STUDIES ON YOSA-NAIKAI

2. CONSIDERATIONS UPON THE RANGE OF THE STAGNATION AND THE INFLUENCES BY THE RIVER NODA AND THE OPEN SEA.*

By

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Yosa-Naikai is a lagoon separated from Miyazu Bay by a sand bar which is known as Amanohashidate. The river Noda flows into the lagoon at the southwestern part and two narrow channels connect the lagoon with the open sea, at the southeastern corner. It is said recently that the fish catch has decreased much because of the higher stagnation of the lagoon water caused by the narrowing of the channels due to the drift sand. Thus, it becomes highly desirable to estimate the range of the strong stagnation of the lagoon water and the influences of the river Noda and the open sea on this lagoon.

In the followings I want to report the results of the survey during 10 to 12 of May 1950 and give some considerations upon them.

Before going further I must express my hearty thanks to Prof. Dr. D. MIYADI (Kyôto University) for his kind guidance, and also to Dr. T. TOKIOKA and Mr. T. HABE for their kind advices and to Mr. S. IKINAGA who helped me much during the survey.

RESULTS

Observations were made at the same stations (Fig. 1) as adopted by Mr. T. HABE during his survey on the 4th of April 1945, by the same methods as shown in my previous report.

The temperature of the surface water varies considerably according to the station. But, in the water deeper than 2 m, the horizontal change of the temperature is not conspicuous.

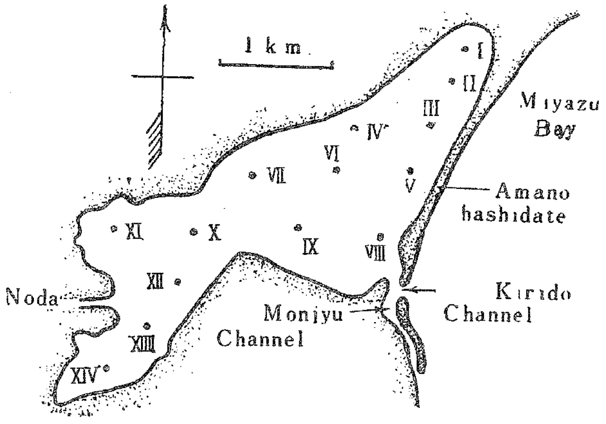

Fig. 1. The sketch map of Yosa-Naikai. Roman numbers indicate the position of stations.

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Table 1. Oceanographical conditions of Yosa—Naikai (May 10—12, 1950).

