Nat. Hist. Res., Special Issue No. 3: 97–109. March 1997.

Existing Conditions and Problems on Nori (*Porphyra*) Cultivation at the Coast of Chiba Prefecture in Tokyo Bay

Taneo Tanaka[1], Jun Kakino[1] and Masahiko Miyata[2]

[1] Chiba Prefectural Fisheries Experiment Station, Futtsu
3091 Kokubo, Futtsu-shi, Chiba 293, Japan
[2] Natural History Museum and Institute, Chiba
955–2 Aoba-cho, Chuo-ku, Chiba 260, Japan

Abstract Nori (*Porphyra*) cultivation have been curtailed due to diminished dry beach areas in Tokyo Bay during post World War II high economic growth period in Japan, and Nori cultivation is presently maintained only at three regions; Ichikawa-Funabashi, Kisarazu and Futtsu. However, volume and value of Nori production in Chiba Prefecture account for very high percentages of total production volume and value of fishery cultivation industry in Chiba Prefecture in Japan, especially its production value of ¥7,300 million in 1994 held No. 1 position.

Technological developments had been made 1960 to 1980 including; stabilization of seeding with development of artificial concospore seeding technique, increasing number of nets and extended period of cultivation with development of seeding net freezing storage technologies, expansion of Nori cultivation fishing farms (Nori-fields) to offshore with development of floating cultivation technologies, development of artificial emersion, development of acid treatment agent, mechanization of reaping. Under these conditions, both of production volume and value per Nori-cultivator family are on the increasing trend. The number of sheets have increased to about 15 times from 66,000 (1965) to 960,000 sheets (1994), and the amount also have increased to about 24 times from ¥460,000 to ¥11,200,000.

The most important problem is how to maintain the stabilized production of high quality Nori against quality deterioration and a poor harvest year that occurs in every few years time. Several countermeasures are reviewed as follows; 1. to construct cultivation process conforming to weather and sea conditions of each year, 2. to select the appropriate kind of Nori applicable to the regional environment characteristics, and to improve such kinds of Nori, 3. to improve production processes, 4. to develop advanced harvesting techniques.

Key words: Nori (*Porphyra*) cultivation, *Porphyra yezoensis* f. *narawaensis*, existing conditions and problems, Chiba Prefecture, Tokyo Bay, Japan.

Nori (*Porphyra*) cultivation farms have been curtailed due to diminished dry beach areas in Tokyo Bay as more of them had been reclaimed during Japanese post war high economic growth period (Fujimori, 1971; Katada, 1989) , and Nori cultivation is presently maintained only at three regions, Ichikawa-Funabashi, Kisarazu and Futtsu, by using *Porphyra yezoensis* f. *narawaensis*. However, volume and value of Nori production in Chiba Prefecture account for very high percentages of total production volume and value of fishery cultivation industry in Chiba Prefecture in Japan, especially its production value of ¥7,300 million in 1994 held No. 1 position (Kanto Regional Agricultural Administration, Chiba Statistics and Information Office, 1995).

The purpose of this study is to describe details of existing situations and problems of Nori cultivation in Tokyo Bay.

Technological Revolution Process on Nori Cultivation in Chiba Prefecture (Fig. 1)

In the latter period of 'Edo' era, Nori cultivation was introduced by Jinbei Omiya in

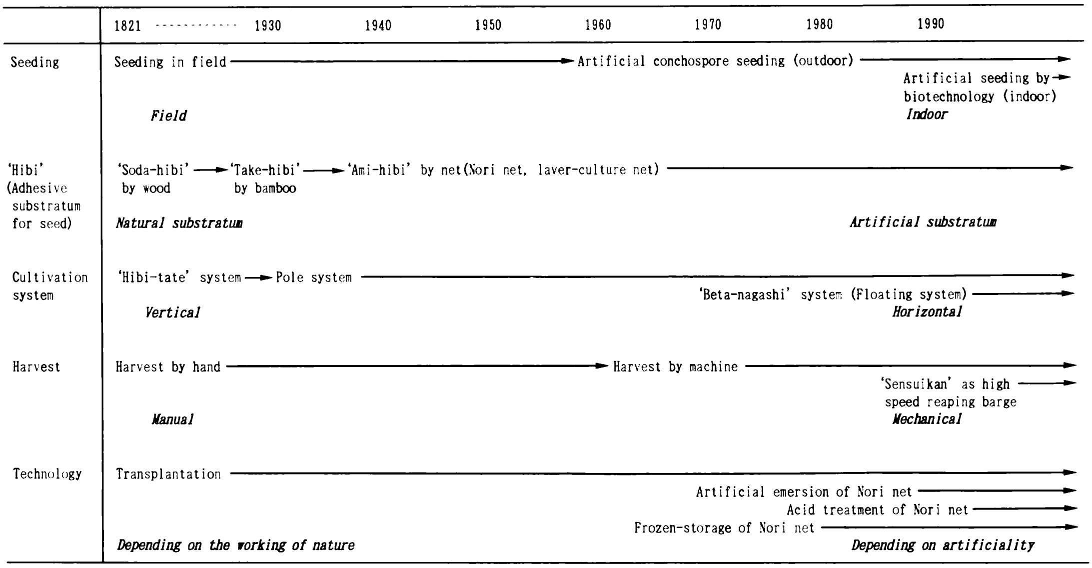

Fig. 1. Historical transition of technological development and employment on Nori cultivation in Chiba Prefecture (1996).

1821, and the first cultivation was started at Hitomi, Kimitsu-shi. The cultivation style at that time was to pick off naturally adhered Nori thalli on spore collectors, 'Hibi', which were erected in the sea (Kanto Regional Agricultural Administration, Chiba Statistics and Information Office, 1980b).

