STUDIES ON *ISOYAKE* OR "DECREASE OF SEAWEEDS" ALONG THE COAST OF NORTHERN JAPAN.

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INTRODUCTION

Recently, at various places along the coast of Aomori Prefecture and southern Hokkaido, especially in Higashitsugaru-gun and Shimokita-gun facing the Tsugaru Straits and at a part in Nishitsugaru-gun facing the Japan Sea, respectively in Aomori Prefecture, and in Kayabe-gun in Hokkaido, useful algae such as *Laminaria japonica, Undaria pinnatifida* etc. have been severely decreasing in quantity, and abalones also are markedly decreasing in amount. Therefore, increased attention has been paid to the phenomena concerning *Isoyake* or "Decrease of seaweeds".

In order to investigate the condition of *Isoyake* and to study the marine flora from the point of ecology, the writer visited Higashitsugaru-gun and Shimokita-gun in August 1949 and again Shimokita-gun and Nishitsugaru-gun during July and August 1950 and Kayabe-gun in December 1950.

With the exception of Shimokita-gun, precise investigations at the above-named places have been reserved for future study, because of insufficient time for an exacting investigation. The present report, therefore, is concerned chiefly with Shimokita-gun.

Before going further, the writer wishes to express his gratitude to Mr. T. Takehana, Chief of the Ōhata Branch of Aomori Fisheries Experimental Station, for his kind assistance in the conduct of this study.

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OBSERVATION

General condition along the coast of the investigated district.

In former times, the district along the coast of Mimmaya Bay, from Ippongi-mura to Cape Tappi was noted as the home habitat of Mimmaya-kombu or *Laminaria japonica*. In about 1923, ca.200,000 kan (1 kan=3.75 kgs.) of *Laminaria japonica* and considerable amount of *Undaria pinnatifida*, *Kjellmaniella crassifolia* and *Gelidium Amansii* etc. were yielded there, but since then the yield of *Laminaria japonica* has been diminishing, especially markedly since 1943. We can recognize its decline from the table1.

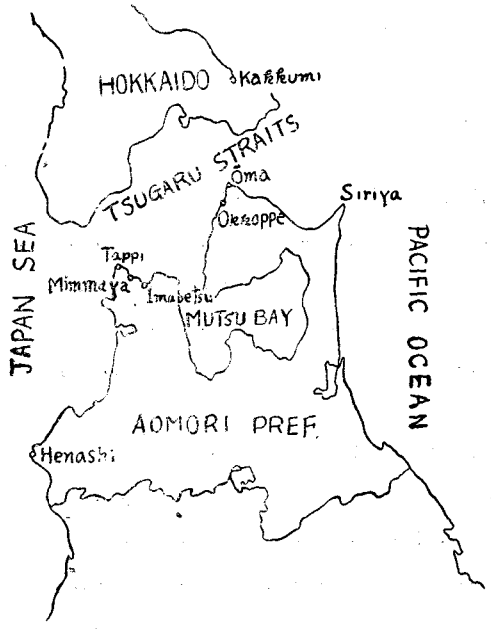

Fig. 1. Map of the Tsugaru Straits showing *"Isoyake"* region.

Table 1. Yield of *Laminaria japonica* at Mimmaya.[1]

Year	Weight in kan	Remarks
1943	47,100	Data before 1943 are unknown.
-44	879	
-45	6,784	
-46	14,000	
-47	7,780	
-48	3,700	
-49	24,000	

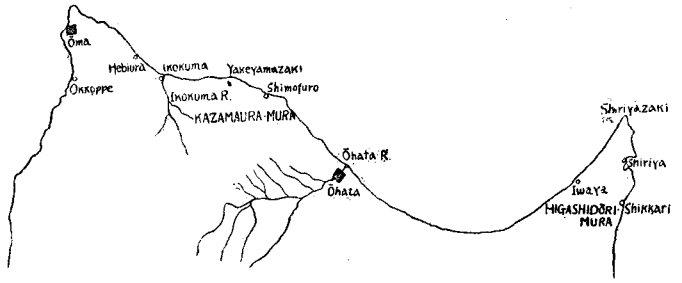

Fig. 2. Map of Shimokita District, Aomori Prefecture.