Station number	Depth of station (m)	Transparency (m)	Depth of sample (m)	Water temp. (°C)	Chlorinity (‰)	Satur. percentage of dissol. O_2	pH	Silicate—Si (γ/L)	Phosphate—P (γ/L)	Bottom character	Mud temp. (°C)	Settling vol. of plankton (cc/L)
II	9.5	5.7	0	16.1	11.12	98.3	8.6	1910	Trace	Black ooze grayish blue surrace	13.7	1.0
			3	18.2	15.53	108.8	8.6	620	17.5			1.1
			6	16.4	15.98	91.0	8.3	1280	51.1			0.8
			9	14.4	16.42	4.8	7.9	1930	105.7			0.15
III	12.9	5.5	0	18.0	11.20	99.5	8.4	1740	22.9	Black ooze grayish blue surface	14.0	0.3
			5	17.5	15.83	111.5	8.4	960	37.6			1.1
			10	14.5	16.13	79.7	8.0	2600	100.7			0.1
			12	14.5	16.42	5.6	8.0	3320	77.1			0.1
V	12.7	6.0	0	16.6	10.75	109.0	8.6	1660	10.3	Black ooze grayish blue surface	14.0	0.2
			3	17.9	15.68	110.7	8.6	670	26.8			0.6
			6	16.3	16.27	94.9	8.5	900	42.5			0.1
			9	14.6	16.42	7.4	7.8	1820	90.6			0.1
			12	14.4	16.72	18.4	8.0	1170	60.8			0.1
VI	12.2	6.7	0	18.7	11.94	95.2	8.5	1980	21.6	Black ooze	14.6	0.4
			2	19.0	14.63	104.1	8.6	1220	29.3			1.9
			4	17.5	16.13	102.2	8.5	1160	30.1			1.1
			6	16.0	16.27	48.0	8.3	1050	56.9			1.2
			8	15.3	16.42	10.3	7.9	1670	65.0			0.2
			10	14.5	16.42	0.0	7.8	1740	121.6			0.2
			12	14.2	16.42	0.0	7.8	1790	144.0			0.1
VII	12.3	5.5	0	19.0	10.90	99.7	8.4	1850	17.5	Black ooze	14.0	0.2
			6	16.5	16.13	69.4	8.4	1090	52.1			0.3
			11	14.7	16.42	0.5	7.9	2070	122.9			0.1
VIII	12.7	6.0	0	18.0	10.75	110.9	8.4	2220	11.4	Black ooze brown surface	14.0	0.8
			3	17.8	15.38	106.2	8.4	1000	22.4			0.3
			6	17.0	16.57	81.7	8.3	640	30.7			0.5
			9	16.0	16.57	35.5	8.1	1930	83.1			0.2
			12	14.6	16.87	8.5	7.8	1640	11.4			0.1
IX	13.0	6.0	0	18.5	10.60	102.2	8.3	2100	Trace	Black ooze	14.5	0.4
			3	18.7	15.68	114.7	8.3	850	29.0			1.0
			6	17.0	16.27	102.6	8.3	980	35.4			0.3
			9	15.0	16.57	12.8	7.9	1600	106.2			0.2
			12	15.0	—	—	—	—	—			0.1
XI	9.0	4.5	0	19.7	6.87	97.1	8.3	3330	23.3	Black ooze gray surface	14.5	0.1
			5	17.5	15.83	110.6	8.5	900	38.7			0.4
			8.5	15.5	16.13	0.0	7.8	1970	133.1			0.3
XII	7.5	4.5	0	18.0	0.60	91.9	7.7	5150	34.0	Black ooze	14.8	0.3
			2	19.0	14.93	95.7	8.5	1290	34.3			1.0
			4	18.5	15.98	107.2	8.5	940	50.8			2.7
			6.5	16.0	16.13	59.1	8.3	1400	76.5			0.7
XIII	6.3	5.5	0	19.0	7.61	96.1	8.3	3100	17.9	Black ooze brown surface	16.0	0.2
			3	18.8	15.23	107.9	8.4	980	30.0			0.8
			5.5	16.7	15.68	67.6	8.3	1450	45.5			0.8
XIV	5.8	4.0	0	17.0	2.69	97.0	7.9	4990	23.8	Black ooze	16.5	0.2
			2	19.8	14.48	104.2	8.5	1360	20.2			0.7
			5	17.0	15.08	81.8	8.3	990	45.3			

Table 2. Composition of thanatocoenosis in Yosa-Naiakai (May 10–12, 1950). (1/0.02m²)

Station number		II	III	V	VI	VII	VIII	IX	XI	XII	XIII	XIV
Depth of fhe station (m)		9.5	12.9	12.7	12.2	12.3	12.7	13.0	9.0	7.5	6.3	5.8
Lamellibranchia												
Anadara subcrenata (LISCHKE)							2				1	
Brachidontes senhousia (BENSON)		1								8		1
Fulvia hungerfordi (SOWERBY)				1		1	2	1			3	
F muticam (REEVE)							3					
Dosinia japonica (REEVE)											2	
Venerupis semidecussata (REEVE)						1		2			1	
Raeta yokohamaensis PILSBRY				1	5	1	3	3			2	5
Theora lubrica GOULD		17	10	54	26	42	202	131	25	1	110	86
Mya japonica JAY						2						
GastropoPa												
Cipangopaludina malleata (REEVE)							1					
Fulviocingula nipponica KURODA							4				2	
Stenothyra iyadii KURODA											1	
Cingula matumsisna NOMURA												1
Diala vitres SOWERBY				1			2					
D. varia A.ADASMS						1						
Cerithmiu sp.											1	
Pyramidellidae					1							
Odostomia sp.											1	
Nassarius japonica (A.ADAMS)							1					
Ringicula doliaris GOULD											2	
Retusa minima YAMAKAWA												1
Philline japonica LISCHKE							1					1
Total	Number of valves	18	10	57	32	48	221	137	25	9	126	95
	Number of species	2	1	4	3	6	10	4	1	2	11	6

The layer of the maximum temperature is observed near the surface, as found in the 1950's observation(March 19); the temperature decreases towards both deeper and shallower layers. The mud temperature is slightly lower than that of the bottom water.

