

26. *On some Probable Influence of Earthquakes upon Fisheries.*

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Some causal connection between the occurrence of earthquakes and the amount of catch of some or other kinds of fishes on a certain fishing ground in the locality affected by the shocks, have not infrequently been spoken about. According to Dr. N. Nasu, it was remarked by Mr. Miura, Director of the Prefectural Fishery Institute at Itô, Idu, that the kinds of fishes most abundantly caught before the remarkable swarm-earthquakes in that district were quite different from those caught after the earthquakes. Again, according to Prof. Nagaoka, it is said that in the summer of 1923 just preceding the Great Kwantô Earthquake, an abundant catch of full grown mackerels (*Scomber*) was noted as an unusual phenomenon among the fishermen in the vicinity of Miura Peninsula, as the season was that of horse mackerel (*Caranx*) fishery in the normal years.

The present author was interested with this problem but unable to undertake any systematic investigation in this line on account of the lack of reliable fishery data. Recently, he received from Mr. Kinoshige Kimura of the Imperial Fisheries Institute a copy of the reprints of his paper dealing with the annual variation of the status of fisheries on the fishing ground at Awasima, which was read before the meeting of Colloquium in the Institute.¹⁾ In this paper are given a number of diagrams showing the daily amounts of catch of different kinds of fishes which were caught in the fishing ground of Awasima at the northern end of the Bay of Suruga and recorded in the book kept at the Office of that place. These data which are referred to the six years 1924-1929, seemed to be convenient for carrying out a preliminary investigation of the relation in question. It occurred to the present author, however, that the fishery data for 1930 will be most interesting for the first step

1) 水産物理談話會報 15 (July 1931).

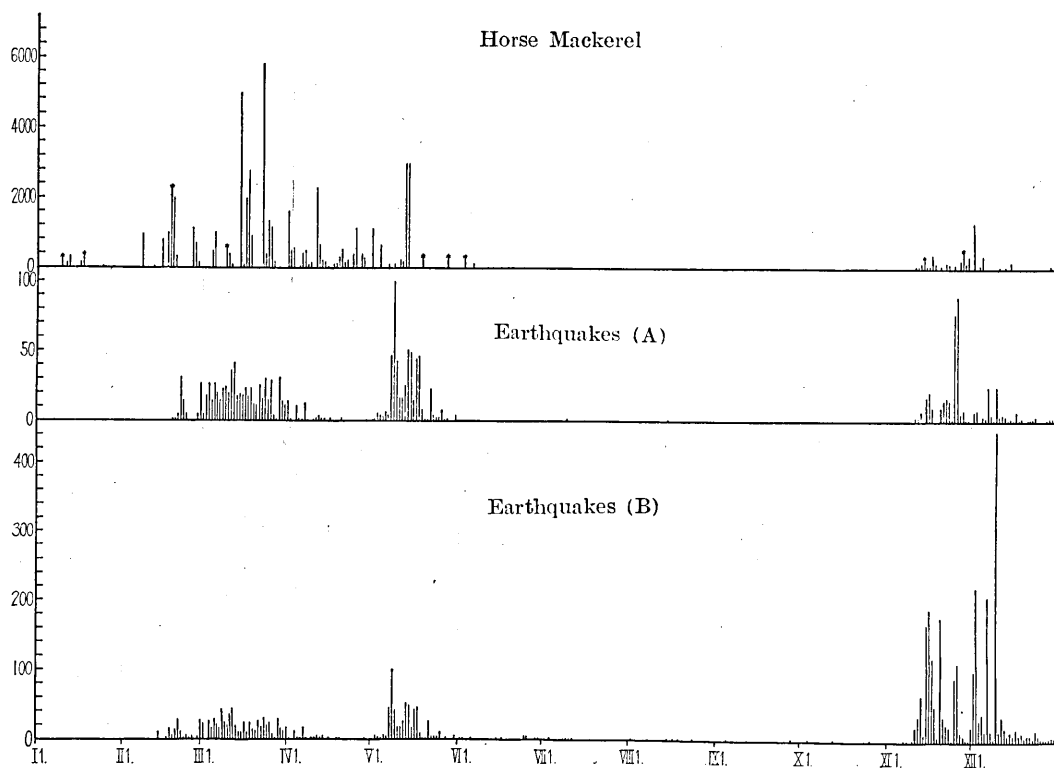


Fig. 1. Earthquakes (A) means the no. of "felt" earthquakes in N-Idu and Itô.

