the centers of the schools —— secondarily the total number of the schools regardless of their population-size is estimative. Moreover, it is far easier to translate the facts guessed out from the results of the arrangement analysis into the projected distribution pattern recorded actually than to translate those of the spacing analysis into it; and also when we refer to the results of the arrangement analysis together with the projected distribution pattern recorded actually, far more detailed facts than those from the results of the spacing one are deducible —— for examples, the numbers of the schools of respective population-size, their probable positions, widths, consequently occupied-rates, *etc.*, of course including the distances among their centers.

In addition to these merits, it is one of the most powerful merits of adopting the arrangement analysis that the individuals forming respective aggregations pointed out from the results of the arrangement analysis have theoretically a definite proof supporting that these individuals are hooked aggregatively, in contrast with the fact that the observed-value at a certain k in the spacing analysis exceeds largely the theoretical one simply means, strictly speaking, that the pairs of the individuals spaced by this length each other are more frequently observable than those expected from the chance distribution and this fact does not necessarily mean, or there is no proof supporting, that each one of the individuals from respective pairs of individuals is hooked aggregatively (or forming aggregations).

But it is one of the most fatal demerits of adopting the arrangement analysis that, when a little longer key-length is used, both the observed-values and the estimated ones become far lower, which makes it impossible to obtain the results being suffered from scarcely any influence of accidental error from the examples in which not so many individuals are hooked, even if the hooked population-size in these examples is regarded to be large enough capable of getting the results somewhat free from the influence of accidental error when they are applied to the spacing method. And it seems to be worth while to describe the fact that it becomes very easy to count the observed-values in the arrangement analysis, in contrast with the fact that it is very troublesome to count those in the spacing one; while for the estimated-values it is *vice versa*.

Besides the above-mentioned theoretical comparison, as many as or more interest than that in them should be taken in what kinds of superficial and essential coincidences and differences are observable between the decoded patterns of the same examples through these two different analysis methods —— the arrangement analysis and the spacing one. Accordingly, the decoded pattern through the arrangement analysis will be compared with that through the spacing one, example by example. Here, exactly speaking, the structure at respective steps of analysis should be discussed; but, only the results of comparisons of the structures at the highest order observable within a whole length of a row will be described briefly in the below.

Example Y 1 : The arrangement analysis tells us that the population contains three clear schools and a doubtful one; and the clear ones are guessed to be hooked at the positions respectively from the 70th to the 102th, from the 176th to the 219th and from the 277th to the 319th baskets, while a doubtful one is from the 340th to the 358th basket. But the spacing analysis reveals that the hooked positions of the centers of the schools are guessed out to be at the positions around the 80th, the 200th, the 300th and the 350th baskets, respectively. Therefore, no difference is found out between the decoded structures through these two different analysis-methods.

Example Y 2 : The spacing analysis shows that there is a group of schools constituted of no more than five schools; and also the presence of two other schools is suggested, although the significance of one of which is doubtful. The probable hooked-positions of the schools pointed lastly through the spacing analysis (the positions around the 50th and the 150th baskets, in which the latter is doubtful) coincide with those guessed out through the arrangement analysis. But, for the detailed structure within the group of schools, we will find some differences. And they are thought to be due to the facts that, the hooked positions guessed out through the arrangement analysis together with Table 12 have less risk being suffered from the influence of accidental error, but those estimated through the spacing analysis bear some uncertainties due to the fact that not so appropriate clue to estimate the hooked positions as that in the arrangement analysis is found out, consequently there is no help for guessing the probable positions from the distances among the school-centers considering together with the positions of the most heavily-occupied lots of five consecutive basket width represented in Fig. 4.

Example Y 3 : A school of very weak contagiousness is pointed out from the results of the spacing analysis; and this is thought to be covering the part from the 140th to the 315th basket and is constituted of neither less than three nor more than seven schools of the subordinate orders. But the arrangement analysis tells us that there are three schools hooked in the ranges respectively from the 146th to the 179th, from the 185th to the 205th and from the 245th to the 315th baskets; and the school hooked in the latter-most range is constituted of three schools of the subordinate orders of relatively large population-size. Therefore, any essential difference can not be found out between the decoded patterns through these two different analysis-methods.

Example Y 4 : Any school of large population-size and of strong contagiousness is not found out from the results of the arrangement analysis. Therefore, it is easily assumable preliminarily from this fact that no clear symptom suggesting the presence of any clear school of large population-size is expected to be observable in the results of the spacing analysis; and the actually obtained results through the spacing analysis support the above-mentioned prediction. And it may well be said that the spacing analysis is effectively applied to finding out the relation among the hooked positions of the schools only when the population contains any clear aggregation, otherwise the spacing analysis tells us the periodicity of the hooked positions of the individuals; thus, the facts deducible from the results of the spacing analysis and those from the arrangement one in this example are thought to represent the patterns to consider from quite the different points of views; consequently, the possibility of occurrence in such a difference as observed actually is easily recognizable.

Example Y 5 : The spacing analysis shows that the population contains two schools the centers of which are hooked at the positions around the 100th and the 350th baskets respectively. But the arrangement analysis shows that there is a school covering the part from the 265th basket to the hindmost one of the hauling of a row; besides this, the presence of three probable schools is suspected, and these schools are thought to cover the ranges respectively from the 95th to the 103th, from the 190th to the 205th and from the 216th to the 229th baskets. Thus, the hooked positions of the definite school and that of one of the probable ones are in common with the results of both analyses, while no corresponding symptom suggesting the presence of the probable one hooked at the position around the 200th basket is observable in the results of the spacing analysis; and this is thought to be, at least partly, due to the widely covering structure of the school hooked at the latter-most part and due to small population-size of all the schools including the definite one.

Example Y 6 : High occupied-rate causes a sharp decrease in the observed-values and the estimated ones in the interval analysis with increase in k, which makes it impossible to discuss the structure at the higher orders being suffered from scarcely any influence of accidental error in determining the key-length. Therefore, comparison is omitted. And I wish to describe here only the fact that considerably well coincident pattern with that assumable from Table 16, which is constructed of the original record based on the same idea as the arrangement analysis, is obtained from the results of the spacing analysis; and the similar consideration to the comparison of them, which should be treated in this paragraph, was already described in the paragraph of the results of the spacing analysis.

Example Y 7 : The arrangement analysis shows that the population contains four schools hooked at the parts respectively from the 127th to the 217th, from the 221th to the 262th, from the 301th to the 335th and from the 340th to the 377th baskets. But the distance between the first two schools and that between the last two are short as compared with their widths although they are separated clearly; consequently the spacing analysis is unable to find out these breaks of the schools but these schools are estimated to be continuous ones hooked at the parts around the 200th and the 350th baskets, respectively; while concerning the heavily-occupied part around the 50th basket, the presence of which is suspected only from the spacing analysis, no clear symptom suggesting the presence of it is found out from the results of the arrangement analysis. But when we consider a little strong influence of gradient together with the description in Example Y 5 in this paragraph, it seems to be better to give some significance to the symptom suggesting the presence of the group of the apparent clusters hooked in the range from the 19th to the 63th basket. Thus, it may be concluded that not so serious difference is observable between the decoded patterns through these two different analysis-methods.

Example Y 8 : The low occupied-rate and the short length of a row make it impossible to get high observed-values and the estimated ones in the arrangement analysis enough to get the results somewhat rid of the influence of accidental error. But the presence of three schools covering the parts respectively from the 77th to the 87th, from the 102th to the 122th and from the 147th to the 156th basket is guessed out. On the other hand, the spacing analysis suggests the presence of three schools hooked at the positions around the 20th, the 80th and the 150th baskets, respectively. Thus, concerning the presence of the schools located at the positions around the 80th and the 150th baskets, the same results are obtained through these two different analysis-methods. But, for the rests of it (the schools hooked at the positions around the 20th and the 110th baskets), no corresponding symptom suggesting the presence of them is found out in the results of each other's method. But examining more in detail, I found that the school hooked at the position around the 110th basket was constituted of rather scattered individuals and that the presence of the other was suspected from the high observed-value at $k = 13$ in the spacing analysis, which was for convenience' sake represented as high, but actually, did not reach the value worth while to give some significance. Thus, the significance of the presence of these schools causing the apparent differences is highly doubtful. Therefore, it may well be concluded that no serious difference can be found out between the decoded patterns through the different analysis-methods.

Example Y 9 : Like the preceding example, the low occupied-rate and the short length of a row make it impossible to obtain any structure of significance. And even if dare to say committing against severe influence of accidental error, no true-cluster but few of those of small population-size can be pointed out through the arrangement analysis; and it is very hard to guess their hooked positions. Therefore, I can not tell whether any significant difference is observable between the decoded patterns through the different analysis-methods or not; moreover, if some apparent difference might be found out, any significance should hardly give them.

Example Y 10 : The arrangement analysis suggests the presence of two schools of not so strong contagiousness and constituted of 25 hooked-individuals and these schools are thought to be hooked at the positions around the 210th and the 270th baskets, respectively. And the same fact is also found out from the results of the spacing analysis. But the latter method tells us that there is another obscure school hooked at the position around the 345th basket; and Table 20 also suspects its presence. But we can hardly give any significance to the apparent difference of the observed-values in the arrangement analysis from the estimated ones, because none of the observed-values are so large as one. Therefore, I am obliged to keep it still pending to answer the question whether we can find any symptom from the arrangement analysis suggesting the presence of the school hooked at the position around the 345th basket or not, consequently to the question whether we can find out any significant difference in the decoded pattern through the arrangement analysis from that through the spacing one.