Since 1939, the yield of abalones has been diminishing and as a consequence causing a severe reduction of *Laminaria*. Only about 1 % of the output of former times now is being produced for household use. In this district *Sargassum Thunbergii* is found at the highest degree of luxuriancy of all algae. On the other hand, such useful algae as *Nemacystus decipiens*, *Hijikia fusiforme*, *porphyra sp.*, *Gelidium Amansii*, *G. vagum*, *Rhodoglossum pulchrum*,

1. According to statistics furnished by Mimmaya Fisheries Association.

Grateloupia Okamurai, Ceramium rubrum, C. Boydenii and *Campylaephora hypnaeoides* are found in poor development, and calcareous red algae belonging to family *Corallinaceae* are covering the substrata. *Phyllospadix iwatensis* similarly is found in abundance here and there.

At Henashi, Fukaura-machi, Nishitsugaru-gun, *Undaria pinnatifida* diminished in amount, so the rocky bottom at the depth of 3–4–3 fathoms is covered by thick coralline algae.

In Shimokita District, *Laminaria japonica* likewise has diminished remarkably. About 360 m. off the beach along the coast of Shimofuro, Kuwahata, Ikokuma and from Tsubana-zaki to Tarumi River at Hebiura and at a part of Ōma-machi, in zones deeper than five fathoms, *Laminaria japonica, Gelidium Amansii* and *Pachymenia carnosa* occurred profusely before but now are very poor in quantity. The deeper the depth, the more remarkable the degree of decrease in growth.

At the high-tide mark in an exposed area, no tendency toward reduction of algae can be recognized. For instance, at Shimofuro *Laminaria*-grounds are found only in zones at two to three fathoms deep near the water-breaker in the harbour. In spite of the remarkable decreases in *Laminaria, Undaria, Alaria* and *Rhodoglossum* there is none in *Porphyra, Gloiopeltis* and *Chondrus.*

Therefore, the general condition of the Shimokita coast shows that much damage has been inflicted on algae growing in a lower zone, with no damage discernable on algae growing at the high-tide mark. An additional condition indicates that such algae as *Rhodoglossum* and *Laminaria* growing in colder currents are decreasing, but such as *Hijikia, Sargassum Thunbergii* growing in warmer currents and some of the cold water algae like *Pelvetia* and *Rhodoglossum* show no damage.

I. Algae found in Shimokita District are arranged in order from upper zones to lower ones.

A. Growing in the littoral zone.

Porphyra sp.
Gloiopeltis furcata Post. et Rupr.
Ulva pertusa kjellm.
Enteromorpha intestinalis (L.) Link
Chaetomorpha Linum (Muell.) Kuetz.
Cladophora densa Harv.
C. utriculosa Kuetz.
Gigartina intermedia Sur.
Gracilaria confervoides (L.) Grev.
Hijikia fusiforme (Harv.) Okam.
Caulacanthus Okamurai Yamada
Pelvetia Wrightii (Harv.) Yendo
Rhodomela Larix (Turn.) C. Ag.
Sargassum Thunbergii (Mert.) O. Kuntze
Heterochordaria abietina (Rupr.) Set. et Gard.
Gymnogongrus flabelliformis Harv.
Pachymenia carnosa J. Ag.

Grateloupia filicina (Wulf.) Ag.
G. divaricata Okam.
G. Okamurai Yamada
Hydroclathrus clathratus (Bory) Howe
Lomentaria catenata Harv.
Bryopsis hypnoides Lamx.
Carpopeltis flabellata (Holm.) Okam.
Coccophora Langsdorfii (Turn.) Grev.
Chondria dasyphylla (Woodw.) C. Ag.
Symphyocladia latiuscula (Harv.) Yamada
Gigartina unalaskensis Rupr.
Neodilsea Yendoana Tokida
Chondrus ocellatus Holmes

B. Growing under the littoral zone.

Chondrus pinnulatus (Harv.) Okam.
Grateloupia turuturu Yamada
Rhodoglossum pulchrum (Kuetz) S. et G
Acrosorium Yendoi Yamada
Sargassum confusum Ag.
Cystophyllum hakodatense Yendo
Campylaephora hypnaeoides J. Ag.
Sargassum Horneri (Turn.) C. Ag.
Codium fragile (Sur.) Hariot
Gelidium Amansii Lamx.
G. subfastigiatum Okam.
G. vagum Okam.
Pterocladia tenuis Okam.
Laminaria japonica Aresch.
Kjellmaniella crassifolia Miyabe
Undaria pinnatifida (Harv.) Sur.
Costaria costata (Turn.) Saund.
Alaria crassifolia Kjellm.

