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低気圧とブリ波
(英文)

宇田

# RELATION BETWEEN THE DAILY CATCH OF FISH AND THE METEOROLOGICAL ELEMENTS.—PART I. STATISTICAL STUDIES IN THE INFLUENCE OF THE MOTION OF CYCLONE UPON THE FISHING.

By

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The materials utilized in the following study have been taken from the daily records of the catch of "*Buri*" (*Seriola quinqueradiata* Temminck and Schlegel) by means of *Ôsikiami* (a kind of pound net), kept during 9 years from 1918 to 1926 at Nisimura Fishing Station in Nagasaki Prefecture. The method of procedure adopted is as follows:

The day on which the centre of any cyclone is located nearest to the station above mentioned is taken as the origin of time i.e. 0 day, which can easily be determined from the weather chart. The day before 0 day is taken as −1 day, the next day as +1 day and so on. In order to see the distribution of the catch during a period of a few days before and after 0 day, the daily catch of fishes is then tabulated as indicated in Table I.

TABLE I 1925 (Taisyô 14 nen.) The catch of "*Buri*" at Nisimura Fishing Station in Nagasaki Prefecture.

| The date of 0 day \ day | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| II. 6 | 18 | 61 | 26 | 2 | 0 | 0 | 679 | 2037 | 0 |
| | 2 | 0 | 0 | 679 | 2037 | 0 | 1615 | 4845 | 0 |
| 16 | 4845 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 0 | 388 | 1162 | 0 | 0 | 0 | 0 | 0 | 1979 |
| III. 1 | 1162 | 0 | 0 | 0 | 0 | 0 | 1979 | 5935 | 63 |
| 4 | 0 | 0 | 0 | 1979 | 5935 | 63 | 189 | 455 | 1771 |
| 9 | 63 | 189 | 455 | 1771 | 1223 | 0 | 0 | 403 | 1209 |
| 11 | 455 | 1779 | 1223 | 0 | 0 | 403 | 1209 | 455 | 1937 |
| 15 | 0 | 403 | 1209 | 452 | 1937 | 1746 | 0 | 0 | 0 |
| 23 | 0 | 22 | 66 | 609 | 1825 | 0 | 0 | 0 | 1081 |
| 27 | 1825 | 0 | 0 | 0 | 1081 | 3233 | 0 | 1739 | 5233 |
| 30 | 0 | 1081 | 3233 | 0 | 1739 | 5233 | 42 | 0 | 0 |

| The date of o day \ day | −4 | −3 | −2 | −1 | o | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| IV. 2 | o | 1739 | 5233 | 42 | o | o | o | 30 | 4641 |
| 4 | 5233 | 42 | o | o | o | 30 | 4641 | 13703 | 147 |
| 8 | o | 30 | 4641 | 13703 | 147 | 2863 | 8589 | 36 | 107 |
| 12 | 147 | 2863 | 8589 | 36 | 107 | o | 58 | 174 | o |
| 15 | 36 | 107 | o | 58 | 174 | o | o | o | o |
| 21 | o | o | o | o | o | o | o | 2234 | 6701 |
| 28 | 2234 | 6701 | o | 47 | 142 | 2534 | 7800 | 602 | o |
| The total sum in each column | 16020 | 15405 | 25837 | 19378 | 16338 | 16105 | 26801 | 32645 | 28869 |

In the present investigation the variety in the course and other characteristics of each cyclone are put aside. The discussion on these points involves, indeed, many important problems relating to the effects of the tidal currents, the topographical feature of the bay, etc., which are intended to be discussed in other days.

For the present, however, we will confine our study to the statistical results regardless of the intensities of various cyclones.

It must be remarked here that unfortunately our records are destitute of the separate descriptions of the catch of fish obtained by the morning-net[1] and that by the evening-net[2] respectively, except in those of 1926.

Therefore, the author has tried to take this fact into account by transferring one fourth of the catch into that of the day before. The number of catch given in Table I represents the values thus reduced to the value of the catch at noon of the day considered. In this way, Table I still contains the whole of the catch without any omission.

In Table II is given yearly catch for each of the nine years.