Earthquakes (B) means the sum of the numbers of earthquakes, felt and unfelt earthquakes in Idu Peninsula and the Bay of Suruga *plus* the number of conspicuous or rather conspicuous earthquakes in Musasi, Sagami, Suruga and Kai. The mark * on fish-diagram means that the amount of catch is not exactly known though abundant.

of investigation, since in this very year there occurred a series of conspicuous swarms of earthquakes in the Province of Idu not far from the said fishing ground. Upon the request of the author, Mr. Kimura kindly took the trouble of preparing a copy of the data for this year, containing the daily numbers of catch for different kinds of fishes and for a number of fishing grounds of the same district. A provisory review of these data revealed a rather remarkable fact that the epochs with abundant catch of horse mackerel, *Caranx*, at Sigedera coincided nearly with the periods in which the seismic activity was at its full display. Fig. 1²⁾

2) The earthquake data here plotted in the diagram are taken from the Report of North Idu Earthquake issued by the Central Meteorological Observatory.

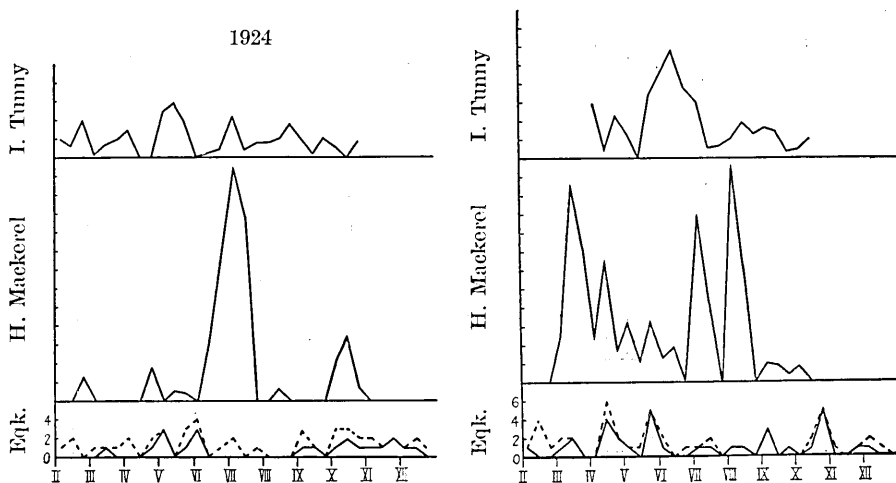
will illustrate this rather striking coincidence. Especially interesting is the comparison of the two data in Nov.-Dec.