Although a major technological innovation was not made for about 60 years thereafter, Takejiro Hirano at Ohori Village, early in 'Meiji' era, developed a new technique in 1883, so called 'transplantation' which separates spore collection area from rearing cultivating area to reaping area.

Early in 'Showa' era, cultivation facility called 'floating system of cultivation' was developed, with which the cultivation system has gradually and increasingly transformed from the vertical Nori cultivation with spore collectors erected in the sea to that by horizontal floating seeding nets and so on. Especially, before and after implementation of Nori-culture net, the number of produced Nori sheets increased by one figure from 10 million unit to 100 million unit.

After Drew (1949) made clear that spore keeps staying in shells as filamentous thallus (*Conchocelis*) during summer season, new technological developments had been made in 20 years from 1960 to 1980 including: stabilization of seeding with development of artificial conchospore seeding technique; increasing number of nets and extended period of cultivation with development of seeding net freezing storage technologies; expansion of Nori-fields to offshore with development of floating cultivation technologies (Watanabe, 1979); development of artificial emersion; development of acid treatment agent; and further, mechanization of reaping which had been manually done for 140 years since the beginning of Nori cultivation, and so on. Under these developments, production volume of Nori has maintained 400–600 million sheets per year despite decrease of producers as well as cultivation fences.

In recent years, as land seeding technology has been implemented after 1992 under prefectural government subsidy, stabilization of conchospore seeding has been achieved, and in turn, seeding nets were secured, which finally led to stabilization of Nori sheets production volume.

Transition of Nori Cultivation in Chiba Prefecture in Recent Years

1. Transition of Nori cultivation fishing farms (Nori-fields)

Nori cultivation fishing farms in 1953 were extended in long, narrow strip coastal area from Urayasu, Ichikawa-shi to Amaha, Futtsu-shi, including 42 fishermen's coopera-

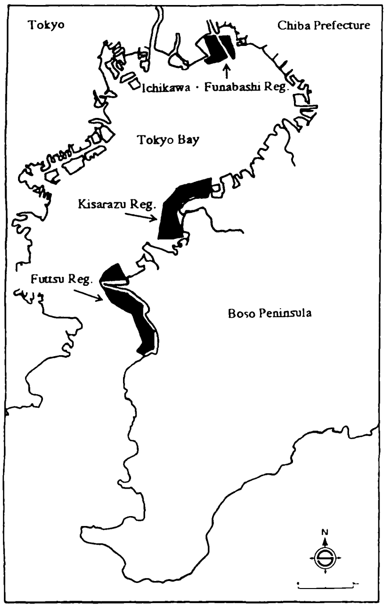

Fig. 2. Locations of Nori (*Porphyra*) cultivation fishing farms (Nori-fields) in Tokyo Bay, Japan.

tive associations, and about 11,000 Nori-cultivator families had engaged in Nori cultivation (Kanto Regional Agricultural Administration, Chiba Statistics and Information Office, 1980b). However, due to the abandonment of fishery rights caused by industrial development, Nori fishing grounds have rapidly curtailed, and on and after 1970, the Nori fishing grounds have almostly concentrated into today's 3 areas of Ichikawa-Funabashi Region (hereinafter described as Chiba Northern Region), Kisarazu Region and Futtsu Region (Ninomiya and Magami, 1971) (Fig. 2).

Distribution of Nori cultivation facilities in each region at 1975, 1985 and 1993 was shown on Fig. 3. You can see considerable decrease of struts fences (Saku: 1 Saku = 18.2 m × 1.5 m) in dry beach area in Chiba Northern Region and Kisarazu Region. For the floating fences in offshore area in Kisarazu Region, the numbers are under steadily decreasing trend, and in Chiba Northern Region, though increased in 1985 compared to in 1975, they are also under the decreasing trend in recent years. In Futtsu Region, although new Nori fishing area was developed in northern sea area of inner part of Boso Peninsula in around 1975, which followed by the industrial development of northern part of Futtsu headland, you can see considerable decrease of struts fences in closer areas to the shore and south of Takeoka branch office of Amaha Fishermen's Cooperative Association. Besides, in 1950s, Nori cultivation had also been engaged in Hota, Tomiyama, Tomiura and Tateyama, and its operation was continued up to around 1980 at Tomiura.

2. Trend of the number of Nori-cultivator families, production volume and value (Table 1)

According to Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries (Kanto Regional Agricultural Administration, Chiba Statistics and Information Office, 1959, 1966 –1995), the number of farming families engaged in Nori cultivation has decreased after peaking in 1958 at 11,828 families, as especially significant decrease can be seen during 1970 and 1980.

Total yield of sheets after 1965 have fluctuated from 350 million sheets to 780 million sheets and a poor harvest years were experienced once in 4 to 8 years. However, production adjustment has been made after 1987 by setting up the standard at 500 million sheets. And, the total production values have also fluctuated from ¥4 billion to ¥10 billion as almost parallel with production volume. However, as can be seen in 1968, despite the number of sheets produced decreased to 58% of the previous year, total production value increased by 15% from the previous year. In the recent 10 years, production volume and value are somewhat in the decreasing trend while both of them still being fluctuated.

Under the above trend on the number of Nori-cultivator families and production, both of production volume and value per Nori-cultivator family are on the increasing trend. The number of sheets have increased to about 15 times from 66,000 sheets in 1965 to 960,000 sheets in 1994, and the amount also have increased to about 24 times from ¥460,000 to ¥11,200,000.