With a view to make the statistical results of Table II more obvious, the total sum of

TABLE II.

| Year \ day | −4 | −3 | −2 | −1 | o | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 4983 | 10836 | 4429 | 3275 | 734 | 2268 | 8454 | 6454 | 4053 |
| 8 | 21871 | 26256 | 27221 | 25152 | 16972 | 17995 | 35893 | 21731 | 17299 |
| 9 | 11384 | 11371 | 12432 | 11316 | 9812 | 9615 | 19324 | 8184 | 5730 |
| 10 | 3779 | 2707 | 9451 | 11293 | 5700 | 3227 | 3605 | 5494 | 8510 |

1) It means the net which is laid at about 6h P.M. of the preceding day and hoisted at about 6h A.M. on the day.

2) The net laid at about 6h A.M. and hoisted at about 6h. P.M.

| Year \ day | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 2237 | 3596 | 4502 | 3359 | 3890 | 3395 | 5000 | 4386 | 3616 |
| 12 | 3995 | 4457 | 2054 | 2232 | 1382 | 1670 | 3770 | 5265 | 1026 |
| 13 | 90 | 560 | 973 | 383 | 243 | 287 | 738 | 248 | 80 |
| 14 | 16020 | 15405 | 25837 | 19378 | 16338 | 16105 | 26801 | 32645 | 28869 |
| 15 | 7792 | 14196 | 20688 | 23844 | 9021 | 6532 | 11274 | 13610 | 20044 |
| The total sum in each column | 72171 | 89384 | 107587 | 100232 | 64092 | 65074 | 114859 | 98020 | 89221 |

each column is plotted in Fig. I, where N′ denotes the number of the catch and t, the time.

As seen from Table I, the mode of distribution of the catch before and after the day on which the centre of a cyclone is located nearest to our fishing station is rather obscure.

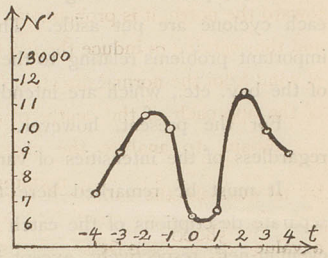

Fig. I.

From Table II, however, we recognize a remarkable feature common to every year for the modes of distribution of the catch. Moreover, we see that the minimum of the catch curve throughout 9 years coincides with the position of the time axis corresponding to +0.5 day (half a day after 0 day). We can also easily notice that the maxima are two in number before and after 0 day, the one lying between −3 day and −1 day and the other, between +2 day and +3 day. The author attributes the cause of the slight discordane of the positions of these maxima in different years to the yearly differences in the intervals between the days of successive approaches of cyclones. On account of the yearly differences in the modes of superposition on the catch-curves of the influences of the consecutive cyclones, the values of catch for ±3 day or ±4 day are more or less different for different every year. Calculating the average time-interval for the successive approaches of the cyclones accompanied by amounts of the catch above 1000 in the fishing-season now in problem and superposing the curve displaced by the time interval thus obtained upon the original catch-curve, he ascertained that the idea above stated is pretty correct. Supposing, however, that by taking the statistical mean for 9 years the accidental discordances of maxima above stated may cancel each other for the most parts (the both ends of the curve in Fig. I are excepted), he considered that the total sum of each column in Table II may represent the general features of the catch-curve. Thus, Fig. I was constructed.

In the author's opinion the positions of the minimum and the maxima represented in this curve may play a role very important for the practice of stationary fishing. The minimum lies at +0.5 day, while the maxima are two in number, of which the one corresponds to −1.5 day and the other to +2.5 day. By these results the empirical facts known to the fishermen as "*Maeryô*" (Prefishing[1]) and "*Atoryô*" (Postfishing[1]) are proved statistically. There is a general belief among the fishermen at Nisimura Fishing Station that NNE wind in this season brings a hopeful catch. This can be easily explained, since the wind blowing counter-clockwise about the centre of a cyclone appears as NNE wind as the cyclone approaches to the fishing station from SWW to NEE on the south side. And, moreover, remembering that the mouth of the bay faces toward the north, it is probable that this wind is most effective in stirring the water of bay and thus serving to induce the fish towards the fishing station. Therefore, a sudden change of wind from the normal direction (NW∼W) to NNE may be considered as a prediction of the approach of the centre of a cyclone or indirectly of an abundant catch.[2]

Again, to analyse the character of the curve above obtained a little further, let us evaluate the ratio, $\frac{\text{maximum value} - \text{minimum value}}{\text{average value}} = \frac{\text{amplitude}}{\text{average value}}$. We obtain a value $\frac{58000}{89000} = 0.65$.