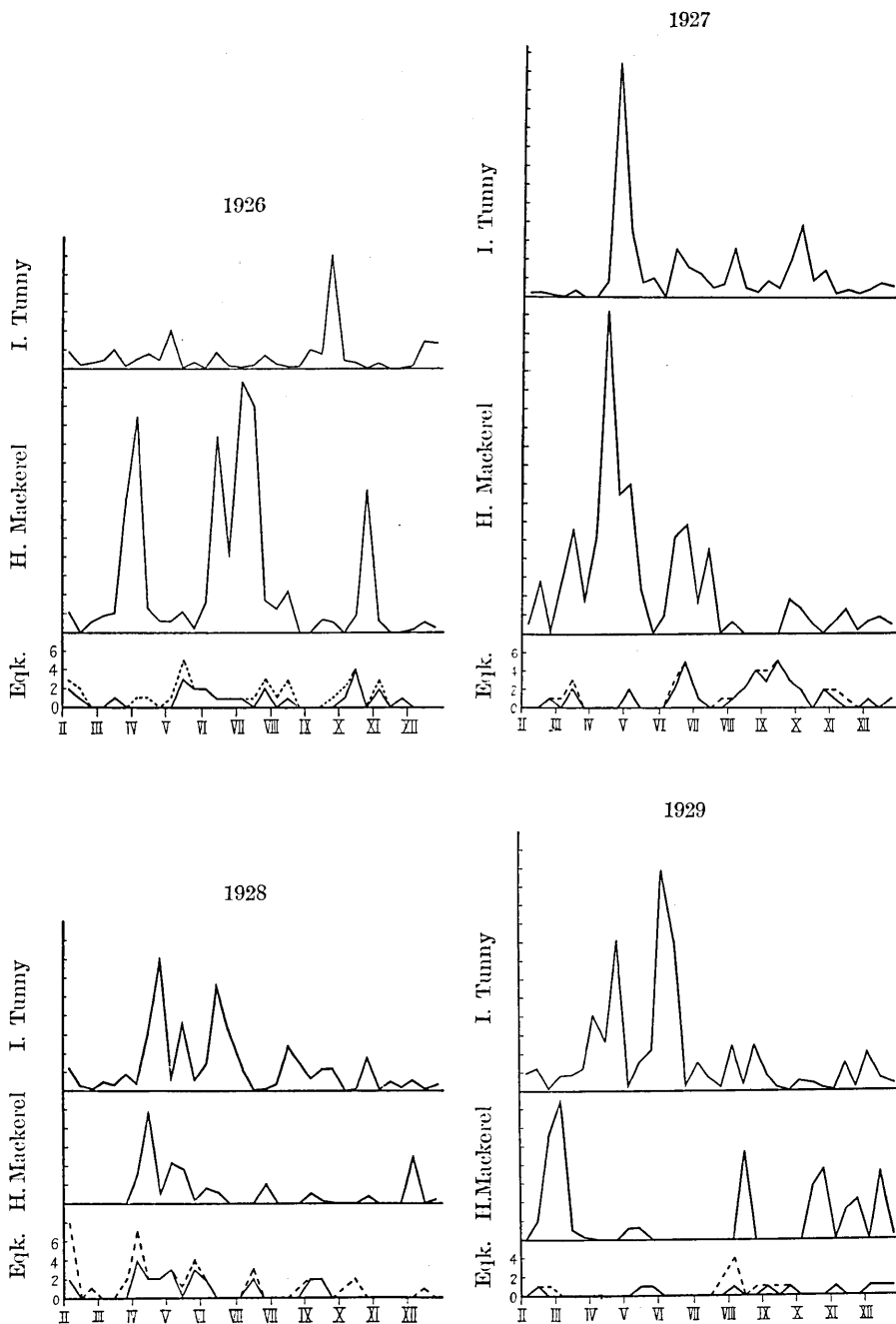
The result of this first trial seemed encouraging so that a further step was taken for a more systematic investigation by taking the data for the other six years given in the paper cited. In the diagrams given there, the daily amounts of catch are plotted as the ordinates y , not proportional to the number n of the fish caught, but in a peculiar deformed scale such that the length of y is multiplied by $3/2$ when n is doubled, i. e. $y=n^a$, where $a=\log 3/2 \div \log 2=0.585$. Such a kind of scale seems not only convenient but also quite rational. Suppose that the number of fishes caught is a fraction f of the total number N of the swarm of fishes present and f may increase with N by different reasons such that $f=\alpha N^b$, α being a constant. Then the catch is $n=\alpha N^{b+1}$ and therefore $N=\frac{1}{\alpha}n^{\frac{1}{b+1}}$. If f be simply proportional to N , we have $b=1$ and $N \propto n^{0.5}$ which is not very different from y as above defined.