Example Y 11 : The spacing analysis shows that there are two schools or groups of schools hooked at the positions around the 25th and the 325th baskets. But, as represented in the exposition of particular example, the arrangement analysis tells us that as many as or more than 11 schools of not so strong contagiousness are scattered in a row, among which the hooked positions of the larger four are estimative but those of the rests of it are not estimative because it is very hard to distinguish the true ones from the false ones of respective population-size. But it can safely be said that the arrangement analysis suggests the presence of many schools distributed at the position around the 325th basket. On the other hand, the position around the 25th basket is one of the probable positions where a school constituted of eight hooked-individuals is hooked, meanwhile two schools constituted of each eight hooked-individuals among three are thought to be the true ones. Accordingly, it may also be safely said that any serious difference can not be found out between the decoded patterns through these two different analysis-methods.

Example Y 12 : The spacing analysis tells us that the population contains many schools rather scattered throughout a row. On the other hand, the arrangement analysis shows that the population contains seven or more schools, among which two or three are constituted of six hooked-individuals, one or two are of ten hooked-individuals; and all the hooked positions of these schools, except those of the larger three, are unable to be estimated. But it may well be said that all the probable positions of the schools, including the definite ones, are rather scattered throughout a row.

Accordingly, we may be able to conclude that not so serious difference can be observed between the results obtained through these two different analysis-methods.

Summarized results of the comparison : Generally speaking, any serious difference can not be observed between the decoded patterns through the spacing analysis and the arrangement one, especially in the examples in which the presence of some of the schools are clearly certified through both analysis-methods. But, for the examples in which the presence of some of the schools is not so clearly represented in the results of each or both of these two analysis-methods, some difference may be found out; and they are thought to be chiefly due to the uncertainty in the hooked positions of these schools guessed out through the spacing analysis. Moreover, for the examples in which the presence of no clear school is pointed out through the arrangement analysis, considerable differences in the decoded structures may be found out, because the facts deduced from the spacing analysis and those from the arrangement analysis represent the patterns to see from quite the different points of views due to the following reasons: the fact that the observed-value in the spacing analysis at k largely exceeds corresponding theoretical one simply means that the pairs of the individuals spaced by k each other are more frequently observable than expected from the chance distribution, but this fact has no proof supporting each one individual from respective pairs is hooked in some restricted parts, consequently the above-mentiond fact results in indicating the periodicity of the hooked positions of the individuals.

Accordingly, the arrangement analysis is thought to have many advantages. But when the distribution shows somewhat strong gradient, the arrangement analysis fades its ability, because of the following reasons: short intervals, consequently the lots constituted of successively arranged ones, have to be more frequently observable with approach to the final end of hauling of a row; accordingly, the key-length and the population-size have to be changed keeping some functional relations between the hooked positions; but it is very hard to take the influence of these facts on the arrangement analysis into consideration, and no correction for these influences is yet made in the theoretical-values in the arrangement analysis. Besides this, when the gears are heavily-occupied, both the observed-values and the estimated ones in the interval analysis decrease sharply with increase in k, which makes it impossible to find out any key-length in the arrangement analysis free from the influence of accidental error. But the same fact causes the high observed-values and the estimated ones in the spacing analysis, consequently high significance can be given to the deduced facts. Thus, each method has some merits effective under different conditions. Therefore, when we want to find out the distribution pattern more easily and clearly, it is desirable to adopt the arrangement analysis combining together with the spacing one.

Trials for the exclusion of the influence of the presence of the buoy-lines upon the estimated-values in the arrangement analysis

As already mentioned in the introductive section in this part, the presence of the buoy-lines where no individual is able to be hooked has some influences upon the observed-values and the estimated ones in the arrangement analysis, but these influences are not yet taken into consideration to construct the above-mentiond formulae applicable to this method. Accordingly, here, I want to show some tracks of the construction of the formulae in which these influences are taken into consideration, although no complete formula practically applicable to is yet established.

In order to make it easier to proceed with the discussion, the influence of both the gradient of the occupied-rate due to that of soaking time and the difference in the occupied-rate of the hooks at the different depth levels due to the slackness of main-lines are put out of consideration; consequently, the occupied-rates of all the hooks are set to be the same. And a row of gears is set to be constituted of a connected series of m baskets attached by four hooks a basket. And also the way of thinking is changed and the conception of total length of each lot, $K=5A+R$, is introduced, because it is very difficult to take the influence of the presence of the buoy-lines into consideration extending to the same idea as in the constructing-process of the used formulae.

1. Track of the construction of the formulae representing the expectant number of the lots of K long, constituted of a connected series of the intervals each of which is as long as or shorter than k hook-intervals

1) $k=1$

(1) $K=1$

i) When one starts to count the lot from the first hook in a certain basket, the lot ends to be counted in the second hook in the same basket (the rate of all the hooks in the lot occupied fully is as equal as P^2). Meanwhile, in order to be isolated this lot from the others, at least all the hooks located within both the preceding and succeeding k hook-intervals to the lot must be kept unoccupied. Here, the hook preceding to the lot is the buoy-line; consequently there is no need to pay any attention to it, because the probability of keeping unoccupied is as equal as 1. And the succeeding hook to each lot is the third hook in the same basket and this also must be kept unoccupied, and the probability of keeping unoccupied is as equal as q. Accordingly, the expectant number of such a lot observable in a row is mP^2q.

ii) When one starts to count the lot from the second hook in a certain basket, the lot ends to be counted in the third hook in the same basket; and the hook preceding to the lot is the first hook in the same basket, the unoccupied rate of which is as equal as q; but the hook succeeding to the lot is the last hook in the same basket, the unoccupied rate of which is also as equal as q. Accordingly, the expectant number of such a lot observable in a row is mP^2q^2.

iii) When one starts to count the lot from the third hook in a certain basket, the lot ends to be counted in the last hook in the same basket; and the preceding hook is the second one, the unoccupied rate of which is as equal as q; but the succeeding hook is a buoy-line, the unoccupied rate of which is as equal as 1. Accordingly, the expectant number of such a lot observable in a row is estimated to be mP^2q.

iv) And when one starts to count the lot from the last hook in a certain basket, the lot ends to be counted in the buoy-line. Accordingly, no lot fitted for this condition is theoretically expected to occur.

Therefore, the expectant number of the lots ($K=1$, $k=1$) is estimative summing the above-mentioned four terms, *i. e.*,

$$mP^2p(2+q).$$

(2) $K=2$

The lots fitted for this column are (1) those starting to be counted from the first hook and ending in the third hook and (2) those starting to be counted from the second hook and ending in the last hook in respective baskets. Consequently, the fully occupied rate of the hooks in each lot is as equal as P^3. But the preceding hook to the lot of the former group is the buoy-line, the unoccupied rate of which is as equal as 1; while the succeeding hook is the last one in the same basket, the unoccupied rate of which is as equal as q. And the preceding hook to the lot of the latter group is the first hook in the same basket, the unoccupied rate of which is as equal as q; while the succeeding one is the buoy-line, the unoccupied rate of which is as equal as 1. Accordingly, the expectant number of the lots ($K=2$, $k=1$) observable in a row is estimated to be as equal as $2mP^3q$.

(3) $K=3$

The lots fitted for this column are the fully occupied baskets. Accordingly, the expectant number is estimated to be as equal as mP^4.

(4) $K \geqq 4$

When $K \geqq 4$, the presence of the buoy-lines prohibits the occurrence in such a lot.

2) $k \leqq 2$

All the formulae representing the expectant number of the lots of K long with some unoccupied-hooks observable in a row, which will be described in the below, are constructed from the formulae representing the expectant number of the fully occupied lots by correcting the influence of the presence of the unoccupied-hooks on the expectant numbers.

(1) $R=1$ $(K=5A+R)$

i) The expectant number, when one starts to count the lot from the first hook in a certain basket

The lot begins with the first hook in the *ith* basket, while ends in the second hook in the $(i+A)th$ one. Therefore, there are $(4A+2)$ hooks and A buoy-lines in a lot. And the fully occupied rate of the hooks in the lot is $P^{(4A+2)}$. But, here, in order to be isolated this lot from the others, at least all the hooks located within both k hook-interval widths preceding and succeeding to the lot must be kept unoccupied. The last hook in the $(i-1)th$ basket and a buoy-line are corresponding to the preceding part, while the third hook and the last one in the $(i+A)th$ basket are the succeeding part. Accordingly, when the lot is started to be counted from the other baskets than the first, three hooks and a buoy-line are located in the above-mentioned range and the rate of all the hooks kept unoccupied is q^3; while when one starts to count the lot from the first basket, the last hook in the $(i-1)th$ basket is protruded from a row, thus, there is no need to pay any attention to it, and the rate of all the hooks kept unoccupied becomes as equal as q^2. Accordingly, the expectant number of the occurrence in the fully occupied lots is

$$P^{(4A+2)}q^2(1+\overline{m-A-1}\,q).$$

Then, let us correct the influence of the unoccupied hooks. The lot covers $(A+1)$ baskets; here, there is no hook in the last basket not necessarily to be occupied, while each one of the second hook and the third one in each of other A baskets is not necessarily to be occupied. Accordingly, the admissible manner of the occurrence in the first unoccupied hook is $2A$, that in the second one is $2(A-1)$, ·········and that in the jth is $2(A-j+1)$. Thus, the admissible manner of the occurrence in j unoccupied hooks (here, j can not exceed A) is $2^J{}_AC_J$. But there are $4A$ inserted hooks, and the manner of picking up j hooks among them is ${}_{4A}C_J$. Accordingly, the probability of occurrence in the admissible cases is $2^J\frac{{}_AC_J}{{}_{4A}C_J}$. And the expectant number is

$$2^J\frac{{}_AC_J}{{}_{4A}C_J}(1+\overline{m-A-1}\,q)P^{(4A+2-J)}q^{(J+2)}.$$

ii) The expectant number, when one starts to count the lot from the second hook in a certain basket

The lot begins to be counted with the second hook in the *ith* basket and ends in the third hook in the $(i+A)th$ one. Therefore, there are $(4A+2)$ hooks and A buoy-lines in a lot. And the rate of all the hooks in the lot occupied fully is $P^{(4A+2)}$. The first hook in the *ith* basket and a buoy-line are located in the range preceding to the lot while the last hook in the $(i+A)th$ basket and a buoy-line are situated in the succeeding range, and the rate of all the hooks kept unoccupied is as equal as

q^2. Accordingly, the expectant number of occurrence in such a lot is $P^{(4A+2)}q^2(m-A)$.