Chlorinity increases suddenly in a shallower layer. Below this layer its increase becomes very slow.

Phosphate shows a gradual increase with the depth. Silicate increases towards both shallower and deeper layers from the middle layer where it shows the minimum values. The dissolved oxygen decreases suddenly in the range from 6 to 9 m ; in the deeper water than that layer, the oxygen shows much lower values.

CONSIDERATION UPON THE OCEANOGRAPHICAL CONDITIONS

In stagnant water, phosphate and silicate increase with depth, on the contrary dissolved oxygen decreases with depth and the value of pH also becomes lower towards the bottom. On these facts, it may be possible to presume the vertical position of the border layer of the stagnant by pursuing a conspicuous change in each of those four factors. Here, I take up the two time or more increase of phosphate and silicate, decrease of saturation percentage of dissolved oxygen below a half value and the fall of pH value more than 0.4 as indicators of the chemocline, the depth of which may be determined by the presence of conspicuous changes in more than three of these four factors in the same layer. The layer shallower than the chemocline layer may be considered as the upper layer, while the deeper layer than the chemocline layer may be called as the stagnant layer.

Table 3. Determination of the depth of the chemocline.

Station	II	III	V	VI	VII	VIII	IX	XI	XII	XIII	XIV
Dissol. oxygen decreasing interval	6—9	10—12	6—9	4—6 6—8 8—10	6—B	6—9 9—12	6—9	5—B	4—6	—	—
Phosphate increasing interval	0—3 3—6 6—9	5—10	0—3 6—9	—	0—6 6—B	6—9	6—9	5—B	—	—	2—B
Silicate increasing interval	3—6	5—10	6—9	—	—	6—9	—	5—B	—	—	—
pH value falling interval	6—9	5—10	6—9	6—8	6—B	9—12	6—9	5—B	—	—	—
Frequency of various water layers playing as a "cline" interval	0—3:1 3—6:2 6—9:3	5-10:3 10-12:1	0—3:1 6—9:4	4—6:1 6—8:2 8-10:1	0—6:1 6—B:3	6—9:3 9-12:2	6—9:3	5—B:4	4—6:1	—	2—B:1

Dissolved oxygen decreasing interval shows the interval where the saturation percentage of dissolved oxygen decreases $^1/_2$ or more of the value.
Phosphate increasing interval shows the interval where the concentration of phosphate increases more than two times of the value.
Silicate increasing interval shows the interval where the concentration of silicate increases more than two times of the value.
pH value falling interval shows the interval where the pH value shows the decrease more than 0.4.
The interval is regarded as the chemocline when three or more of four factors show the changes in the range described above.
At St. VI, the interval 6—8m can be regarded as the chemocline.

There are two water masses pouring into this lagoon from other water systems, namely the water from the river Noda and that from the open sea, that is, Miyazu Bay. On the fact that the water affected by river(brackish layer)is poor in chlorine, while it is rich in silicate, the boundary between the brackish layer and the upper layer of the lagoon is defined at the depth, for convenience' sake, where the difference of chlorinity becomes more than 5‰ and silicate increases in the shallower part. The water of Miyazu Bay (**Miyazu Bay water layer**) is characterized by higher saturation degree of dissolved oxygen and lower concentration of both silicate and phosphate than in the stagnant water of the lagoon. Thus, it is possible to settle the boundary between the stagnant water of the lagoon and Miyazu Bay water layer at the zone where more than two of these factors change at the same time, if we take up the increase of dissolved oxygen and the decrease of silicate and phosphate near the bottom as indicators of the existence of Miyazu

Table 4. Determination of the boundary of the brackish layer.