3. Progress on total number of fences, the number of fences per Nori-cultivator family, the number of sheets produced per fence

Total number of cultivation fences in Pole system (calculated in terms of 20 ken (ken=

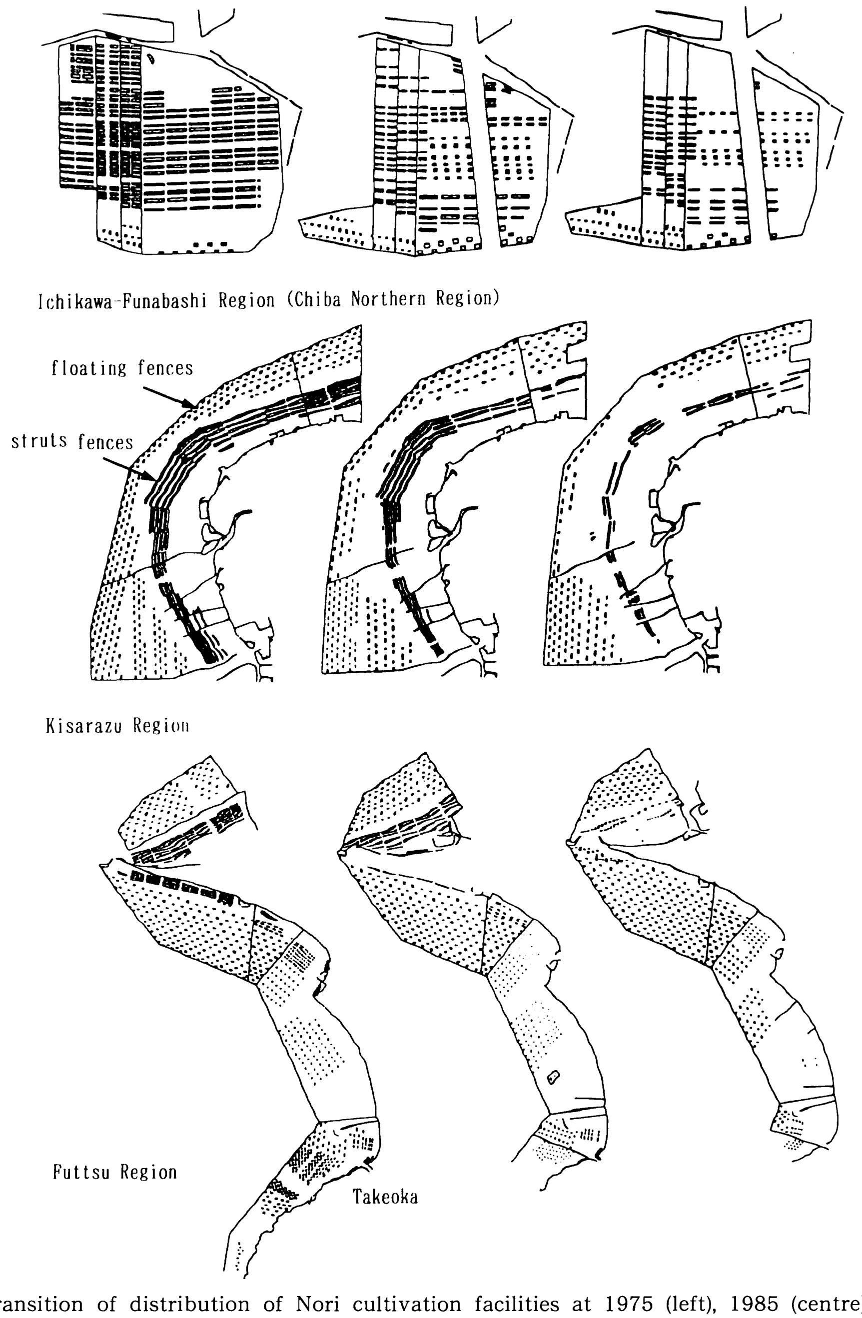

Fig. 3. Transition of distribution of Nori cultivation facilities at 1975 (left), 1985 (centre) and 1993 (right) at three fishing ground; Ichikawa-Funabashi Region (Chiba Northern Region) (top), Kisarazu Region (centre) and Futtsu Region (bottom).

5.965 ft.) was about 200,000 in 1965, but it gradually decreased to 150,000 in 1975, 65,000 in 1985, 51,000 in 1994 which is equivalent to 1/4 of that in 1965 (Kanto Regional Agricultural Administration, Chiba Statistics and Information Office, 1966–1995). However, compared to the number of Nori-cultivator families which fell down to 1/14 from 9,013 in 1965 to 654 in 1994, scale of decrease can be said as relatively small. Therefore, working number of fences per Nori-cultivator family has increased by 4

Table 1. Changes on total number of Nori-cultivator families (N.F.), fences number (F.N.), yield of sheets (Y.S.) and production value (P.V.), on Nori cultivation in Chiba Prefecture (1965–1994).