Next, setting that j hooks in the lot are kept unoccupied, let us give correction for it. The lot covers $(A+1)$ baskets, in which the third hook in the ith basket, the second hook in the $(i+A)th$ one and each one of the second hook and the third one in the inserted baskets are admissible to be not necessarily occupied. And for convenience' sake of explanation, I wish to treat the lots separately according to the number of the hooks kept unoccupied in the foremost basket and in the hindmost one of the lot. (1) When all the unoccupied hooks are located in the inserted baskets, the admissible manner of the occurrence in the first unoccupied hook is $2(A-1)$, that in the second one is $2(A-2)$ ········ and that in the jth one is $2(A-j)$. But the manner of picking up j hooks from $4A$ inserted hooks is ${}_{4A}C_J$. Accordingly, the probability of occurrence in the admissible cases is $2^J\frac{{}_{(A-1)}C_J}{{}_{4A}C_J}$. (2) When each one of the hooks in the foremost or the hindmost baskets admissible to be not necessarily occupied and other $(j-1)$ admissible ones in the inserted baskets are kept unoccupied, the admissible manner of the occurrence in the terminal one is ${}_2C_1=2$, while that in other $(j-1)$ hooks is $2^{(J-1)}{}_{(A-1)}C_{(J-1)}$; accordingly, there are $2^J{}_{(A-1)}C_{(J-1)}$ admissible manner; but the manner of picking up j hooks is the same as that mentioned above. And the probability of occurrence in the admissible cases is $2^J\frac{{}_{(A-1)}C_{(J-1)}}{{}_{4A}C_J}$. (3) But when both of the hooks in the foremost and the hindmost baskets of the lot admissible to be not necessarily occupied and other $(j-2)$ ones in the inserted baskets are kept unoccupied, there is a manner keeping unoccupied both of the admissible hooks of the former group; while for the latter group, there are $2^{(J-2)}{}_{(A-1)}C_{(J-2)}$ admissible manner. But the manner of picking up j hooks from $4A$ inserted ones is also ${}_{4A}C_J$. Accordingly, the probability of the occurrence in the admissible cases is $2^{(J-2)}\frac{{}_{(A-1)}C_{(J-2)}}{{}_{4A}C_J}$. And, the probability of the occurrence in the lots of K long with j unoccupied hooks and constituted of the intervals, each of which is as long as or shorter than two hook-intervals, is

$$2^J\frac{{}_{(A-1)}C_J}{{}_{4A}C_J}+2^J\frac{{}_{(A-1)}C_{(J-1)}}{{}_{4A}C_J}+2^{(J-2)}\frac{{}_{(A-1)}C_{(J-2)}}{{}_{4A}C_J}$$
$$=\frac{2^{(J-2)}{}_{(A-1)}C_J}{{}_{4A}C_J}\left\{\frac{4A}{A-J}+\frac{J(J-1)}{(A-J)(A-J+1)}\right\}.$$

Accordingly, the expectant number of the lots constituted of $(4A+2-j)$ hooked-individuals, each of which is spaced by an interval as long as or shorter than two hook-intervals from the adjoining ones, is

$$\frac{2^{(J-2)}{}_{(A-1)}C_J}{{}_{4A}C_J}\left\{\frac{4A}{A-J}+\frac{J(J-1)}{(A-J)(A-J+1)}\right\}(m-A)P^{(4A+2-J)}q^{(J+2)}.$$

iii) When one starts to count the lot from the third hook in a certain basket, the same results as those when one starts to count the lot from the first hook in the basket are obtained. And this fact may be easily recognizable, when we suppose to count the hook number and the basket number from the counter direction to the hauling of the gears. That is to say,

$$2^{J}\frac{{}_{A}C_{J}}{{}_{4A}C_{J}}(1+\overline{m-A-1}q)P^{(4A+2-J)}q^{(J+2)}.$$

iv) But when one starts to count the lot from the last hook in a certain basket, the lot ends in a buoy-line; this means that no case fitted for this condition is theoretically supposed to occur.

Accordingly, the expectant number of the lots of $K=5A+1$ long constituted of $(4A+2-j)$ hooked-individuals, each of which is spaced by an interval as long as or shorter than two hook-intervals from the adjoining ones, is represented as follows, by summing up the above-mentioned formulae:

$$P^{(4A+2-J)}q^{(J+2)}\,2^{J}\frac{{}_{A}C_{J}}{{}_{4A}C_{J}}\left[2\left\{1+(m-A-1)q\right\}+(m-A)\left\{1+\frac{J(J-1)}{4A(A-J+1)}\right\}\right].$$

Notes:

1) J can not exceed A.

2) All terms containing J or A should be positive, otherwise omitted.

(2) $R=2$

Through quite the same manner as those mentioned above, the expectant number, when one starts to count the lot from the first hook in the basket, is represented as follows:

$$P^{(4A+3-J)}q^{(J+1)}2^{J}\frac{{}_{A}C_{J}}{{}_{(4A+1)}C_{J}}\left\{1+(m-A-1)q\right\}\left\{1+\frac{J}{2(A-J+1)}\right\}.$$

That, when one starts to count the lot from the second hook in the basket, is also the same as this; while when one starts to count the lot from the third hook in the basket, the interval ends to be counted in a buoy-line and no lot fitted for this condition is theoretically expected to occur. But when one starts to count the lot from the last hook in the basket, the lot covers $(A+2)$ baskets and contains $(A+1)$ buoy-lines; therefore, substitute $(j-1)$ for j for the purpose of adjusting the number of the occupied hooks in the lot, expectant number is represented as follows:

$$P^{(4A+3-J)}q^{(J+3)}2^{(J-1)}\frac{{}_{A}C_{(J-1)}}{{}_{4A}C_{(J-1)}}(m-A-1).$$

Accordingly, the expectant number of the lots of $K=5A+2$ long constituted of $(4A+3-j)$ hooked-individuals, each of which is spaced by an interval as long as or shorter than two hook-intervals from the adjoining ones, is represented as follows, by summing up these formulae:

$$P^{(4A+3-J)}q^{(J+1)}2^{(J-1)}\frac{{}_{A}C_{J}}{{}_{4A+1}C_{J}}\left[4\left\{1+\frac{J}{2(A-J+1)}\right\}\left\{1+(m-A-1)q\right\}\right.$$
$$\left.+(m-A-1)q^{2}\frac{(4A+1)}{(A-J+1)}\right].$$

Note: The same as (1) $R=1$.

(3) $R=3$

Through quite the same manner as that mentioned in the above, the expectant number of the lots of $K=5A+3$ long constituted of $(4A+4-j)$ hooked-individuals, each of which is spaced by an interval as long as or shorter than two hook-intervals from the adjoining ones, is represented as follows:

When one starts to count the lot from the first hook in the basket:

$$2^{J}P^{(4A+4-J)}q^{(J+1)}\frac{{}_{(A+1)}C_{J}}{{}_{(4A+2)}C_{J}}\{1+(m-A-1)q\}$$

from the second hook: 0

from the third hook: $2^{(J-1)}P^{(4A+4-J)}q^{(J+3)}\frac{{}_{A}C_{(J-1)}}{{}_{(4A+1)}C_{(J-1)}}(m-A-1)$

from the last hook: The same as the above.

Accordingly, the expectant number of the lots of $K=5A+3$ long constituted of $(4A+4-j)$ hooked-individuals, each of which is spaced by an interval as long as or shorter than two hook-intervals from the adjoining ones, is

$$P^{(4A+4-J)}q^{(J+1)}2^{J}\frac{{}_{(A+1)}C_{J}}{{}_{(4A+2)}C_{J}}\left[\{1+(m-A-1)q\}+\frac{4A+2}{A+1}q^{2}\right].$$

(4) $R=4$

When one starts to count the lot from the first hook in the basket: 0

from the second hook:

$$2^{(J-1)}P^{(4A+5-J)}q^{(J+2)}\frac{{}_{A}C_{(J-1)}}{{}_{(4A+2)}C_{(J-1)}}\left\{1+\frac{(J-1)}{2(A-J+1)}\right\}(m-A-1)$$

from the third hook:

$$2^{(J-1)}P^{(4A+5-J)}q^{(J+3)}\frac{{}_{A}C_{(J-1)}}{{}_{(4A+2)}C_{(J-1)}}(m-A-1)$$

from the last hook: The same as that from the second hook.

Accordingly, the expectant number of the lots of $K=5A+4$ long constituted of $(4A+5-j)$ hooked-individuals, each of which is spaced by an interval as long as or shorter than two hook-intervals from the adjoining ones, is

$$P^{(4A+5-J)}q^{(J+2)}2^{(J-1)}\frac{{}_{A}C_{(J-1)}}{{}_{(4A+2)}C_{(J-1)}}(m-A-1)\left\{2+\frac{(J-1)}{(A-J+2)}+q\right\}.$$

(5) $R=0$

When one starts to count the lot from the first hook in the basket:

$$2^{J}P^{(4A+1-J)}q^{(J+2)}\frac{{}_{A}C_{J}}{{}_{(4A-1)}C_{J}}(1+\overline{m-A-1}q)$$

from the second hook:

$$2^{J}P^{(4A+1-J)}q^{(J+4)}\frac{{}_{A}C_{J}}{{}_{(4A-1)}C_{J}}\left\{1+\frac{J}{2(A-J+1)}\right\}(m-A)$$

from the third hook: The same as that from the second hook.

from the last hook: The same as that from the first hook.