Station	II	III	V	VI	VII	VIII	IX	XI	XII	XIII	XIV
Halocline	0—3	0—5	0—3	0—2	0—6	0—3	0—3	0—3	0—2	0—3	0—2
Silicate concentration reversing interval	0—3	0—5	0—3	0—2 2—4 4—6	0—6	0—3 3—6	0—3	0—3	0—2 2—4	0—3	0—2 2—B
Frequency of various water layers playing as a "cline" interval	0—3: 2	0—5: 2	0—3: 2	0—2: 2 2—4: 1 4—6: 1	0—6: 2	0—3: 2 3—6: 1	0—3: 2	0—3: 2	0—2: 2 2—4: 1	0—3: 2	0—2: 2 2—B: 1
Boundary between the brackish layer and the upper layer	0—3	0—5	0—3	0—2	0—6	0—3	0—3	0—3	0—2	0—3	0—2

Halocline means the interval where the chlorinity shows the change larger than 5‰.
Silicate concentration reversing interval is the interval where the concentration of silicate of the shallower layer is higher than that of the deeper layer.

Table 5. Determination of the boundary of the Miyazu Bay water layer.

Station	II	III	V	VI	VII	VIII	IX	XI	XII	XIII	XIV
Phosphate reversing interval	—	10—12	9—12	—	—	9—12		—	—	—	0—2
Silicate reversing interval	—	—	9—12	—	—	9—12		—	—	—	—
Oxygen reversing interval	—	—	9—12	—	—	—		—	—	—	—
Frequency of various water layers playing as a "cline" interval	—	10-12: 1	9-12: 3	—	—	9-12: 2		—	—	—	0—2: 1
Boundary beween the stagnant layer and the Miyazu Bay water layer	—	—	9—12	—	—	9—12	*9—12	—	—	—	—

Phosphate reversing interval is the interval where the concentration of phosphate of the deeper layer is smaller than that of the shallower water.
Silicate reversing interval is defined as in the case of phosphate reversing interval.
Oxygen reversing interval is the interval where the saturation percentage of the dissolved oxygen of the deeper layer is higher than that of the shallower layer.
The interval is regarded as the boundary when more than two of three factors show the change defined above.
*Considering other factors, the interval 9 — 12m at St. IX is regarded as the boundary.

Bay water layer.

Examining the data on the criterion mentioned above, I have come to the conclusion that the brackish layer streches over the whole surface of the lagoon in a layer thinner than 2 m, the upper layer of the lagoon is found under the brackish layer and extending to the depth of *ca.* 6 m, the layer from 6 m to 9 m is the chemocline, the stagnant layer occupies the deeper water than the chemocline, and Miyazu Bay water layer streches along the bottom near St. V, St. VIII and St. IX.