Year	N.F. (family)	F.N. (fence)	Y.S. (1,000 sheets)	P.V. (million yen)	Y.S./N.F. (sheet)	P.V./N.F. (yen)	Y.S./F.N. (sheet)
1965	9,013	196,475	590,673	4,174	65,536	463,109	3,006
1966	8,488	176,886	591,026	5,977	69,631	704,171	3,341
1967	8,079	172,578	610,373	8,207	75,551	1,015,844	3,537
1968	8,015	183,857	351,137	9,416	43,810	1,174,797	1,910
1969	7,614	174,363	571,648	6,466	75,079	849,225	3,278
1970	7,712	170,853	506,364	7,586	65,659	983,662	2,964
1971	6,012	161,589	525,388	7,037	87,390	1,170,492	3,251
1972	5,147	135,159	612,812	7,242	119,062	1,407,033	4,534
1973	4,218	129,456	611,845	9,485	145,056	2,248,696	4,726
1974	3,590	121,302	616,046	8,325	171,601	2,318,942	5,079
1975	3,368	117,298	546,612	7,633	162,296	2,266,330	4,660
1976	3,079	111,745	394,762	6,735	128,211	2,187,399	3,533
1977	2,843	98,977	372,866	6,203	131,152	2,181,850	3,767
1978	2,183	89,651	716,930	10,336	328,415	4,734,769	7,997
1979	2,067	88,806	459,749	10,251	239,840	4,959,361	5,582
1980	2,000	87,508	530,821	9,708	265,411	4,854,000	6,066
1981	1,951	82,022	610,105	9,051	312,714	4,639,159	7,438
1982	1,896	72,855	382,116	6,672	201,538	3,518,987	5,245
1983	1,587	70,600	775,108	8,703	488,411	5,483,932	10,979
1984	1,540	71,108	566,210	9,338	367,669	6,063,636	7,963
1985	1,337	64,779	524,082	7,235	391,984	5,411,369	8,090
1986	1,282	57,996	510,406	7,675	398,133	5,986,739	8,801
1987	1,178	64,699	533,647	6,511	453,011	5,527,165	8,248
1988	1,086	61,495	704,977	9,323	649,150	8,584,715	11,464
1989	1,011	60,107	585,787	7,778	579,413	7,693,373	9,746
1990	895	55,332	463,325	6,092	517,682	6,806,704	8,374
1991	834	49,614	375,629	5,957	450,394	7,142,686	7,571
1992	774	52,615	502,495	5,558	649,218	7,180,879	9,550
1993	737	51,622	551,598	6,042	748,437	8,198,100	10,685
1994	654	51,183	629,315	7,322	962,255	11,195,719	12,295

times from about 22 in 1965 to about 80 in 1994.

Fig. 4 shows the relationship between working numbers of fences per Nori-cultivator family and the number of sheets produced per fence (Kanto Regional Agricultural Administration, Chiba Statistics and Information Office, 1966–1995). We can see some differences in production per fences levels between the period from 1960 to former half of 1970s and that of after the latter half of 1970s. Coming in to 1960s, together with gradually increased number of working fences per Nori-cultivator family by mechanization of harvest and expanded Nori-fields, the number of sheets produced per fence increased accordingly, added by stabilization of seeding by artificial conchorespore seeding. In the beginning of 1980s, number of sheets produced per fence has rapidly increased from 6,000 sheets figure to 8,000 sheets figure, by extended fishing period through permeation of seeding net freezing storage technology, and based on sound 'Ikubyo-ki' (seed-nursing) technologies such as artificial emersion and acid treatment etc. And, while both of numbers of working fence per Nori-cultivator family and the numbers of sheets produced are in gradual increase trend, increasing rate of the latter has somewhat been slowing down trend.

Characteristics of Each Nori Fishing Ground (Table 2)

In the Nori cultivation fishing farms in existing 3 regions, sea conditions which

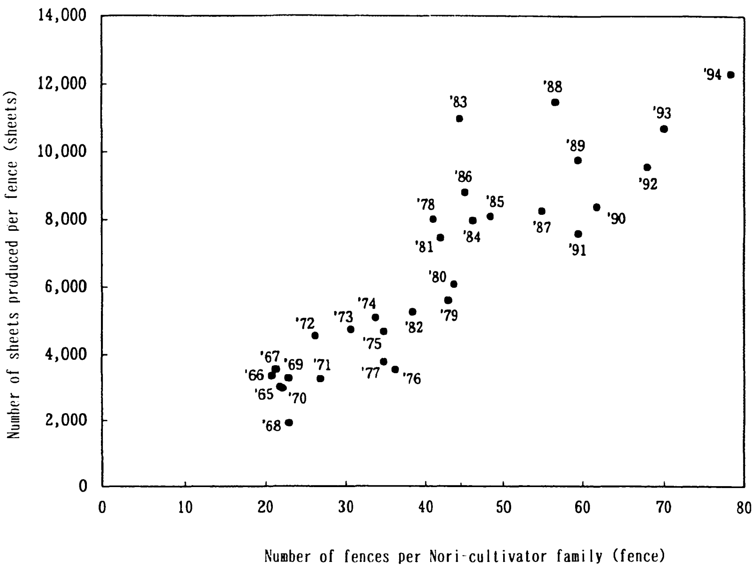

Fig. 4. Relationship between working number of fences (Saku: 1 Saku = 18.2 m × 1.5 m) per Nori-cultivator family and number of sheets produced per fence (1965–1994).

Table 2. Comparison of sea water temperature and volume of nutrient salts at three fishing grounds (unpublished data by Chiba Prefectural Fisheries Experiment Station, Futtsu, 1994); Ichikawa-Funabashi (Chiba Northern part), Kisarazu and Futtsu, on Nori cultivation.