Accordingly, the expectant number of the lots of $K=5A$ long constituted of $(4A+1-j)$ hooked-individuals, each of which is spaced by an interval as long as or shorter than two hook-intervals from the adjoining ones, is

$$P^{(4A+1-J)}q^{(J+2)}2^{(J+1)}\frac{{}_{A}C_{J}}{{}_{(4A-1)}C_{J}}\left[\{1+(m-A-1)q\}+\left\{1+\frac{J}{2(A-J+1)}\right\}(m-A)q^{2}\right].$$

3) $k \leqq 3$

When $k \leqq 2$, the hooks admissible to be not necessarily occupied are limited to be each one of the second hook and the third one in respective baskets, regardless of the manner of the presence of the hooks in the preceding basket and in the succeeding one actually kept unoccupied. But, in contrast with this, when $k \leqq 3$, the combinations of the hooks admissible to be not necessarily occupied are (1) buoy-line —— the first hook, (2) the second hook —— the third one and (3) the last hook —— buoy-line. But, here, when the hooks in a certain basket are actually kept unoccupied following the manner symbolized as (1), the last hook in the preceding basket and the second hook in the same basket are necessarily occupied; this means that the manner in the occurrence of the hooks in the preceding basket admissible to be not necessarily occupied is limited to be each one of the manner (1) or (2), and that of the same basket is also limited to the manner (3); when following (2), the presence of the unoccupied hooks causes no influence upon the manner of the admissible hooks to be not necessarily occupied in the preceding basket and in the succeeding one, while no other manner allows to occur in the same basket; while when following (3), no other manner than (1) allows to occur in the same basket, moreover the admissible manner of the hooks in the succeeding one not necessarily occupied is limited to be each one of the (2) and (3). Thus, the manner in occurrence of the hooks in a certain basket *admissible* to be not necessarily occupied is affected by the manner of the hooks in the preceding basket and in the same one *actually* kept unoccupied, and the manner of the presence of the hooks in a certain basket *actually* kept unoccupied affects the manner of the hooks in the succeeding basket *admissible* to be not necessarily occupied. Moreover, all the hooks admissible to be not necessarily occupied are not always kept unoccupied. Accordingly, if the formulae which can represent the expectant numbers were established, they may be too complicated to use on the actual computation or contain too much computation error. Moreover, when $k \leqq 4$, or longer, I am afraid that the formulae must be far complicated. In addition to these difficulties, even if these formulae were established, I am afraid that they are unable to apply to the actual analysis, because the lots, even the total number of which is preliminarily thought to be not so many, are divided into too many groups——respective k, K and j——, which results in far lower observed-values and the estimated ones, consequently there are many risk to introduce severe influence of accidental error into decoding the pattern. Accordingly, the method, in which the lots are treated classifying into not so many groups, is desirable to be established. And an example of tracks based on this idea will be represented in the next paragraph.

2. Track of the construction of another estimation-method of the expectant number of the schools regarding the individuals spaced by an interval as long as or shorter than k hook-intervals are aggregating each other

This method has some characteristics to resemble the interval analysis as well as the arrangement one. Therefore, there is no need to use together with the interval analysis, although not so many facts as those from the arrangement analysis can be drawn out.

Before entering into the construction of the formulae, I must give some preliminary consideration to the meanings of the interval between the individuals of k hook-intervals wide. (1) When all the hooks located within at least $(k+1)$ hook-interval widths preceding to and succeeding to this interval are not occupied, this interval should be regarded as an isolated school constituted of a pair of hooked-individuals. (2) When there is no occupied-hook within at least $(k+1)$ hook-intervals preceding to the beginning of the interval and at the same time there is one or more occupied-hooks in $(k+1)$ hook-intervals succeeding to the end of the interval, this interval ought to be regarded as the beginning interval of a school, and (3) when *vice versa*, this interval should be regarded as the ending interval of a school. (4) But when there is at least each one or more occupied-hooks in $(k+1)$ hook-interval widths preceding to and succeeding to the interval, this interval should be regarded as the inserted interval of a school. Accordingly, the number of schools, when we set k as the key-length to the school-formation, is estimated to be as many as $(1)+\frac{(2)+(3)}{2}$. And by the similar manner to the interval analysis, respective k showing the maxima of increase in the number of schools per increase in k should be regarded as the key-lengths to respective steps of school-formation. Then, the numbers of the apparent-schools and of the true ones at respective steps can be estimative, although any clue to estimating the population-size of respective schools can not be found out yet.

(1) $R=1$ (here, $k=5a+R$)

When one starts to count the interval from the first hook in the *ith* basket, the interval ends to be counted in the second hook in the $(i+a)th$ basket (the hook number starting to count the interval is symbolized as 1, 2, 3 and 4 in the first letter of the formula-number). But the preceding range under consideration begins with the last hook in the $(i-a-1)th$ basket and the succeeding one ends in the last hook in the $(i+2a)th$ one. Therefore, (1) when i is neither smaller than 1 nor larger than $(a+1)$, at least a part of the preceding range under consideration is protruded from a row, although all the parts of the interval itself and the succeeding range are situated within a row. (2) When i is neither smaller than $(a+2)$ nor larger than $(m-2a)$, all the parts in the preceding range and the succeeding one to the interval under consideration, naturally including the interval itself, are located within a row. (3) But when i is neither smaller than $(m-2a+1)$ nor larger than $(m-a)$, at least a part of the succeeding range to the interval is protruded from a row, although whole part of the interval itself and the preceding range to it is not protruded from a row. And these three ranges of i should be treated separately. The formulae corresponding to respective ranges of i are symbolized by the second letter in the formula-number. But the last letter in each formula-number represents the classification of the intervals by their meanings described in the above. And the expectant numbers of respective conditions are estimative through the following formulae (for their constructing-processes, refer to those in respective analysis-methods already mentioned).

111 $P^2q^{4a}q^{4a+2}\sum_{i=0}^{a} q^{4i}$

112 $P^2q^{4a}(1-q^{4a+2})\sum_{i=0}^{a} q^{4i}$

113 $P^2q^{4a}q^{4a+2}\sum_{i=0}^{a} (1-q^{4i})$

114 $P^2q^{4a}(1-q^{4a+2})\sum_{i=0}^{a} (1-q^{4i})$

121 $(m-3a-1)P^2q^{4a}q^{4a+1}q^{4a+2}$

122 $(m-3a-1)P^2q^{4a}q^{4a+1}(1-q^{4a+2})$

123 $(m-3a-1)P^2q^{4a}(1-q^{4a+1})q^{4a+2}$

124 $(m-3a-1)P^2q^{4a}(1-q^{4a+1})(1-q^{4a+2})$

131 $P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1} q^{4i+2}$

132 $P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1} (1-q^{4i+2})$

133 $P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1} q^{4i+2}$

134 $P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1} (1-q^{4i+2})$

Accordingly, the partial sums of the expectant numbers of the intervals of respective meanings, when one starts to count the interval from the first hook in respective baskets, are represented as follows:

1·1 $$P^2q^{4a}\left[(m-3a-1)q^{4a+1}q^{4a+2}+q^{4a+2}\sum_{i=0}^{a}q^{4i}+q^{4a+1}\sum_{i=0}^{a-1}q^{4i+2}\right]$$

1·2 $$P^2q^{4a}\left[(m-3a-1)q^{4a+1}(1-q^{4a+2})+(1-q^{4a+2})\sum_{i=0}^{a}q^{4i}+q^{4a+1}\sum_{i=0}^{a-1}(1-q^{4i+2})\right]$$

1·3 $$P^2q^{4a}\left[(m-3a-1)(1-q^{4a+1})q^{4a+2}+q^{4a+2}\sum_{i=0}^{a}(1-q^{4i})+(1-q^{4a+1})\sum_{i=0}^{a-1}q^{4i+2}\right]$$

1·4 $$P^2q^{4a}\left[(m-3a-1)(1-q^{4a+1})(1-q^{4a+2})+(1-q^{4a+2})\sum_{i=0}^{a}(1-q^{4i})+(1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+2})\right]$$

When one starts to count the interval from the second hook in the *ith* basket, the interval ends to be counted in the third hook in the $(i+a)th$ one while the preceding range under consideration begins with the buoy-line located at the junction of the $(i-a-1)th$ basket and the $(i-a)th$ one, and that succeeding one ends also in another buoy-line located at the junction of the $(i+2a)th$ basket and the $(i+2a+1)th$ one, consequently the lot constituted of a connected series of these three intervals begins with the first hook in the $(i-a)th$ basket and ends in the last hook in the $(i+2a)th$ one. Thus, i in column (1) is able to vary from 1 to a and that in column (2) does from $(a+1)$ to $(m-2a)$, while that in column (3) is suffered from no influence. Accordingly, the formulae representing the expectant numbers of the intervals of respective conditions are obtained as follows:

211 $$P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1}q^{4i+1}$$

212 $$P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1}q^{4i+1}$$

213 $$P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1}(1-q^{4i+1})$$

214 $$P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+1})$$

221 $$P^2q^{4a}(m-3a)q^{4a+1}q^{4a+1}$$

222 $$P^2q^{4a}(m-3a)q^{4a+1}(1-q^{4a+1})$$

223 $P^2q^{4a}(m-3a)q^{4a+1}(1-q^{4a+1})$

224 $P^2q^{4a}(m-3a)(1-q^{4a+1})(1-q^{4a+1})$

231 $P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1}q^{4i+1}$

232 $P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1}(1-q^{4i+1})$

233 $P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1}q^{4i+1}$

234 $P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+1})$

Accordingly, the partial sums of the expectant numbers of the intervals of respective meanings, when one starts to count the interval from the second hook in respective baskets, are represented as follows:

2·1 $P^2q^{4a}\left[(m-3a)\ (q^{4a+1})^2+2q^{4a+1}\sum_{i=0}^{a-1}q^{4i+1}\right]$

2·2 $P^2q^{4a}\left[(m-3a)\ q^{4a+1}(1-q^{4a+1})\right.$

$\left.+q^{4a+1}\sum_{i=0}^{a-1}(1-q^{4i+1})+(1-q^{4a+1})\sum_{i=0}^{a-1}q^{4i+1}\right]$

2·3 $P^2q^{4a}\left[(m-3a)\ q^{4a+1}(1-q^{4a+1})\right.$

$\left.+q^{4a+1}\sum_{i=0}^{a-1}(1-q^{4i+1})+(1-q^{4a+1})\sum_{i=0}^{a-1}q^{4i+1}\right]$

2·4 $P^2q^{4a}\left[(m-3a)\ (1-q^{4a+1})^2+2(1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+1})\right]$

When one starts to count the interval from the third hook in respective baskets, the following results are obtained:

311 $P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1}q^{4i+2}$

312 $P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1}q^{4i+2}$

313 $P^2q^{4a}q^{4a+1}\sum_{i=0}^{a-1}(1-q^{4i+2})$

314 $P^2q^{4a}(1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+2})$

321 $(m-3a-1)\ P^2q^{4a}q^{4a+2}q^{4a+1}$

322 $(m-3a-1)\ P^2q^{4a}q^{4a+2}(1-q^{4a+1})$

323 $(m-3a-1)\ P^2q^{4a}(1-q^{4a+2})q^{4a+1}$

324 $(m-3a-1)\ P^2q^{4a}(1-q^{4a+2})\ (1-q^{4a+1})$

331 $P^2q^{4a}q^{4a+2}\sum_{i=0}^{a}q^{4i}$

332 $P^2q^{4a}q^{4a+2}\sum_{i=0}^{a}(1-q^{4i})$

333 $P^2q^{4a}(1-q^{4a+2})\sum_{i=0}^{a}q^{4i}$

334 $P^2q^{4a}(1-q^{4a+2})\sum_{i=0}^{a}(1-q^{4i})$

Accordingly, the partial sums of the expectant numbers of the intervals of respective meanings, when one starts to count the interval from the third hook in respective baskets, are represented as follows:

3・1 $P^2q^{4a}\left[(m-3a-1)\ q^{4a+2}q^{4a+1}+q^{4a+1}\sum_{i=0}^{a-1}q^{4i+2}+q^{4a+2}\sum_{i=0}^{a}q^{4i}\right]$

3・2 $$P^2q^{4a}\left[(m-3a-1)\ q^{4a+2}(1-q^{4a+1}) + (1-q^{4a+1})\sum_{i=0}^{a-1}q^{4i+2}+q^{4a+2}\sum_{i=0}^{a}(1-q^{4i})\right]$$

3・3 $$P^2q^{4a}\left[(m-3a-1)\ (1-q^{4a+2})q^{4a+1} + q^{4a+1}\sum_{i=0}^{a-1}(1-q^{4i+2})+(1-q^{4a+2})\sum_{i=0}^{a}q^{4i}\right]$$

3・4 $$P^2q^{4a}\left[(m-3a-1)\ (1-q^{4a+2})\ (1-q^{4a+1}) + (1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+2})+(1-q^{4a+2})\sum_{i=0}^{a}(1-q^{4i})\right]$$

But when one starts to count the interval from the last hook in respective baskets, the interval ends to be counted in the buoy-line; thus, no interval is theoretically expected to occur.

Accordingly, the formulae representing the expectant numbers of the intervals of respective meanings observable in a row are as follows:

(1) $$2P^2q^{4a}\left[(m-3a-1)\ q^{4a+2}q^{4a+1}+q^{4a+2}\sum_{i=0}^{a} q^{4i}+q^{4a+1}\sum_{i=0}^{a-1} q^{4i+2}\right]$$

$$+P^2q^{4a}\left[(m-3a)\ (q^{4a+1})^2+2q^{4a+1}\sum_{i=0}^{a-1} q^{4i+1}\right]$$

(2) $$P^2q^{4a}\left[(m-3a-1)\left\{(1-q^{4a+2})\ q^{4a+1}+q^{4a+2}(1-q^{4a+1})\right\}\right.$$

$$+(m-3a)\ (1-q^{4a+1})q^{4a+1}+q^{4a+1}\left\{\sum_{i=0}^{a-1}(1-q^{4i+2})+q\sum_{i=0}^{a}(1-q^{4i})\right.$$

$$\left.+\sum_{i=0}^{a-1}(1-q^{4i+1})\right\}+\left\{(1-q^{4a+1})\sum_{i=0}^{a-1} q^{4i+1}+(1-q^{4a+2})\sum_{i=0}^{a} q^{4i}\right.$$

$$\left.\left.+(1-q^{4a+1})\sum_{i=0}^{a-1} q^{4i+2}\right\}\right]$$

(3) The same as the above.

(4) $$2P^2q^{4a}\left[(m-3a-1)\ (1-q^{4a+1})\ (1-q^{4a+2})+(1-q^{4a+2})\sum_{i=0}^{a}(1-q^{4i})\right.$$

$$\left.+(1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+2})\right]$$

$$+P^2q^{4a}\left[(m-3a)\ (1-q^{4a+1})^2+2(1-q^{4a+1})\sum_{i=0}^{a-1}(1-q^{4i+1})\right]$$

And by the similar manner to that mentioned above, the formulae applicable to other R are obtained as follows:

(2) $R=2$

1·1 $$P^2q^{4a+1}\left[(m-3a-2)\ q^{4a+2}q^{4a+2}+q^{4a+2}\left\{\sum_{i=0}^{a} q^{4i}+\sum_{i=0}^{a} q^{4i+1}\right\}\right]$$

1·2 $$P^2q^{4a+1}\left[(m-3a-2)\ q^{4a+2}(1-q^{4a+2})\right.$$

$$\left.+(1-q^{4a+2})\sum_{i=0}^{a} q^{4i}+q^{4a+2}\sum_{i=0}^{a}(1-q^{4i+1})\right]$$

1·3 $$P^2q^{4a+1}\Big[(m-3a-2)(1-q^{4a+2})q^{4a+2} + q^{4a+2}\sum_{i=0}^{a}(1-q^{4i}) + (1-q^{4a+2})\sum_{i=0}^{a}q^{4i+1}\Big]$$

1·4 $$P^2q^{4a+1}\Big[(m-3a-2)(1-q^{4a+2})(1-q^{4a+2}) + (1-q^{4a+2})\Big\{\sum_{i=0}^{a}(1-q^{4i}) + \sum_{i=0}^{a}(1-q^{4i+1})\Big\}\Big]$$

2·1 = 1·1

2·2 = 1·3

2·3 = 1·2

2·4 = 1·4

3·1 = 3·2 = 3·3 = 3·4 = 0

4·1 $$P^2q^{4a}q^{4a+3}\Big[(m-3a-1)q^{4a+3} + 2\sum_{i=0}^{a-1}q^{4i+3}\Big]$$

4·2 $$P^2q^{4a}\Big[(m-3a-1)q^{4a+3}(1-q^{4a+3}) + (1-q^{4a+3})\sum_{i=0}^{a-1}q^{4i+3} + q^{4a+3}\sum_{i=0}^{a-1}(1-q^{4i+3})\Big]$$

4·3 = 4·2

4·4 $$P^2q^{4a}(1-q^{4a+3})\Big[(m-3a-1)(1-q^{4a+3}) + 2\sum_{i=0}^{a-1}(1-q^{4i+3})\Big]$$

Accordingly,

(1) $$2P^2q^{4a+1}q^{4a+2}\Big[(m-3a-2)q^{4a+2} + \sum_{i=0}^{a}q^{4i} + \sum_{i=0}^{a}q^{4i+1}\Big] + P^2q^{4a}q^{4a+3}\Big[(m-3a-1)q^{4a+3} + 2\sum_{i=0}^{a-1}q^{4i+3}\Big]$$

(2)=(3) $$P^2q^{4a+1}\Big[2(m-3a-2)(1-q^{4a+2})q^{4a+2} + q^{4a+2}\Big\{\sum_{i=0}^{a}(1-q^{4i}) + \sum_{i=0}^{a}(1-q^{4i+1})\Big\} + (1-q^{4a+2})\Big\{\sum_{i=0}^{a}q^{4i} + \sum_{i=0}^{a}q^{4i}\Big\}\Big]$$

$$+P^2q^{4a}\Big[(m-3a-1)q^{4a+3}(1-q^{4a+3})$$

$$+(1-q^{4a+3})\sum_{i=0}^{a-1} q^{4i+3}+q^{4a+3}\sum_{i=0}^{a-1}(1-q^{4i+3})\Big]$$

(4) $$2P^2q^{4a+1}(1-q^{4a+2})\Big[(m-3a-2)(1-q^{4a+2})+\sum_{i=0}^{a}(1-q^{4i})+\sum_{i=0}^{a}(1-q^{4i+1})\Big]$$

$$+P^2q^{4a}(1-q^{4a+3})\Big[(m-3a-1)(1-q^{4a+3})+2\sum_{i=0}^{a-1}(1-q^{4i+3})\Big]$$