C. Coralline algae which destroy *Laminaria*-grounds are as follows: ——
Order *Cryptonemiales*
Family *Corallinaceae*

Lithothamnion japonicum Fosl.
★ *L. fretense* Fosl.
★ *Dermatolithon sp.*
Lithophyllum Okamurai Fosl.
L. Yendoi Fosl.
★ *L. sp.*
★ *Porolithon sp.*
Amphiroa sp.
Cheilosporum yessoense Yendo
★ *C. anceps* Yendo
Corallina officinalis L.
C. pilulifera P. et R.

★ Identified by Dr. S. Segawa, to whom the writer wishes to express his best thanks.

II. General aspect of yield of useful algae.

Table 2. Yield of *Laminaria japonica* in Aomori Prefecture.[2]

Year	Weight in kan (1kan=3.75kgs.)	Year	Weight in kan (1kan=3.75kgs.)	Year	Weight in kan (1kan=3.75kgs.)
1884	42,158	1906	932,413	1928	810,636
-85	unknown	-07	334,649	-29	1,973,358
-86	unknown	-08	375,431	-30	1,178,818
-87	46,000	-09	125,931	-31	1,736,237
-88	unknown	-10	161,923	-32	1,228,015
-89	155,470	-11	189,400	-33	1,182,336
-90	150,688	-12	123,050	-34	1,866,125
-91	75,022	-13	344,380	-35	1,605,036
-92	219,669	-14	169,920	-36	765,121
-93	205,658	-15	199,465	-37	1,808,740
-94	221,316	-16	358,490	-38	1,132,860
-95	112,171	-17	508,751	-39	2,572,047
-96	227,150	-18	512,200	-40	1,622,111
-97	236,900	-19	626,511	-41	785,231
-98	175,350	-20	435,796	-42	477,413
-99	1,022,080	-21	359,230	-43	447,403
1900	181,704	-22	377,648	-44	605,638
-01	245,285	-23	521,756	-45	170,000
-02	252,499	-24	854,120	-46	936,335
-03	156,978	-25	815,770	-47	512,480
-04	317,679	-26	726,174	-48	1,673,783
-05	329,236	-27	1,858,885		

III. Yield of Useful Algae in Shimokita District.[3]

Table 3-A. OKKOPPE (Weight in kan)

Year	*Laminaria*	Year	*Laminaria*
1936	21,333	1944	106,958
-37	85,961	-45	1,680
-38	4,915	-46	87,875
-39	86,856	-47	12,682
-40	125,228	-48	33,878
-41	74,044	-49	98,000
-42	96,974	-50	48,000
-43	39,954		

Table 3-B. HEBIURA

Year	*Laminaria*	*Gloiopeltis*	*Undaria*	*Hijikia*	*Pachymenia*
1945	14,200	1,400	8,300	—	620
-46	17,000	1,200	6,200	8,600	500
-47	—	2,260	7,500	3,600	—
-48	500	2,800	6,200	4,500	—
-49	1,008	3,000	4,200	—	300
-50	3,500	3,000	5,000	—	350

DISCUSSION

According to Okamura's description on "Decrease of seaweeds" in Shimokita District[4], the oldest phenomenon took place about 1830. He mentions that algae were totally destroyed at that time, and fishermen without necessary equipment could easily catch abalones creeping on the beach because of lack

2. By the Statistics of Agriculture and Forestry.

3. Available statistics from various local fisheries associations in each area.

4. Okamura, K. (1915): Investigation on "Isoyake" in Shimokita-gun, Aomori Prefecture. (In Japanese). Aomori Prefectural Office.