Month	Seawater temperature (℃)			Dissolved inorganic nitrogen ($\mu g/l$)			Phosphate-phosphorus ($\mu g/l$)		
	Ichikawa-Funabashi	Kisarazu	Futtsu	Ichikawa-Funabashi	Kisarazu	Futtsu	Ichikawa-Funabashi	Kisarazu	Futtsu
Sep.	23.9	23.6	23.6	533.82	293.60	174.19	69.39	41.24	23.71
Oct.	19.5	20.0	20.0	757.84	455.49	279.97	81.85	43.16	28.40
Nov.	15.0	16.4	16.1	627.89	462.12	261.65	68.58	39.34	27.88
Dec.	10.4	12.4	12.6	788.65	564.31	276.31	63.26	42.39	27.67
Jan.	7.5	9.4	10.1	838.38	638.43	311.40	49.90	34.14	25.53
Feb.	7.3	8.7	9.4	769.45	568.84	334.60	36.26	25.39	22.76
Mar.	9.7	10.4	11.2	732.22	558.70	285.51	36.42	24.24	18.83

govern quality of Nori cultivation such as reception of weather influence, sea water temperature, specific gravity, nutrient salts, current specifity etc., are different (unpublished data by Chiba Prefectural Fisheries Experiment Station, Futtsu). Characteristics of respective regions are briefly described as follows.

1. **Northern Chiba Region (Fishermen's Cooperative Associations in Minami Gyotoku, Ichikawa-shi Gyotoku, Funabashi-shi)**

This is the region located centrally around so-called 'Sanban-se' dry beach and with struts fences cultivation.

The region is located deep in the bay with weak current due to reclamation made on its both sides, and is a fishing farm with wind and wave dependent style. Average sea water temperature will come down in the earlier stage than other regions after the last 10 days of October that cause lower sea water temperature than other regions at about 1℃ in the first third of November, and about 2℃ from the first 10 days of December until the end of January next year (unpublished data by Chiba Prefectural Fisheries Experiment Station, Futtsu). Nutrient salts of both nitrogen and phosphorus contents are the most affluent among 3 regions. In summary, this region can produce high quality Nori in the former half of fishing period by making the most use of affuluent nutrient salts and by taking advantage of early drop of water temperature.

2. Kisarazu Region (7 Fishermen's Cooperative Associations including Ushigome, Kaneda, Kuzuma, Egawa, Nakazato, Kisarazu and Kisarazu No. 2)

The region is located centrally around 'Banzu' dry beach, calling this 2 Fishermen's Cooperative Associations of Ushigome and Kaneda as the north region as they occupy northern part of 'Obitsu River', and 5 Fishermen's Cooperative Associations located from Kuzuma to Kisarazu calling as the south region. While, both of struts fences and floating cultivation system are employed in this region, percentage of floating system is becoming higher in recent years.

Since Nori cultivation fishing farms of the region are extended around north-west sides of the land, it will be strongly affected by prevailing northerly. Also, as the region is located in estuary, it has a characteristics of easy changeable sea water to fresh water by rainfall, and of easy occurrence of red rot decease. Both of sea water temperature and nutrient salts of the region can be positioned intermediate of those in Northern Chiba Region and Northern Region of inner Boso Peninsula. The region is, except for offshore area, a Nori cultivation fishing ground holding very weak tidal current with wind-wave dependent style. While sea water disturbance is needed in order to make the full use of nutrient salts, they have to face with dillemma with difficulty to control wash-away of thalli and unable to go out fishing when prevailing northerly is severe in the winter season.

3. Futtsu Region (5 Fishermen's Cooperative Associations including Futtu, Shin-Futtsu, Shitazu, Amaha)

The Futtsu Fishermen's Cooperative Association located in northern side of Futtsu headland, has similar characteristics with Kisarazu Region from the viewpoint of easy affectable to prevailing northerly, and with amount of nutrient salts. Also, it still maintains struts fences facilities, though their numbers are very little now.

Four Fishermen's Cooperative Associations of Shin Futtsu–Amaha, located in the southern side of Futtsu headland, are less affected by prevailing northery winds with all floating cultivation system. Although sea water temperature is almost equal with Kisarazu region until December, it becomes about 1℃ higher than Kisarazu Region in the coldest season (unpublished data by Chiba Prefectural Fisheries Experiment Station, Futtsu). The region has a characteristics of oceanic offshore sea water to extend here following to reaching the Kuroshio (kuro= black) Current to the Boso Peninsula, and it may hinder Nori growth when the current is strong. While nutrient salts is the least here, as it is located in bay mouth area where tidal current is excellent, Nori growth will not be hindered if offshore sea water reaches here, as the fishing farms are tidal current dependent style.

As described above, the region can build a peak of Nori products after the turn of the year by making full use of benefits of rapid current and higher sea water temperature in the winter season as well as the lest affected by prevailing northery, by topography of the surrounding land.

Problems in Nori Cultivation in Recent Years

1. Deterioration of quality

Fig. 5 shows the number of joint sales volume of sheets 'Kyouhan-Maisu' by quality and their component ratios by year in Chiba Prefecture (unpublished data by 'Kyohan-jo' (Joint Sales Office)). Classification is made as 'A' for those better than upper 2nd grades, 'B' for 2nd and 3rd grades and 'C' for lower than upper 4th grades. And further, 'N' is for those of normal grades, and 'X' is for those deteriorated quality caused in production processes (e.g. holes, shrinkage), 'Y' is for those deteriorated quality caused by original seaweeds (e.g. Sumi Kumori) and 'Z' is for those deteriorated quality due to inclusion of other foreign elements. At first, as for those below A, B, C classifications, in the recent 11 years, while A was being relatively stabilized at around 10% during 1985–1991 except in 1987, B was at around 30–60% and C had been increasing trend.