(3) $R=3$

(1) $$2P^2q^{4a+1}q^{4a+3}\Big[(m-3a-2)q^{4a+3}+\sum_{i=0}^{a-1}q^{4i+3}+\sum_{i=0}^{a}q^{4i+2}\Big]$$

$$+P^2q^{4a+2}q^{4a+3}\Big[(m-3a-2)q^{4a+3}+2\sum_{i=0}^{a}q^{4i}\Big]$$

(2)=(3) $$P^2q^{4a+1}\Big[2(m-3a-2)q^{4a+3}(1-q^{4a+3})+q^{4a+3}\Big\{\sum_{i=0}^{a}(1-q^{4i+2})$$

$$+\sum_{i=0}^{a-1}(1-q^{4i+3})\Big\}+(1-q^{4a+3})\Big\{\sum_{i=0}^{a-1}q^{4i+3}+\sum_{i=0}^{a}q^{4i+2}\Big\}\Big]$$

$$+P^2q^{4a+2}\Big[(m-3a-2)q^{4a+3}(1-q^{4a+3})$$

$$+(1-q^{4a+3})\sum_{i=0}^{a}q^{4i}+q^{4a+3}\sum_{i=0}^{a}(1-q^{4i})\Big]$$

(4) $$2P^2q^{4a+1}(1-q^{4a+3})\Big[(m-3a-2)(1-q^{4a+3})+\sum_{i=0}^{a-1}(1-q^{4i+3})+\sum_{i=0}^{a}(1-q^{4i+2})\Big]$$

$$+P^2q^{4a+2}(1-q^{4a+3})\Big[(m-3a-2)(1-q^{4a+3})+2\sum_{i=0}^{a}(1-q^{4i})\Big]$$

(4) $R=4$

(1) $$P^2q^{4a+2}q^{4a+4}\Big[3(m-3a-3)q^{4a+4}+2\sum_{i=0}^{a}q^{4i+1}+2\sum_{i=0}^{a}q^{4i+2}+2\sum_{i=0}^{a}q^{4i+3}\Big]$$

(2)=(3) $$P^2q^{4a+2}\Big[3(m-3a-3)q^{4a+4}(1-q^{4a+4})+(1-q^{4a+4})\Big\{\sum_{i=0}^{a}q^{4i+1}$$

$$+\sum_{i=0}^{a}q^{4i+2}+\sum_{i=0}^{a}q^{4i+3}\Big\}+q^{4a+4}\Big\{\sum_{i=0}^{a}(1-q^{4i+1})+\sum_{i=0}^{a}(1-q^{4i+2})$$

$$+\sum_{i=0}^{a}(1-q^{4i+3})\Big\}\Big]$$

(4) $$P^2q^{4a+2}(1-q^{4a+4})\Big[3(m-3a-3)(1-q^{4a+4})+2\sum_{i=0}^{a}(1-q^{4i+1})$$
$$+2\sum_{i=0}^{a}(1-q^{4i+2})+2\sum_{i=0}^{a}(1-q^{4i+3})\Big]$$

(5) $R=0$

(1) $$2P^2q^{4a-1}\Big[q^{4a+1}\Big\{(m-3a)(q^{4a}+q^{4a+1})+\sum_{i=0}^{a-1}q^{4i}+\sum_{i=0}^{a-1}q^{4i+1}$$
$$+\sum_{i=0}^{a-1}q^{4i+2}\Big\}+q^{4a}\sum_{i=0}^{a-1}q^{4i+3}\Big]$$

(2)=(3) $$P^2q^{4a-1}\Big[(1-q^{4a+1})\Big\{(m-3a)(q^{4a}+2q^{4a+1})+\sum_{i=0}^{a-1}q^{4i}$$
$$+\sum_{i=0}^{a-1}q^{4i+1}+\sum_{i=0}^{a-1}q^{4i+2}\Big\}+q^{4a}\sum_{i=0}^{a-1}(1-q^{4i+3})+q^{4a+1}\Big\{\sum_{i=0}^{a-1}(1-q^{4i})$$
$$+\sum_{i=0}^{a-1}(1-q^{4i+1})+\sum_{i=0}^{a-1}(1-q^{4i+2})\Big\}+(1-q^{4a})\Big\{(m-3a)q^{4a+1}+\sum_{i=0}^{a-1}q^{4i+3}\Big\}\Big]$$

(4) $$2P^2q^{4a-1}\Big[(1-q^{4a+1})\Big\{(m-3a)(2-q^{4a}-q^{4a+1})+\sum_{i=0}^{a-1}(1-q^{4i})$$
$$+\sum_{i=0}^{a-1}(1-q^{4i+1})+\sum_{i=0}^{a-1}(1-q^{4i+2})\Big\}+(1-q^{4a})\sum_{i=0}^{a-1}(1-q^{4i+3})\Big]$$

Thus, the expectant numbers of the schools at respective k, in which the influence of the presence of the buoy-lines is taken into consideration, become estimative; and this series of the estimated-values and the observed ones corresponds to $\sum_{W=1}^{N-1}\Psi_{(W\cdot k)}$. Accordingly, the influence of the presence of the buoy-lines on total number of schools at respective k can be corrected; but there is no clue to solve a question how the correction-term is fractionated into respective W, against the fact that considerably much effort is obliged to be paid to the computation of this series of theoretical-values. Moreover, if the influences of the slackness of the main-lines and of the gradient of the soaking time on the occupied-rates of the hooks were taken into consideration, the computation becomes, if possible, far more troublesome; this comes to introduce severe computation error, the magnitude of which is sometimes supposed to exceed or reach that of the correction-term. And, in addition to the above-mentioned facts, the theoretical-values of the arrangement analysis themselves have many other sources of error, the influences of which remain untouched; therefore, it becomes doubtful whether a correction bearing much risk to introduce such high computation-error as this should be tried paying much effort or not. And, here, I want to dare to describe the fact that this series of works is attempted to finding out the distribution pattern of the tuna projected along long-line to see from ecological point of view; and, I am afraid that it has much risk to loose the sight of the subject of this series of works to pay too much mathematical effort for seaking about better methods, although it is naturally desirable to use the method bearing less sources of error and introducing less computation error. Therefore, neither any actual computation using this series of formulae is tried, nor any further effort is paid to finding out any other advanced method, in which the influence of any other source of error is taken into consideration.

Discussion and Conclusion

Applying the similar method to that used in this report, I analyzed the distribution patterns of the salmons projected along a row of drift-net observed in the waters south of the Aleutian Islands and came to the conclusion that the salmons did not form any school other than the considerably dispersed ones (MAÉDA, 1953). And the facts supporting well this conclusion were reported by UCHIHASHI (1953) through the detailed comparative morphological studies on the fish brains in relation to their habits and by HASHIMOTO and MANIWA (1956) through the echo-sounder specially designed for the purpose of finding out even a single individual. Furthermore, recently, TAGUCHI (1959) analyzed the frequency distribution of catch by respective sections in a row of salmon drift-net and that of the daily catch by respective boats, and he also came to the conclusion well supporting the above-mentioned results.

On the other hand, I had constructed the series of formulae of sequence analysis based on the theory of probability, in which most of the peculiar conditions specific to long-line gears are fulfilled (called spacing analysis), and the distribution patterns of three species of tuna of commercial importance projected along a row of long-line gears were analyzed by using these formulae. The results tell us that the tuna forms schools of various scales of such weak contagiousness that the distribution to consider a row as a whole does not differ so much from the chance distribution (MAÉDA, 1960). And the analyses by using the more advanced methods —— the interval analysis and the arrangement one ——, which are illustrated in Parts II and III of this report, also reveal the structures quite coincident with those through the spacing analysis. And these results of analyses are not so different from the structures suggested by MURPHY and ELLIOT (1954) through the analysis method of the most probable number of runs. IWASHITA (M. S.) recorded the distributions of deep swimming tuna in its fishing ground by an echo-sounder specially deviced out capable of finding out a single individual of tuna. The outline of his records suggests the presence of some aggregations, but the estimation on the intervals between the individuals from ship's speed during the recording tells us that the fishes ——, most of which are assumed, from the catch, to be the yellow-fin tuna and the big-eye tuna —— do not form any school but the considerably dispersed ones. Thus, it may well be concluded that the analysis-methods proposed in this series of works can lead us to the suggestion on school-formation of some confidence; and also it may well be considered that pelagic fish swimming in the ocean such as the salmons and the tunas form considerably dispersed schools.

And, for the purpose of giving some consideration to the reasons why these pelagic-fishes do not form any school other than considerably dispersed ones in their usual habitat —— in the off-shore ——, let us examine on the relation of the schooling-tendencies of some common pelagic-fishes to their food habits, the distribution of their prey, that of their predators, their body length, their swimming ability, fishing method by which they are caught.

The anchovy is the smallest of all the surface swimmers commonly observable and measures 9~13 cm in body length; consequently, this is hardly thought to be quick and active-swimmer. We can rather frequently observe its dense school. The remarkable variability in catch by beach-seine and by small purse-seine supports the formation of small but dense schools. Its foods, phyto- and zoo-plankton, are thought to be distributed rather densely in its habitat; accordingly, dense schooling does not cause any obstacle to get their foods. Moreover, this fish is thought to be taken by almost every pelagic-fish of medium- and large-size; accordingly, the dense schooling may be more profitable to survive well against severe attack by its predators.