Table 3-C. IKOKUMA

Year	*Laminaria*	*Gloiopeltis*	*Undaria*	*Rhodoglossum*	*Pachymenia*
1947	4,096	2,163	5,526	616	454
-48	4,345	2,169	5,276	494	740
-49	64	2,553	963	818	992
-50	——	2,430	2,540	520	400

Table 3-D. SHIMOFURO

Year	*Laminaria*	*Gloiopeltis*	*Undaria*
1945	103	1,788	——
-46	344	2,568	4,110
-47	296	2,586	5,660
-48	100	2,664	3,579
-49	——	2,899	2,035
-50	——	2,652	4,720

Table 3-E. IWAYA

Year	*Laminaria*	*Gloiopeltis*	*Undaria*
1947	——	2,200	3,600
-48	6,500	3,500	800
-49	——	3,738	160
-50	7,000	3,050	3,140

of food. Thereafter, remarkable decreases of seaweeds also took place in 1895, 1902 and from 1909 to 1915.

Generally speaking, we can cite natural causes and artificial ones for the decrease of algae. The former are due mainly to the change of currents and the latter are chiefly due to floods originating from disforestation at head-waters.

In the latter event it happens that as the quality of the water and the condition of the substrata are changed the algae are covered directly by mud and soon die.

According to Imabetsu fishermen, propagation of *Laminaria* at Imabetsu-mura along the coast of Mimmaya Bay has been disturbed by the minute chips of wood discharged from a wood mill lately built at the estuary of Imabetsu River.

In Shimokita District, volcanic ashes drifted and heaped up in layers upon the sea-bottom at less than 14–15 fathoms during the eruption of Mt. Komagadake in June 1929. The volcanic pile was the largest between Ōma and Shikkari. At Hebiura it piled up 1 m. At Iwaya and Shiriya, Higashidōri-mura, it also heaped up heavily. Thus *Laminaria*-grounds were destroyed and coralline algae increased in luxuriancy taking the place of *Laminaria*.

Adding another point of information, people say that at Shimofuro hamlet in Kazamaura-mura muddy waters stayed a fortnight approximately 2 miles off the shore because of the overflowing of Shimofuro River caused by heavy rainfall in September 1937. As mud piled heavily on the water bottoms, the depth became shallower and thus *Laminaria* rapidly decreased in quantity.

When we look over the current in the Tsugaru Straits in order to examine the above mentioned facts, one finds that the warmer current flowing northward in the Japan Sea weakens its influence at the tip of Cape Tappi, Aomori Prefecture, and divides into two streams in the neighbourhood of Islands Ōshima and Kojima lying in Province Oshima, Hokkaido. The main current moves northward along the coast of the Japan Sea; and the branch enters eastward into the Tsugaru

Straits. The latter again divides into two, one flowing from Ōma-zaki to Cape Shiriya and the other along the shore of Shimokita District. The last one partially flows backward to Ōma-zaki through Ikokuma and Hebiura touching against Yakeyama-zaki, then partially flowing towards Cape Shiriya and again back to Ōhata. By the influence of these currents, Ikokuma River and other streams sometimes run from Hebiura to Ōma, while at other times they take the contrary direction towards Cape Shiriya.

In both cases, however, the writer is convinced that they do not strongly influence the algae vegetal growth in view of their feeble capacity.

When the writer visited Kakkumi Fisheries Association, Province Oshima, Hokkaido in December 1950 for the purpose of examining the condition of the grounds exploded in November 1949, he was acquainted with the splendid results showing large increase in reproduction of algae. The new substrata made by explosion with dynamite were covered with far richer young fronds of *Laminaria* than in other places as shown in the accompanying table.

The growth frequency of young *Laminaria* fronds per one irregularly polygonal rock splinter, ca. 27–45 cm. diam. is as Table 4:—

Table. 4

Number of fronds	Number of rock splinter	Remarks
0– 5	16	Average number of fronds attaching on a rock splinter of the substrata left as they were before is less than 3.
6–10	23	
11–15	6	
16–20	6	
21–25	3	
26–28	2	
Average 9.7	Total 56	

Since shore-waves beat with considerable power at right angles upon the bottom where the depth of water is shallower than 7–8 fathoms, the setting down of rocks and stones to improve the propagation of algae can hardly be expected to give remarkable effects since the rocks and stones are often buried under the sand if they are placed down between the two long blocks of rock surrounded by sand lying at right angles to the shore as shown in Fig. 3. A. They should thus be arranged between two blocks of rock parallel with the shore (as shown in Fig. 3. B.) to prevent being buried under the sand.