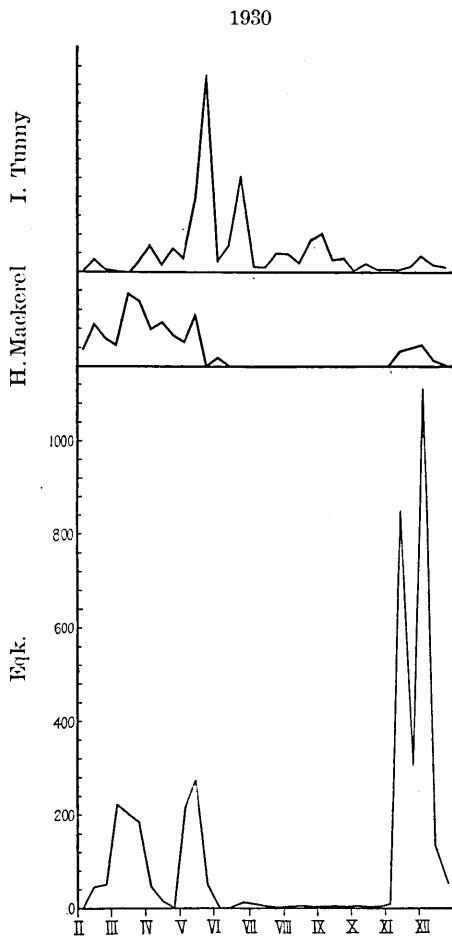
At any rate, we could adopt y of these diagrams as an arbitrary measure of the amount of catch in the present investigation where any

Fig. 2. Lowest curve gives the decade number of earthquakes; full line for the sum of unfelt, felt, rather conspicuous and conspicuous earthquakes originated in Idu Peninsula and the Bay of Suruga; dotted line for the sum (No. of felt and unfelt ones in Idu, the Bay of Suruga and W part of the Bay of Sagami)+(No. of conspicuous and rather conspicuous shocks in Musasi, Sagami, Suruga, Kai, Idu). Middle curve gives the decade amount of catch of horse mackerel and top curve that of immature tunny, both in an arbitrary scale.

1925







these earthquakes were counted and then the sum of their numbers for each of the three parts of each month was calculated and plotted in the similar manner as in the case of fish data.

In the case of 1930, the fish curve refers to the fishing place different from that for the other years as already mentioned. This lack of uniformity will, however, be of little importance in the present qualitative investigations, as the two stations are not far from each other.

Examining Fig. 2, it will be seen that the parallelism between the two curves to be compared is most striking in the case of 1928 beside 1930, but not generally very conspicuous in the other years.

If we consider, however, that the amount of catch at a certain

convenient measure may be allowed, as long as it reproduces the relative magnitudes of the daily values in their right order of sequence.

As the daily values of y show very irregular fluctuations which depend partly on natural and partly on artificial circumstances, a smoothing procedure was taken in the following manner. Each month was divided into the three parts: 1-10, 11-20 and 21-end of the month. The sum of y 's contained in each of these parts was calculated and plotted as ordinates against the time axis. The result is shown in Fig. 2.

As for the seismic activity to be compared with these fishery data, the materials were exclusively taken from Kisyô-Yoran of the Central Meteorological Observatory, from which we picked out all the "felt" as well as "unfelt" earthquakes originated in a limited area including Idu Province and the Bay of Suruga with its marginal districts. The daily numbers of

fishing ground may depend upon very widely varying circumstances, i. e. not only upon the arrival and presence of a fish-swarm, but also on the fishing activity on the part of fishermen, which are again influenced by many natural and artificial circumstances such as weathers (even earthquakes!), holidays, religious festivals and the like, it will be of no wonder if the statistical correlation here in question may, even if really existing, reveal itself only seldom under a rare combination of favourable circumstances. In view of these considerations, we are warned not to attribute the above coincidence in a few limited number of years too hastily to a mere play of accident, but to pursue the systematic statistical investigations a step further.