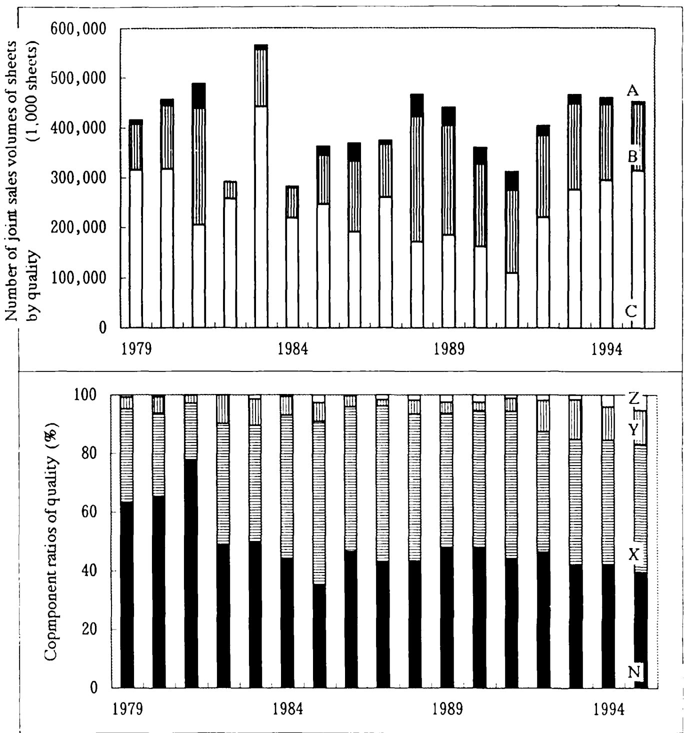

Fig. 5. Transition of number of joint sales volumes of sheets ('Kyouhan-Maisu') by quality and their component ratios of quality (1979–1994). Grade: A: better than upper 2nd grade, B: 2nd grade–3rd grade, C: lower than upper 4th grade. Quality: N: normal grade being A–C, X: deteriorated quality by production process, Y: deteriorated quality by original seaweeds, Z: deteriorated quality by inclusion of other foreign elements.

Similarly, with regard to ratios for N, X, Y and Z, although component ratios of those had been relatively stabilized during 1986–1991, we can see a trend, in recent years, of decreasing ratio of N and increasing ratios of Y and Z, which means quality deterioration has continued.

2. Weather and sea conditions, and a phenomenon in seed-nursing period

As described above, since characteristics of respective Nori cultivation fishing farms are different, and therefore, problems that can be seen in the regions related to weather and sea conditions during 'Ikubyo-ki' (seed-nursing period) are also different. Some representative phenomenon in Futtsu region is showed, as an example, as its production accounts for 60–70% on total volume in this prefecture.

Mild winter tendency has continued after 1987, and accordingly, average sea water temperatures have kept about 1℃ higher than those of before 1986, but sea water temperature fluctuation phenomenon in each year were naturally variable. Fig. 6 shows the calculated 10 days moving average of sea water temperature during September 1 and November 30, and the average sea water temperature in the last 10 days of September holds higher than 23℃ which means the basis of the start of spore collection, and further, two different tendencies can bee seen, as for one with higher than 22℃ average sea water temperature years in the first 10 days of October (1990, 1991, 1994, higher temperature years), and for the other with those lower than 23℃ from the last 10 days of September (1989, 1992, 1993, 1995, early cooled-down years). On the other hand, Table 3 shows some matters arised during 'Ikubyo-ki' (seed-growing) period in each year, and 'Me-tsuke' (seed rooting) situation at the time of freezing net storage, both were arranged from the past materials (unpublished data by Chiba Prefectural Fishe-

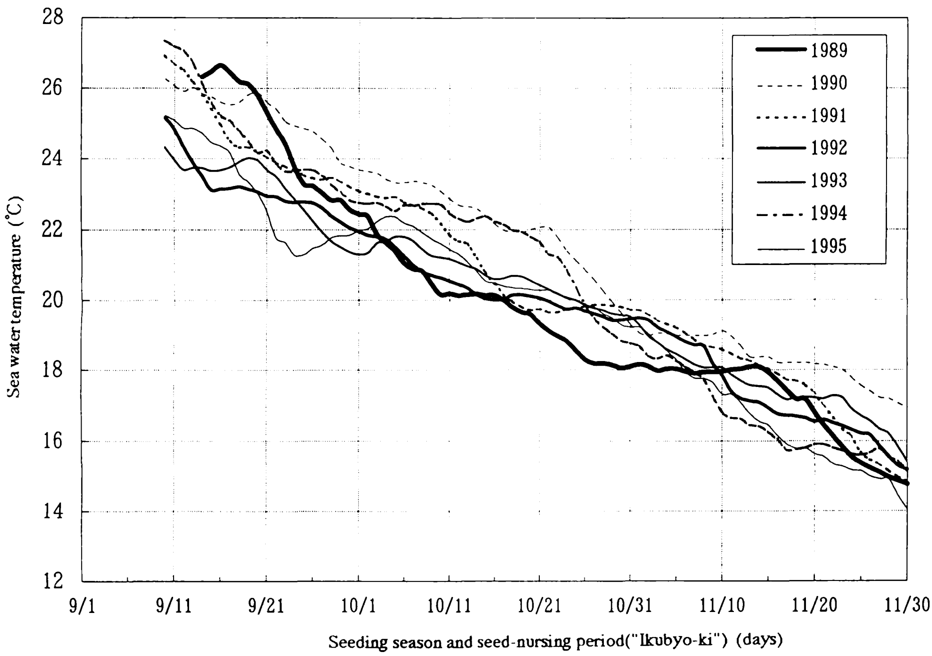

Fig. 6. Change of sea water temperature during seeding season and seed-nursing period ('Ikubyo-ki') (9/11–11/30) at Shin-Futtsu, Futtsu fishing ground (1989–1995).