CONCLUSION

The results obtained from the writer's investigation are as follows:—

1. The decrease of seaweeds along the coast of Aomori Prefecture is directly attributable to the fact that volcanic ashes from the eruption of Mt. Komagadake in 1929, drifted and heaped upon the water bottoms where *Laminaria* and other

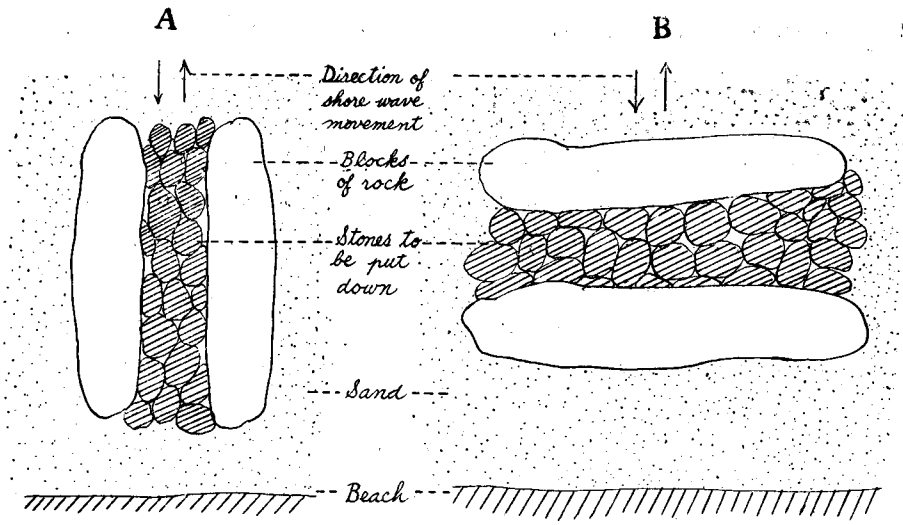

Fig. 3. Diagram illustrating the relation between the arrangement of blocks of rock and stones to be put down.
A. Ineffective arrangement.
B. Recommended arrangement.

useful algae were growing in abundance thus causing the destruction of the algal vegetation.

This is deduced from the following two facts:—

1. The normal growth of such high-tide mark algae as *Gloiopeltis furcata* remained unaffected.

2. The volcanic ashes that had drifted on the shore were carried about 200 to 300 m. away from the high hide mark by the wave action then sank to the bottom, where white-colored deposits may be observed.

II. Resulting from a predominance of warm current, the algae of the colder currents, such as *Laminaria* and *Alaria* not only received a setback in their propagation, but also, and contrary to it, coralline algae, the original inhabitants of the warmer currents were quickened to vegetate.

III. The writer is not convinced that the present phenomenon under concern is a temporary one owing to changes in the quality of water, for the same phenomenon is recognizable along the coast of Kameda-gun, Kayabe-gun and Matsumae-gun, all in the Province of Oshima in Hokkaido at the opposite side of the Tsugaru Straits where there are no large rivers which seem to affect the quality of the adjacent sea-water. A similar condition obtains related to the rivers in Shimokita District in Aomori Prefecture.

IV. Taking adequate measures to meet the decrease of algae should be based upon the ecological study on coralline algae, which are harmful to *Laminaria*, especially

in clarifying their fructifying season.

V. Of the methods now well-established to overcome the decrease of useful algae and to improve their propagation__i. e., 1. raking away obstructions from substrata; 2. exploding them with dynamite; and 3. setting sea-bottoms with rocks and stones to be attached to by algae__the one that the writer has found most effetive is the explosion of obstructions on the sea-bottoms. This one is recommended on the basis of examination findings, especially for large-scale operations.

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(3) —— (1903): "Isoyake" in the Prefecture of Chiba. (in Japanese) ibid., pp. 34–38.

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