For this latter purpose, the following procedure was here taken which seemed relatively simple and still appropriate for the present preliminary stage of research.

At first, the numbers of maxima and minima of the fish curves as well as of the earthquake curves were respectively counted for each of the seven years. In this counting the zero value of the ordinates was counted each time as a minimum, whether it occurs singly between two finite ordinates or it appears repeatedly for a number of successive epochs. The numbers thus counted are shown in Table I.

Table I. Number of Maxima and Minima.

Year	Earthquake		Fish. (H. Mackerel)	
	Max.	Min.	Max.	Min.
1924	7	21	6	20
1925	13	16	9	19
1926	8	18	9	11
1927	8	18	10	15
1928	7	25	7	21
1929	10	23	6	19
1930	5	20	7	22

From these numbers we could calculate the values of the probability of accidental coincidence for different combinations of maxima or minima of one curve with maxima and minima of the other. Thus, denoting by M and m the numbers of maxima and minima respectively and distinguishing the cases for fish and earthquake respectively by the suffixes f and s , we have

For Coincidence of					Probability
I.	Fish	max.	and	Eqk. max.,	$M_f M_s / N^2 = P_1,$
II.	"	min.	"	" min.,	$m_f m_s / N^2 = P_2,$
III.	"	max.	"	" min.,	$M_f m_s / N^2 = P_3,$
IV.	"	min.	"	" max.,	$m_f M_s / N^2 = P_4,$

where N is the number of the points on the time axis, i. e. $3 \times 11 = 33$ in the present case, as January is lacking.

On the other hand, we may count the actual numbers of the four cases I, II, III and IV above mentioned, from the curves of Fig. 2. Dividing these numbers respectively by N we obtain the probabilities Q_1, Q_2, Q_3 and Q_4 in the actual case. If there exists any positive correlation between the two curves to be compared, we may expect that

$$\begin{aligned} Q_1 &> P_1, & Q_2 &> P_2, \\ Q_3 &< P_3, & Q_4 &< P_4. \end{aligned}$$

Table II will show the result of statistics carried out in the manner above described. The asterisk * in the table marks the cases for which the relative magnitudes of P and Q are in favour of a positive correlation such as shown in the above inequalities.

Table II.

Year	P_1	Q_1	P_2	Q_2	P	Q_3	P_4	Q_4
1924	0.039 *	0.182	0.386	0.333	0.129	0.167	0.116 *	0.061
1925	.107	.030	.279 *	.394	.227 *	.181	.132 *	.121
1926	.066 *	.091	.182	.182	.081 *	.000	.149 *	.091
1927	.073 *	.091	.248	.212	.110	.167	.165	.167
1928	.045 *	.061	.482 *	.546	.135 *	.091	.161	.167
1929	.055 *	.061	.401	.394	.175	.182	.127 *	.121
1930	.032 *	.061	.404 *	.455	.101 *	.030	.129 *	.061
Mean	0.059 *	0.081	0.340 *	0.359	0.137 *	0.117	0.139 *	0.113

Thus, for the case I, $Q_1 > P_1$ except for 1925, in which year however II, III and IV show the favourable relations. The year 1930 shows exceptionally favourable relation as already mentioned. Lastly, the mean values of the seven years are all in favour of the positive correlation.

Again, we may calculate the ratios

$$\frac{P_1 + P_2}{P_3 + P_4} \quad \text{and} \quad \frac{Q_1 + Q_2}{Q_3 + Q_4}$$

for comparison. Table III shows the result.

Table III.