The sardine is a little larger than the anchovy and measures 10 ~ 25 cm in body length; this is thought to be able to swim a little more quickly than the latter and can swim *ca.* 3.3 miles per day (this means neither the maximum speed, nor actually swimming one, but indicates the average of daily pass estimated from its migration; therefore, I am afraid it is not suitable to show such a value for the material of the discussion treated here). This fish is also the plankton-feeder, but the proportion of zooplankton to total plankton taken by this fish is larger than that of the anchovy; meanwhile, it is evident that the zooplankton is distributed far less densely than phytoplankton, even if the former is distributed considerably dense in the coastal waters; on the other hand, increase in size induces to lessen the risk to be attacked by any other fish. This fish is also caught by beach-seine and by small purse-seine, although the scale of the gears for this fish is somewhat larger than that for the anchovy; and the remarkable variability of catch suggests the formation of a little large and dense schools. Meanwhile, in some districts, drift-net is used to catch the grown-up individuals of this fish; this may well be thought to be more or less related to a little dispersed structure of its schools, although it is self-evident that a little large size, which naturally induces to rise in the market price, has clearly some relations to this fishing method. Thus, it may well be thought that the sardine forms large and dense schools but its aggregative tendency is not so strong as that of the anchovy. Here, the dense schooling is hardly thought to cause any obstacle but is thought to be more profitable to survive well.

The horse mackerel and the mackerel are the most common on-shore fishes swimming in surface layer and situated at a little higher trophic levels than the sardine. The horse mackerel is as large as or a little larger than the sardine in body length. The mackerel is also a little larger than the sardine and measures about 40 cm in body length; this is thought to be able to swim 0.2 ~ 10 miles per day. The purse-seine is the most usual method to catch these fishes. But it is necessary to concentrate them by fish-gathering lamp or rarely by ground bait before hauling, against the fact that the gears for them are far larger than those for the anchovy and the sardine. And the catch deviates severely haul by haul, day by day or seiner by seiner. These facts seem to suggest the formation of large but somewhat dispersed schools. On the other hand, these fishes are also caught by long-line and drift-net and those gathered by fish-gathering lamp or by ground bait are angled up; these differences in fishing method are chiefly due to the difference in their food habits as well as size which induces to rise in the market price, but may have some relations to the dispersed structure of their schools. The scarcity of the fishes attacking them does not cause any obstacle to form the dispersed schools.

Another large on-shore-surface-swimmer is the yellowtail. This fish is far larger than the above-mentioned four fishes, and attains to about 80 cm in body length; this can swim far rapidly and its swimming ability is estimated to be a large value such as from 10 to 50 miles per day. But this fish is thought to be more beneficial to forming considerably dense schools than to swimming in scatter, against its considerable ability to swim and its large size, because of the dense schooling of its principal prey, the anchovy. This fish occasionally visits the waters nearer than 1 km off the coast. The dishomogeneity in its environmental conditions may contribute to forming dense school. Major of this fish is caught by set-net; this fact and the remarkable variability in catch support the large- and dense-school formation. Meanwhile, some of catch are brought from domesticate fishing, angling and trolling; this suggests the presence of some scattered individuals.

The salmons, which are the typical surface-swimmers living in the subpolar offshore waters, are a little smaller than the yellowtail and are as large as from 40 to 60 cm in body length; consequently, their swimming ability is a little inferior to the yellowtail and they are estimated to be able to swim 7 ~ 30 miles per day. The dense-school formation in the coastal waters, where extremely dense prey and considerable dishomogeneity in the environmental conditions are expected, is suggested from the good catch by purse-seine and by set-net and the severe variability in them. In off shore, however, the environmental conditions are thought to be far homogeneous than that of on shore and each of their prey —— large-sized zooplankton, small squids and some fish fry —— is thought neither to form clear schools nor to be distributed so densely. These facts are well thought to induce the salmons to form such a scattered structure as suggested from many records and analyses on the distribution along drift-net or along long-line and on the variability in catch by these fishing methods. And a little strong swimming-ability may more or less contribute to showing such a dispersed structures.

The skipjacks and the albacore may well be thought to be the fishes in the mid- and low-latitudal waters corresponding to the salmons in the higher-latitudal waters. The skipjacks, which are about 50 cm in body length, feed chiefly on zooplankton and partly on small fishes and squids. As easily acceptable from the fact that major of skipjacks is caught chiefly by angling and partly by huge purse-seine, it is evident that this fish forms considerably large and compact schools even in the off-shore. But those caught by these methods are the migrating schools chiefly constituted of the individuals not older than four ages. Moreover, the profitable fishing-grounds are found only around the polar front or any other convergence line, where the environmental conditions may be considerably dishomogeneous and the distribution of prey is rather dense and considerably dishomogeneous. Nearly the similar suggestions to those mentioned above may give the young albacore, which is not longer than 60 cm in body length. But the grown-up albacore, inhabiting in lower-latitudal waters than the young, is caught chiefly by long-line. But there is no proper fishing-method of catching the grown-up skipjacks, although they are occasionally caught by tuna long-line. Therefore, the grown-up individuals of these fishes are thought to be distributed forming scattered structure. The environmental conditions of their fishing ground in the low-latitudal off-shore waters are, roughly speaking, more homogeneous than those in the young's habitats, moreover, their prey, chiefly large zooplankton, are far less densely distributed in such a waters. These fishes are hardly thought to be so frequently attacked by any other animal. Therefore, the scattered structure is thought to be more profitable to survive well, and not so many obstacles are supposed to be introduced by scattered structure.

The young individuals of the yellow-fin tuna and the big-eye tuna in the coastal waters are caught by huge purse-seine. This suggests that these fishes form schools at young stage. But their grown-up individuals are caught by long-line in the low-latitudal off-shore waters. And analyzing their distribution patterns projected along long-lines, I came to such a conclusion that these fishes were distributed forming extremely scattered schools of negligibly weak contagiousness. The grown-up individuals of these fishes are very large (about as long as 150 cm in body length) and are thought to be active swimmers; consequently it is not so hard to assume that they require considerably wide living-sphere. The principal component of their prey are large zooplankton, small file fishes, small puffers and any other fish, all of which are thought neither to form schools nor to be distributed densely, but are well thought to be scattered less densely in the low-latitudal off-shore waters. Moreover, freely swimming tunas are thought to be attacked by scarcely any predator other than killer whale which is not so abundant animal, although the hooked ones are rather frequently attacked by sharks and other voracious predators. And the environmental conditions in their fishing grounds are hardly thought to be so dishomogeneous as those in the on-shore waters. Therefore, they are thought to form extremely scattered schools of negligibly weak contagiousness except some rare and exceptional cases mentioned in the introduction of the first report of this series, and it is easily supposable that the scattered structure does not cause any obstacle, but causes some profits to survive well.

The largest surface-swimmers in the low-latitudal off-shore waters, the marlins and the spear fishes, are thought to be situated at higher trophic level and able to swim more actively than the tuna and any other fish; and these facts induce to lessen the risk attacked by any other animal and to require wider living-sphere. And deducing from the relation of the distribution pattern to size of fish, density and distribution patterns of prey and predator, swimming ability, *etc.*, I guessed that these fishes were thought to show such a extremely scattered structure as that applicable to harpooning.

The porpoise, the killer whale and many other marine mammals are the typical examples forming schools in the ocean; but they are not the Pisces, but are the Mammalia. Therefore, they are expected to be different in many habits from the fishes; and we can hardly compare their schooling-tendency with those of the fishes.

Summary

1. It is one of the principal subjects of this report to show the correlation of the hooked positions between the individuals of any two species of tuna among the yellow-fin tuna, the big-eye tuna and the albacore. Another importance of this report is given to the discussion on the analysis on the distribution patterns of the tuna projected along long-line gears through the interval analysis and the arrangement one, which are constructed from the spacing method giving some theoretical improvement, against the fact that the analysis through the spacing method was the subject of the first report of this series of works.
2. The data used for the present study was offered by the Dai-fuji Maru obtained in the waters central part of the Indian Ocean during the period from April 5th to 16th, 1955. The sketch chart of the fishing ground is shown in Fig. 1; and the amount of used gears and the catch composition at each station are given in Table 1. And the outline of the gears and of the operation are described in the section "The method for collecting the data".

Part I Correlation Analysis

(Including the spacing analysis, as a preliminary procedure)

3. It is one of the principal subjects of this report to know the correlations of the hooked positions between the individuals of any two species of tuna among the three. But those to consider with large scale are easily presupposable from the distribution patterns of the hooked-individuals of respective species, although those observable within a short range are not easily assumable, despite of much ecological interest and importance. On the other hand, it is also one of the principal subjects to show the decoded patterns through the interval analysis and the arrangement one; accordingly, I must examine what kinds of superficial and fundamental differences and coincidences in the decoded patterns are caused by the differences in the basic assumptions in the newly-added analysis-methods from the spacing one. Therefore, I cannot help describing the results of the decoded patterns of the examples used in this report through the spacing analysis as a preliminary procedure, although many examples analyzed actually through this method and the consideration about the results and the errors contained in them were represented in detail in the first report.
4. The theoretical-values of this reports are computed from the formulae, in which the influence of the gradient of the occupied-rates due to that of the soaking time and that of the periodicity of the occupied-rates due to that of the fishing depths of the hooks are taken into consideration. But their constructing-processes are omitted, because they were already described minutely in the first report.

5. In the first report, the projected distribution patterns were analyzed by adopting three unit-lengths for the decoding, which were five consecutive basket, one basket and one hook-interval widths. But, in this report, two other series of analyses, in which ten and two consecutive basket widths are adopted as the unit-lengths, are added to them.

6. All Δp used in this report are computed, as discussed in the section "Consideration upon the error in the theoretical values" of the first report, from the regression equation of catch on lot number of 20 consecutive basket width, then P is from the equation, $\sum_{i=1}^{M}(P+i\Delta P)=N$, so as to get the constants with the computation error as small as possible.

7. The distribution patterns of three species of tuna projected along each of 12 rows of gears are analyzed through the spacing method. And summarizing the results, I want to describe the following patterns as the general structures of respective species.