Now calculating the frequency of the catch above 1000 (n) for the days before and after 0 day respectively, we have the results as shown in Table III. Fig. II. shows the results diagrammatically.

TABEE III.

| Year \ day | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 3 | 2 | 2 | 2 | 0 | 1 | 4 | 1 | 2 |
| 8 | 7 | 6 | 9 | 7 | 4 | 5 | 10 | 7 | 4 |
| 9 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| 10 | 2 | 0 | 4 | 4 | 3 | 1 | 1 | 3 | 2 |
| 11 | 2 | 1 | 2 | 2 | 2 | 1 | 3 | 0 | 4 |
| 12 | 1 | 2 | 0 | 1 | 0 | 0 | 1 | 2 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 5 | 5 | 7 | 3 | 7 | 5 | 6 | 6 | 8 |
| 15 | 2 | 5 | 7 | 4 | 3 | 2 | 3 | 4 | 4 |
| Total sum in each column | 25 | 24 | 34 | 26 | 21 | 18 | 31 | 25 | 26 |

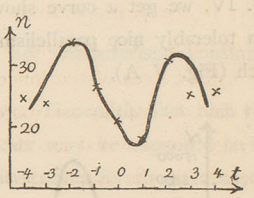


Fig. II.

1) By Pre-and Post-fishing the author means the catch before and after the approach of a cyclone.

2) The author may add in passing that the cyclones which has brought the catch of "*Buri*" in the fishing season are mostly those of Tairiku Senpû (cyclones which are originated from the interiors of Asia Continent and attack Japan Island, generally in winter), especially those of which run from SWW to NEE on the south side of this fishing station.

Glancing at Fig. II, we notice a remarkable resemblance between Fig. II and Fig. I. Further, calculating the ratio $\frac{\text{amplitude}}{\text{average value}}$ from Fig. II we have 0.66. By the way, we have $\frac{\text{amplitude}}{\text{average value}}=0.4$ from the frequency-curve of the catch above 1, and 0.57, from that above 700.

Therefore, the unit of shoals of "*Buri*" may be supposed to be that of the order of 1000. Referring again to Fig. I, we may explain the meaning of that figure as follows. The shoal of "*Buri*," with the number of fish (N) enters into the bay most abundantly when the sea is raging most violently, as is believed generally.

Since the rate of net-reeling (K) becomes worse as the violence of the sea increases, the so called number of the catch N′ is KN; therefore, we have the form of the curve as Fig. I.

To test this idea, the author has tried the following check. Namely, using the material in 1926 with the records of the days, on which the net-reeling was incapable on account of high sea, and calling the ratio $\frac{\text{the number of days in which the net-reeling was incapable}}{\text{the whole number of days of 0 day inserted in the table of 1926}}\times 100$ the rate of net-reeling (K), we obtain the curve as illustrated in Fig. III. The curve in Fig. IV, which was drawn after the example of Table II by selecting the cases in which the net-reeling was capable throughout 7 days before and after 0 day, is proportional to the aggregation-curve[1] of the shoal of "*Buri*."

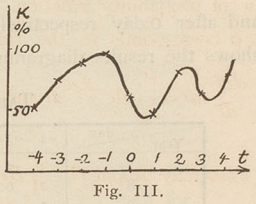

Fig. III.

If we calculate KN by combining Fig. III with Fig. IV, we get a curve shown in Fig. V B which runs in a tolerably nice parallelism with the curve of the actual catch (Fig. V A).

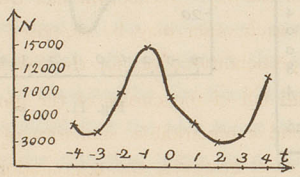

Fig. IV.

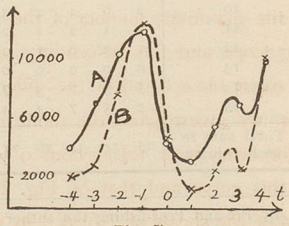

Fig. V.