Table 3. Situation of 'Me-tsuke' (seed-rooting) on seeded nets relating with phenomenon in 'Ikubyou-ki' (seed-growing period) depending on variation of sea water temperature (1989–1994). Thick: Situation of thick seed-rooting on seed nets, Medium: Medium situation between Thick and Thin, Thin: Situation of thin seed-rooting on seed nets.

Years	Situation of 'Me-tsuke' (seed-rooting)			Phenomenon in 'Ikubyo-ki' (seed-growing period)
	Thick	Medium	Thin	
Early cooled-down				
1989	38%	43%	19%	Spread of falling off of seed in early in October
1992	57%	33%	10%	Spread of white rot disease in middle of October
1993	57%	31%	12%	Spread of white rot disease in middle of October
1995	62%	26%	12%	Spread of white rot disease in middle of October
Higher temperature				
1990	11%	45%	44%	Falling off of seed in middle of October
1991	18%	40%	42%	Falling off of seed in middle of October
1994	12%	28%	60%	Falling off of seed in middle of October

ries Experiment Station, Futtsu). As can be seen clearly, adhesion of 'Aonori (green laver)' and 'diatom' is greater in the years with continued higher sea water temperature causing greater fall off of seed as it can be easily entangled by them. As a result, production increase after the turn of the year becomes unable as the number of thinner seed rooted nets will be increased and causing shortage of frozen seeding nets in case of the worst case. In contrast with this, in the years when sea water temperature is lowered earlier, adhesion of 'Aonori (green laver)' and 'diatom' is less, which cause less 'Me-ochi' (fall off of seed) and finally can expect thicker seed rooted nets. However, since the more earlier drop of sea water temperature arises, the longer period of unchanged level continues, and as a result, if neap tide comes at this time, Nori seed will easily show white rot desease and its healthyness will be lost at a breath.

As described above, depending on the sea water temperature drop conditions, phenomenon which emerge in the 'Ikubyo-ki' (seed-nursing period) can be put in order, and the importance of constructing the Nori cultivation processes adjusting to weather and sea conditions was again recognized.

While Chiba Prefectural Fisheries Experiment Station, Futtsu has always advocated to reconstruct autumn seed net production with "Nori cultivation by adjusting to weather and sea conditions", major problem to this issue is how weather can more precisely be predicted as sea conditions always change being linked with weather. On this point, It is important to improve its precision, and it is because producers often say "every year is the first grader for Nori cultivation."

3. Regeneration of white rot disease

After the extremely bad harvest year of 1962 and 1963 due to white rot disease, countermeasures had been taken including reduction of fences, offshore orientation and expansion of Nori fishing farms by implementing floating style cultivation as well as continuously protecting overcrowding farms etc. And quality deterioration due to white rot disease was not seen thereafter. However, in recent years, when temperatures abnormally fell earlier, the disease has generated constantly which led to extreme quality deterioration.

White rot disease is thought as physiological hindrance which generate at some point of time as unavailingly grown thalli which was nurtured in high density become unadaptable to its environment. Due to decrease of Nori-cultivator families in recent years, fences density within the Nori-fields became thinner. However, since numbers of struts fences considerably decreased, and accordingly, weight of floating-style seed-nursing became heavier, the number of seeding nets have relatively increased against total number of fences due to establishment of seeding techniques as well as seeding net freezing storage technology. And further, congested cultivation trend within fences and nets can be seen such as increase of seeding, increased number of multiple nets at the beginning of seed nursing period. On land seeding, those nets with soundly and thickly seed adhered nets can be reset all at once in the fishing farms which cause acceleration of thalli growth in the same rate. And, at the stage in around the middle of October when thalli have grown to several cm, and met with neap tide, white rot disease will arise in the extremely deteriorated sea water condition.

Future Problems

Consumption of Hoshi (dried) Nori sheets in Japan is said to be limited at 9,500 million. On the other hand, total number of sheets produced has reached to 10,000 million every year, which means being overproduced already. Under the such situation, an urgent problem is to establish the way for survival of Nori cultivation in Chiba Prefecture. In Chiba Prefecture, it is needed to aim to establish 'Chiba Brand' by improving quality adding to its traditional excellent 'color' and 'fragrance'.

Although it is not appropriate to think the future of Nori cultivation without taking into consideration of distribution and of successors, it is described at the technological side of Nori cultivation.

As stated hitherto, the most important problem is how to maintain the stabilized production of high quality Nori against quality deterioration and a poor harvest year that occurs in every few years time. Several countermeasures are reviewed as follows; 1. to construct cultivation process conforming to weather and sea condition of each year, 2. to select the appropriate kind of Nori applicable to the regional environment characteristics, and to improve such kinds of Nori, 3. to improve production processes, 4. to develop advanced harvesting techniques.

1. On construction of cultivation processes conforming to weather and sea conditions of each year

Although some measures are being taken to some extent presently, it is needed to organize quick responsive system to immediately deliver information obtained on changing weather and sea conditions as well as to be able to promptly cope with such changes. In the future, it is desired to develop a system to link the Fishery Experiment Station and each association with on-line to provide current situation of weather and sea conditions as well as their simulated information added by necessary management information for the changes.

2. On improvement of a kind

Immobilization technology of excellent phenotype by protoplast has progressed enabling to short-time kind improvement, and new kinds are already being developed. Taking advantage of this technology, following kinds were selected or developed, and a stabilized production of high quality Nori throughout the year can be anticipated by combining the kinds which are conformed to characteristics of each region. Kinds of Nori which are adjusted to 3 peaks of production in Chiba Prefecture for autumn conchospore production period, for minimum sea water temperature period and for increasing sea water temperature period.