8. There is no example of the yellow-fin tuna clearly showing the self-spacing pattern, but the hooked-individuals in each example form the schools of several-fold contagiousness. And the common structure of the highest order observable within a row to all the examples is the schools, the magnitude of width of which is 2 km order. But, in a half number of the examples, the schools of the above-mentioned order further form the schools of not so strong contagiousness each extending from 10 to 30 km.

9. Generally speaking, the hooked density of the big-eye tuna in each example can not attain to the value as high as an individual per 10 consecutive baskets; accordingly, no structure of some significance but the following tendencies can be deduced out: relatively clear school-formation is found out in about a half number of the examples, although the population-size of each school is not so large; while the examples of the rests of them suspect the self-spacing pattern.

10. Like the big-eye tuna, the poor catch of the albacore by each row makes it impossible to get any pattern of some significance; while, for convenience' sake, only the following patterns are described as the general tendency: this species is inclined to form the schools covering a width longer than a half length of a row or sometimes nearly as long as a whole length, in which the individuals are hooked rather self-spacingly.

11. Then, the correlation of the hooked positions between the individuals of any two species among the three are analyzed through the proposed method for the analysis on the correlation. Here, we must pay attention to the fact that the predominance in the hooked population-size of the yellow-fin tuna superficially raises the observed-values and the estimated ones in the correlation analysis falsely large enough as if to be able to give some significance upon the decoded facts, but, actually, not so high significance can be given to the results because of the poor catch of the big-eye tuna and the albacore. Accordingly, hardly any fact can be described on the correlation observable within a short range against its importance and interest.

12. At first, the expectant outline of the correlation to consider a row as a whole is forecasted from the distribution patterns of respective species in respective examples; next, the differences in the actually analyzed ones through the correlation analysis from the forecasted ones are examined example by example; then, the reasons causing these differences are discussed case by case, although not so much differences are found out.
13. It may well be concluded, as the summary of correlation of the hooked positions, that the tendency of occupying the same habitat is the strongest between the yellow-fin tuna and the big-eye tuna, that between the yellow-fin tuna and the albacore is a little weaker than this, and that between the big-eye tuna and the albacore is the weakest of all; and the aggregative relation is observable between the yellow-fin tuna and the big-eye tuna but the individuals of the albacore are inclined to be hooked rather repulsively against these two species. And these facts may be more or less relating to such differences in food habits and in body size as the yellow-fin tuna and the big-eye tuna commonly take zooplankton and small fishes and their sizes are not so different from each other against the fact that the albacore takes zooplankton and is a little smaller than the former two in size.

Part II Interval Analysis

14. The spacing analysis does not touch whether or not any of the inserted-hooks in the interval is occupied; and this makes it sometimes into confusion to translate the results of the analysis into the actually recorded structures. Accordingly, another analysis-method is deviced out, in which the length of the interval between the next individual is treated, *i.e.*, whether or not any of the inserted-hooks in the interval is occupied is taken into consideration. And this method is, for convenience' sake, called "the interval analysis".
15. At first, the constructing-process of the formulae applicable to the simplest condition is explained, in which the difference in the occupied-rate due to the difference in the fishing depths of the hooks caused by the slackness of the main-lines and that of the gradient of occupied-rate due to that of the soaking time are put out of consideration, for beneficial of understanding the way of thinking. Then, how to take the influence of each one of these factors into consideration is represented; and at last combining these two methods of modification, I have induced out the formulae, in which the influences of both factors are taken into consideration.
16. This method is effectively applied only to the examples in which considerably many individuals are hooked, because sum of the observed-values and that of the estimated ones in this method are no more than $(N-1)$. Therefore, the actual application is tried only to take the examples of the yellow-fin tuna, and I can not give any consideration to the difference in the decoded patterns with species, despite of its importance and necessity, because the smallness of the hooked population-size of other

species has much risk to introduce severe influence of accidental error into the decoded patterns.

17. I am obliged to compare the observed-values with the estimated ones in which the influence of only the difference in the occupied-rate due to that of the fishing depths of the hooks is taken into consideration, because I am afraid that the complicated exclusion-method of the influence of the gradient has much risk to introduce severe computation-error into the estimated-values, consequently into the decoding.

18. This method is thought to prove its merits only when this is used as a preliminary step to the next arrangement analysis; accordingly, no fact other than a short description on the characteristics of the deviation of the observed-values from the estimated ones is illustrated.

19. Then, the decoded pattern through this analysis-method is compared with that through the spacing one in which one hook-interval width is adopted as the unit-length of consideration, for the purpose of finding out what kinds of difference in the decoded structures are caused by the difference in the treatment of the inserted-hooks and what structures are suggested from these apparent differences in the decoded patterns.

20. The difference in the observed-value in the spacing analysis from that in the interval one represents the observed-value of the intervals of respective width in which one or more inserted-hook is occupied; and the difference in the estimated-value also represents the estimated number of such intervals. And the difference in the observed-value at k_1 from the estimated one in the spacing analysis represents the similar differences in the interval analysis in the range $0 \leqq k \leqq k_1$ cumulatively. Most of the apparent differences of the results of the spacing analysis from those of the interval ones can be explained from these reasons, while only a little can do so, and they are thought to represent some specific structures.

Part III Arrangement Analysis

21. The spacing analysis can tell us only the fact that how longly spaced pairs of individuals are more frequently observable than in the chance distribution, and the interval analysis can certify only the fact that how longly spaced individuals from the next ones are more frequently observable. But there remains another factor of importance untouched —— this is the manner of the arrangement of the intervals of respective widths.

22. It occurs naturally to our mind that there are some lots, each of which is constituted of some short intervals arranged successively, even if all the individuals are hooked by chance along a row; therefore, the method for estimating the expectant number of the lots, constituted of W successively arranged intervals each of which is as long as or shorter than k when all individuals are hooked by chance, is deviced out; and this method is, for convenience' sake, called the arrangement analysis.

23. Respective k, where the observed-values in the interval analysis exceed the estimated ones, are set to be the key-lengths to the analysis on the school-formation at respective steps, and the distribution patterns at respective steps in respective examples of the yellow-fin tuna are analyzed and the results are described in detail.

24. The results of the arrangement analysis are summarized as follows: population usually has the contagious schools of several folds and it is suggested as the structure of the highest order observable within a row that about a half of catch constitutes several schools of from 10 to 30 km in the projected widths and the average occupied-rate of the hooks in the part covered by these schools is estimated to be from several tenths to several times higher than that computed from throughout a row. But there are some examples showing some special structures. For examples, small population-size of the clusters at respective steps is one of the characteristics of the distribution pattern in Example Y 4, while large population-size is that in Example Y 7; weakly aggregative cluster-formation is that in Example Y 10, while narrow but dense cluster-formation is that in Example Y 12.

25. The results of the arrangement analysis can tell us the numbers of the clusters of respective population-size, in contrast with the fact that the spacing analysis can simply tell us the probable distance among the centers of the schools —— secondarily, the total number of the schools regardless of their population-size is estimative. Moreover, it is far easier to translate the facts guessed out from the arrangement analysis into the projected distribution pattern recorded actually than to translate the facts guessed out from the spacing one into it; and also when we refer to the results of analysis together with the projected distribution pattern recorded actually, far more detailed facts are deducible from the arrangement analysis than from the spacing one, —— for example, the numbers of the schools of respective population-size, their probable positions, widths *etc.*, consequently occupied-rate *etc.*, of course including the distances among their centers.

In addition to these merits, it is one of the most powerful merits of adopting the arrangement analysis that the individuals forming respective aggregations pointed out through the arrangement analysis theoretically have a definite proof supporting that these individuals are hooked aggregatively, in contrast with the fact that the observed-value at a certain k in the spacing analysis exceeds largely the theoretical one, strictly speaking, does not necessarily mean or has no proof supporting that each one of the individuals from respective pairs is hooked aggregatively.

26. The structure at the highest order observable within a row decoded through the arrangement analysis is compared with that through the spacing one, example by example. But generally speaking, no serious difference between the decoded patterns through these two different analysis-methods can be found out in most of the examples in which clear school-formation is suspected; but only a little differences are found out in the examples in which no clear school-formation is suspected and these differences are thought to be due to the fact that the pattern decoded through the spacing analysis and that through the arrangement one in such an example reveal the pattern

to see from quite the different point of view because of the most fatal demerit of the spacing analysis pointed out in paragraph 25.

27. The practically applicable method, in which the influence of the presence of the buoy-lines on the arrangement analysis is excluded, has not yet established; but two tracks of the trials for the exclusion are shown.

28. In the last section of this report, the distribution patterns of some commonly observable pelagic-fishes —— the anchovy, the sardine, the horse mackerel, the mackerel, the yellowtail, the salmons, the skipjacks, the albacore, the yellow-fin tuna, the big-eye tuna and the marlins and the spear fishes——in relation to their food habits, the distribution of their prey, that of their predators, their size, their swimming ability, the fishing methods by which they are caught, are discussed, for the purpose of finding out some suggestions upon the reasons why the tunas and the salmons do not form any school other than considerably dispersed one in their usual habitats and such a pattern may bring what profits and what obstacles to survive well. And as the general tendency, it is found that the denser school is observable, when (1) the denser their prey are distributed, (2) the severer the variability of the density of their prey is, (3) the severer they are attacked by any other animal, (4) the more dishomogeneous the environmental conditions in their habitats are, and (5) the smaller their size is, consequently the weaker their swimming ability is. And also some relations can be suggested between the schooling-tendency and the fishing-methods. And deducing from these facts, I want to conclude that the dispersed structures of the salmons and the tunas are acceptable and many profits and scarcely any obstacle are thought to be introduced to do so.

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