1) By aggregation-curve the author means the curve which represents the mode of the variation of the number of "*Buri*" aggregated at the fishing station in the bay before and after 0 day.

Here it is noticeable that Fig. III and Fig. IV, accordingly Fig. VB, show the influence belonging to a cyclone in the range of 5 days about 0 day. Thus, it may be seen that at least according to the material in 1926, the idea above mentioned is correct and agrees with the actual case. That is to say, the state of aggregation of the shoals of "*Buri*" is represented by the curve which has the maximum at −0.5 day, and that maximum implies that the waves along the sea-bottom of long wave-length caused by the cyclonic disturbance reaches the bay before the arrival of that cyclone and stirs up the water. Thus, as the result of stirring, the turbidity of water in the bay increases and the shoals of "*Buri*" are enticed. In short the higher the sea, i.e. the more conspicuous the turbidity, the more the shoals of "*Buri*" are induced. Hence, the author considers that the inventions and improvements of the fishing-implements as well as of the methods of fishing which may stand against the violence of rough sea are very desirable. Further, the aggregation-curve of the shoal of "*Buri*" shows us that the ascending slope of the curve is less than the descending. In other words, the rate of increase of the number of aggregation of the shoals of "*Buri*" differs from that of its decrease. This fact may be interpreted in the following lines: the shoals of "*Buri*" are induced in the bay and aggregated at the fishing station by the excitation of the rough sea. Moreover it may be considered that the degree of sensitivity of "*Buri*" to the excitation such as that due to the rough sea caused by cyclone in the fishing season i.e. the rate of aggregation is subjected to the law of probability function. Thus, the number of the fish in the bay at time t (,where t=0 corresponds to the time when the entrance of the fish began,) may be put $\int_o^t \frac{dN}{dt}\,dt = \int_o^t Ae^{-h^2t^2}\,dt$ and the number remaining at t after the exit of the fish has begun at $t=0$ may be put $N_o - \int_o^t Be^{-h'^2t^2}\,dt$, where $A$, $B$, $h$ and $h'$ are characteristic constants and $N_0$, the maximum number of the fish entered in the bay. Hence, the fact that the ascending slope and the descending one differ from each other may be supposed to be brought about on account of the difference of the probability-curves for the two cases.

Next, we investigated the mode of the rise and fall of the curves of the monthly catches for every year throughout 9 years and found a remarkable similarity of form between this curve and that of Fig. IV. In this case, however, the aggregation and dispersion of the shoals of "*Buri*" in the fishing season are considered to be connected with the variation in the mean temperature of sea water, instead of the approach of cyclone as in the preceding case.

A further discussion on this interesting problem is to be reserved for a future investigation. Returning to our principal result (Fig. I), it occurred to the author to investigate whether a similar relation as in the case of "*Buri*" may hold or not for the other fishes, that is to say, "*Iwasi*" (*clupea melanosticta* Schlegel) and "*Saba*" (*Scomber Japonicus Houttuyn*). The records available for this purpose are those at Nisimura Fishing Station, 1925 & 1926, obtained with the net, *Ôsikiami*. For the purpose of comparison the records at the Ogusi Fishing Station situated near that of Nisimura were also employed. Those results are given in Table IV & Fig. VI (in 1926 at Nisimura Station), Table V & Fig. VII (in 1925 at Nisimura Station), and Table VI & Fig. VIII (in 1925 at Ogusi Station), where the curve I marked with (---×---) indicates the catch-curve ($N'$) for "*Buri*," and II (——○——) that for "*Iwasi*" and III (—·—△—·—), for "*Saba*."

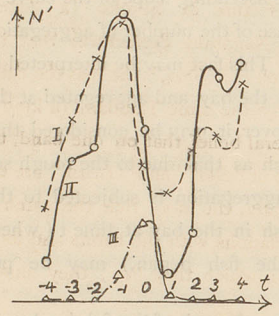


Fig. VI.

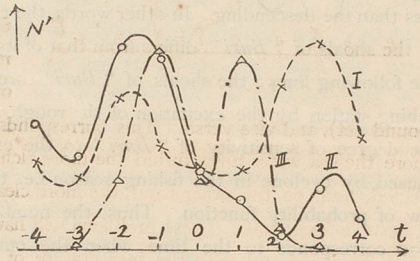


Fig. VII.