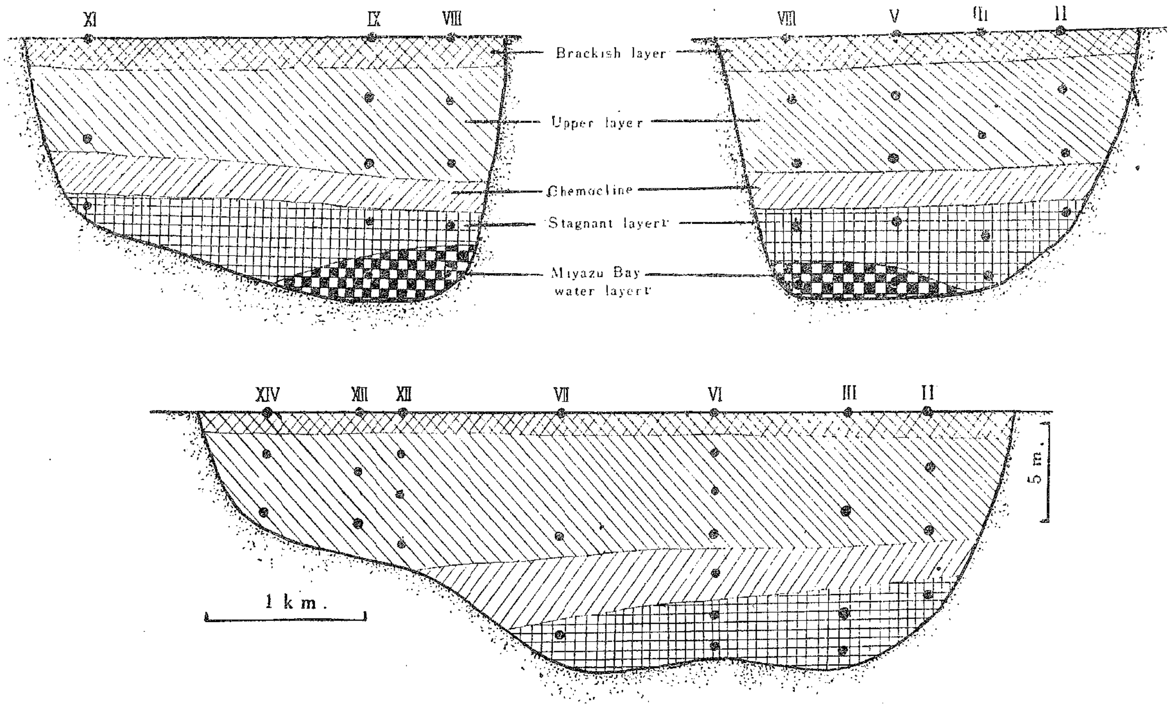

Fig. 2. The vertical sections of Yosa-Naikai.

RELATONS BETWEEN THE LIVING ORGANISMS AND THE OCEANOGRAPHICAL CONDITIONS

1) Relation between the benthos and the oceanographical conditions.

As the only living benthos, *Prionospio* ($11/0.02m^2$) was found at St. XIII. Any definite relation between the number of dead shell valves and the saturation percentage of dissolved oxygen in the bottom water at each station cannot be established. Then, I compared the mean numbers of dead shell valves in the areas covered by respective water layers, mentioned above, in a hope to find a relation between the characteristics of each water layer and the mean number of dead shell valves, but in vain, because the differerences found among the mean numbers of dead shell valves were regarded as insignificant comparing with the deviations in each group (at 0.05 level of signifcance).

Table 6. Mean number of dead shell valves on the bottom of each water layer (1/0.02m²).

	Mean number	Size of sample	Station number
Bottom of the upper layer	76.7	3	XII, XII, XV
Bottom of the stagnant layer	26.6	5	II, III, VI, VII, XI
Bottom of the Miyazu Bay water layer	138.3	3	V, VIII, IX

2) **Relation between the settling volume of plankton and oceanographical conditions.**

A liter of sea water was collected from each station where the chemical analysis of water was performed, and filtered by silk plankton net till the water sample was concentrated 10 c.c. The settling volume of plankton was measured after 24 hrs. on those concentrated samples. Supposing that the distribution of the settling volume of plankton samples taken from the area belonging to the same water layer is regarded as a normal distribution, THOMPSON' s method for rejection was applied at 0.05 level of significance to reject abnormal values out of the samples from respective water layers. Thus, values of 1.0 (St. II) and 0.8 (St. VIII) in the brackish layer samples, 2.7 (St. XII−4 m) and 1.9 (St. VI−2 m) in the upper layer samples, and 0.3 (St. XI−Bottom) in the stagnant water layer samples are found to be rejected from each group of samples. Mean settling volume in each water layer is shown in Table 7; differences among these values are considered to be significant comparing with the variations in each group (at 0.05 level of significance). Then, the settling volume of plankton is the greatest in the upper layer and decreases with the distance from that layer.

Table 7. Settling volume of plankton after 24 hrs in each layer (cc/L).

	Mean volume	Size of sample
Brackish layer	0.26	9
Upper layer	0.69	18
(Chemocline)	(0.2)	(1)
Stagnant layer	0.14	9
Miyazu Bay water layer	0.1	3

SUMMARY

1. The results of the observations in Yosa-Naikai during 10－12 of May 1950 are shown in Tables 1 and 2.

2. The lagoon water is divided into three layers: the chemocline situated at 6－9 m depth, where the water changes suddenly in several characteristics, the upper layer above the chemocline and the stagnant layer under the chemocline.

3. There are two water masses running into the lagoon from other water systems: the river water (brackish layer) streching over the whole surface of the lagoon in the layer thinner than 2 m, and the open sea water (Miyazu Bsy water layer) laying on the bottom near St. V, St. VIII and St. IX.

4. The differences among the mean numbers of the dead shell valves in areas covered by respective water layers can not be regarded as significant at 0.05 level of significance.

5. The settling volume of plankton is the greatest in the upper layer and decreases with the distance from that layer.

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