	$\frac{P_1 + P_2}{P_3 + P_4}$	$\frac{Q_1 + Q_2}{Q_3 + Q_4}$	
1924	1.74	2.43	*
1925	1.08	1.40	*
1926	1.08	3.00	*
1927	1.17	1.00	
1928	1.68	2.50	*
1929	1.52	1.50	
1930	1.90	2.33	*
Mean	1.45	2.02	*

* marks the year favourable for the positive correlation.

It will be seen that the ratios are generally larger for the actual case than for the case of purely accidental coincidence.

As for the fishes other than horse mackerel, we remarked a rather striking fact that the catch curve for "*mezi*," immature tunny (*Thynnus*) in 1928 shows a striking similarity with horse mackerel curve as well as the earthquake curve. It seems that the parallelism is better if the *mezi* curve be shifted about a month towards the left, i. e. the apparent effect of earthquake upon *mezi* fishery are seen to have taken place with a sensible time-lag. Such a relation is, however, not so conspicuous in the other years. A further investigation on this latter point must be reserved for a future when a more abundant and reliable data are at our disposal.

Though it will be premature to propose anything like an explanation of the relation of which the existence has just been sheerly shown here as probable, it will not be useless to point out different possibilities conceivable in connection with the present problem, especially for the purpose of drawing the attention of oceanographers and biologists in seismic countries, without whose collaborations it will be difficult to pursue the present investigation any further. Firstly, the seismic shocks or

some kinds of mechanical stimuli associated with them may be directly felt by fishes and induce them to approach the fishing ground in some or other ways. Secondly, the shocks may somehow affect the depth of the layers with the greatest density of some planktons edible for the fishes.³⁾ Thirdly, the earthquakes may affect the chemical nature of the coastal sea water due to the disturbance of the subterranean water and thus indirectly affect the planktons or fishes. These possibilities could be tested by observations, or by some experiments, if desired. The present result seems at least to encourage than to discourage these kinds of observations or experiments on the sides of marine biologists engaged with the investigation of scientific problems of fisheries.

26. 地震と漁獲との関係

地震研究所 寺田寅彦

駿河湾北端にある漁場の漁獲高の日々の變化と、伊豆及駿河湾附近に於ける地震の日々頻度の變化との間の關係を調べた。先づ昭和五年の伊豆に於ける群起地震の日々頻度と、重寺漁場に於ける鰯の漁獲高と比べて見ると著しい相關のある事が認められる。次に 1924-1929 の六年間につきては淡嶋漁場の漁獲、1930 に就ては上記重寺漁場の漁獲を採り、一ヶ月を三分した其各部分に於ける地震回数と漁獲との間の關係を調べて見た。其方法としては先づ地震の曲線と漁獲の曲線との最高及最低の数を数へ、それからして、地震と漁獲とが無關係な場合に於ける兩曲線最高最低の重なる確率を計算し、それを實際に兩者の重なつて居る比率と對照した。其結果は兩者が全く無關係でなく互に正の相關をもつて居るらしいといふことになつた。此關係は昭和三年、同五年には著しく明瞭であるが年によつては明瞭でない。併し七年間の平均から云へば矢張多少の正相關があると認めなければならない。鰯の外ではメジが矢張多少の關係を示すやうであるが、此に就ては更に研究をしなければ確かな事は云はれない。

此論文に用ゐた漁獲高の材料は水産試験場技師木村喜之助君の好意によつて手に入れる事が出来たものである。茲に同君に對する感謝の意を表する。

3) Dr. K. Tago who was collecting planktons at the mouth of the Bay of Tôkyô on the very morning of Sept. 1, 1923, i. e. the day of the Great Kwantô Earthquake, observed an unusual abundance of planktons in the surface layer combined with the scantiness of them in the middle layer. At the same time, an unusual swarm of *Katuwa* was observed and caught in the vicinity of Okinosima where such thing occurs quite rarely, *Kwagaku-Tisiki*, 3 (1923), No. 11; *Tigakuzassu*, 36 (1923), No. 420.