TABLE IV.

| Name of Fish \ day | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| Buri | 7792 | 14196 | 20688 | 23844 | 9021 | 6532 | 11274 | 13610 | 20044 |
| Iwasi | 259 | 932 | 1025 | 2059 | 1125 | 155 | 818 | 1547 | 1588 |
| Saba | 0 | 0 | 0 | 214 | 642 | 4 | 0 | 0 | 0 |

TABLE V.

| Name of Fish \ day | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| Buri | 16020 | 15405 | 25837 | 19378 | 16338 | 16105 | 26801 | 32645 | 28869 |
| Iwasi | 3552 | 2650 | 4387 | 4147 | 2365 | 1628 | 656 | 1858 | 1134 |
| Saba | 0 | 0 | 1617 | 4850 | 1619 | 4868 | 54 | 0 | 0 |

TABLE VI.

| Name of Fish \ day | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| Buri | 17191 | 7149 | 794 | 10729 | 3133 | 983 | 118 | 21856 | 14106 |
| Iwasi | 346 | 634 | 174 | 266 | 302 | 101 | 265 | 417 | 431 |
| Saba | 11985 | 6565 | 7279 | 2565 | 7937 | 20475 | 12121 | 6101 | 20668 |

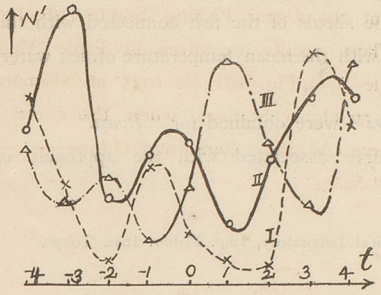


Fig. VIII.

From the curves we notice that $N'$ for "*Iwasi*" varies in the same manner as that of "*Buri*" with respect to the approach of cyclone. On the contrary $N'$ for "*Saba*" represents a variation inverse to that of "*Buri.*" The latter seems to agree with the empirical fact known to the fishermen of *Kôti* Prefecture in Sikoku (a district distant from Nagasaki Prefecture) that the more the catch of "*Buri,*" the less the catch of "*Saba*" by the same Taibôami (a kind of pound net), and vice versa. This corresponds to the general belief that on one hand, the more the sea water turns turbid, the more rich the catches of "*Buri*" and "*Iwasi*" are expected, and, on the other hand, the more clear the sea water, the more rich the catch of "*Saba*" is expected. These problems will have certain relations with the habits and foods of those fishes and with the temperature of sea water in which they live; they should be discussed in future studies.

In conclusion the author wishes to express his cordial thanks to Dr. M. Tauti for his kind guidance during this research, to Dr. T. Terada for his instructions and advices.

## Abstract.

1. From a statistical study of the records of the catch during 9 years at Nisimura Fishing Station in Nagasaki Prefecture the author deduced the state of distribution of the catch of "*Buri*" over several days before and after the day on which the centre of a cyclone was located nearest to that station (say 0 day).
(−) (+)

A maximum of the catch-curve corresponding to so called "*Maeryô.*" (Pre-fishing) appears at −1.5 day, and a minimum of the catch-curve exists at +.5 day.

It has also been found that the position of the maximum corresponding to so called "*Atoryô*" (Post-fishing) lies at +2.5 day.

2. The idea that the catch-curve is the consequence of a combination of the aggregation-curve of the shoal of the fish and the curve of the rate of net-reeling was proposed. It has been ascertained by the only records in 1926, the only material available. Hence it is considered that the more violent the sea rages, the more abundantly the shoals of "*Buri*" enter into the bay.

3. The unit of the shoals of "*Buri*" is probably that of the order of 1000.

4. Comparing the aggregation-curve of the shoals of the fish connected with the approach of a cyclone with the one connected with the mean temperature of sea water, the characteristics of the curve were discussed.

5. The same results as obtained for "*Buri*" were obtained for "*Iwasi.*"

6. A contrary variation of the catch-curve associated with the approach of cyclone was observed in the case of "*Saba.*"

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