3. On production process improvement

From the distribution standpoint, the following requests are strongly raised as to satisfy quality criterion of Hoshi (dried) Nori for business use which accounts for major part of demand in recent years as follows; thorough prevention from foreign inclusions, uniformalization of moistiure contents.

Also, from the producers' standpoint, in order to materialize cost reduction and mass production, it is needed to promote, grouping of production control, and cooperation of production processes.

4. On development of harvesting techniques

At Futtsu Region, high speed harvesting barge has already been implemented almost 100%. However, at Kisarazu Region located at river mouth area of Obitsu River, use of high speed harvesting barge is difficult due to a vast volume of dust which flow into the river, traditional absorbing methods still has to be utilized. If any equipment which can harvest at high speed while uniquely disposing such dust will be developed, improvement in quality and production volume will be achieved as control of submerging treatment for early harvesting and after-harvesting can promptly be made.

As described above, Nori is overproduced even at present, and even though the high quality Nori can steadily be produced, it does not necessarily link with managerial stability of Nori cultivation business. Poor quality Nori has almost no demand at present, and every prefecture is looking for quality improvement, which in turn to cause price collapse if high quality Nori is mass produced. Even as for demand of *Onigiri* through convenient stores has possibility to change in the future, it is also one of the very important issue to try to expand demand by developing the new means of Nori utilization.

Acknowledgements

The authors wish to express our hearty appreciation to Mr. Chikao Kobayashi and Mr. Norimitsu Sakata, Foundation of Chiba Prefectural Nori Seed Center, for giving kind advices and useful comments to this study, and to Dr. Masaru Tamura, Director of Chiba Prefectural Fisheries Experiment Station, who has given first and second authors an opportunity to join the symposium, Present and Future on Biology of *Porphyra*.

References

Kanto Regional Agricultural Administration, Chiba Statistics and Information Office. 1959. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1958. 235 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1966. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1965. 354 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1967. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1966. 345 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1968. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1967. 351 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1969. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1968. 361 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1971. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1969. 387 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1972. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1970. 387 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1973. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1971. 357 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1974. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1972. 367 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1975. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1973. 343 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1976. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1974. 375 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1977. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1975. 311 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1978. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1976. 301 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1979. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1977. 307 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1980a. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1978. 309 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1980b. Nori (*Porphyra*) aquaculture in Chiba. 103 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1981. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1979. 327 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1982. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1980. 337 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1982. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1981. 315 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1983. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1982. 303 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1984. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1983. 301 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1985. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1984. 325 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1986. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1985. 297 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1987. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1986. 293 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1988. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1987. 289 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1989. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1988. 283 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1991. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1989. 327 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1991. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1990. 285 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1992. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1991. 289 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1993. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1992. 293 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1994. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1993. 289 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Ibid. 1995. Statistical Yearbook of Chiba of Agriculture, Forestry and Fisheries, 1994. 331 pp. Chiba Statistical Society of Agriculture, Forestry and Fisheries Corporation, Chiba. (In Japanese)

Drew, K. M. 1949. Conchocelis-phase in the life history of *Porphyra umbilicalis* (L.) Kütz. Nature 164: 748–749.

Fujimori, S. 1971. National developed Nori Cultivation from Edo. *In* The Editorial Board of Vicissitudious History on Fishery in Tokyo Bay, pp. 523–659. Sakuraikouseidou Corp., Tokyo. (In Japanese)

Katada, M. 1989. Vicissitudinous Record of Asakusa-Nori, Nori-500 years. 202 pp. Seizandoushoten Corp., Tokyo. (In Japanese)

Ninomiya, J. and S. Magami. 1971. On Nori aquaculture at the coast of Uchibo areas. Bull. Chiba Prefecture Fisheries Experiment Station 24: 189–225. (In Japanese)

Watanabe, K. 1979. Origin and change on floating laver-culture. *In* Zen Nori Ren (eds.), Guidance of floating laver-culture (Revised edition), pp. 1–14. Zenkoku Nori-Kairui Fisherman Corporation, Tokyo. (In Japanese)

東京湾（千葉県側）におけるノリ養殖の現状と課題

田中種雄[1]・柿野　純[1]・宮田昌彦[2]

[1] 千葉県水産試験場富津分場
〒293 千葉県富津市小久保 3091
[2] 千葉県立中央博物館
〒260 千葉市中央区青葉町 955-2

1827 年にノリ養殖が千葉県で開始されて以降の，近年に至る，千葉県のノリ養殖技術の開発と技術導入の経過について報告した．また，千葉県農林水産統計年報（1958, 1965〜1994 年）からノリ養殖の経営体数，乾ノリ生産枚数，生産金額，1 経営体当たりおよび養殖柵数当たりの生産動向を明らかにした．そして，1 経営体当たりの行使枚数の増加と技術革新による 1 柵当たりの生産量の増大が複合して，1 経営体当たりの生産枚数が，1965 年の 66,000 枚（46 万円）から 1994 年の 960,000 枚（1,120 万円）まで増加したことを示した．また，現在，ノリ養殖をおこなっている東京湾の千葉県側，3 地区（市川・船橋，木更津，富津）のノリ養殖における特性と近年における問題点を明らかにし，その中で 9 月以降の海水温降下が早い年には，“しろぐされ症”が発生して蔓延し，それに起因する乾ノリの品質低下が顕著であることを示した．そして，高品質の乾ノリを安定して生産していくためのノリ養殖技術に関わる課題として，毎年の気象と海況の変化に対応した養殖工程の確立，養殖実施海域の環境特性に対応した適正な品種の選定と改良，乾ノリ製造工程の改良，摘採技術の開発を指摘した．