aquaculture notes

JAPANESE AND SOVIET ATTITUDES TOWARD AQUACULTURE

by

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The fifth Japanese-Soviet Joint Symposium on Aquaculture of the Pacific Region was held September 14-18, 1976, in Tokyo and Sapporo, Japan, under the sponsorship of Tokai University (Japan) and the All-Union Research Institute of Marine Fisheries and Oceanography (USSR).

The symposium followed closely an international conference on aquaculture held in Japan, organized by the United Nations' Food and Agriculture Organization. Principal objectives of the symposium were to exchange present knowledge of aquaculture and to upgrade technical knowledge of mutual interest.

Since 1971, the symposium has provided solutions to some of the far-eastern aquaculture problems. The recent symposium covered physiological and ecological problems, hybridization, acclimatization and technical developments in the field of fish propagation.

In Alaska, the term "aquaculture" is popularly used as synonymous with "salmon culture." When we discuss the feasibility of a culture-based fishery in Alaska other than salmon, we must be aware of the present trends of aquaculture technology in the rest of the world.

This report, the first of a series on the status of aquaculture in northern Pacific regions, is drawn from the fifth Japan-Soviet symposium and presents general and technical information to aid future development of Alaskan aquaculture.

The report is intended to summarize the attitudes of Japan and the Soviet Union toward aquaculture.

During the last decade, both nations have energetically expanded fisheries in world oceans through advanced fishing techniques, gear, and highly sophisticated fishing fleets.

In 1975, Japan recorded a yield of 11 million metric tons and the Soviet Union about 9 million. These figures represent about 30 percent of the total world fishery production.

Elated with success in high-sea fishery development, these countries have been encountering over-exploitation in many fishing grounds. Although the harvestable potential of marine resources in the world oceans has been assessed to be 100 to 120 million metric tons per year, at present only about 70 million metric tons are harvested. Future expansion and exploitation of fishery recources will be impossible unless a switch is made from a hunting type fishery on the high-seas to a more intensive fishery with rational management of ocean resources.

In such a situation, there is a definite motivation for development of aquaculture both in Japan and the USSR, reinforced by international and national situations in both countries. The need for aquaculture was envisaged at the outset.

Establishment of the "200-mile Fisheries Jurisdictional Zone" effectively brings about reformation and reallocation, as well as new jurisdiction and criteria on how to utilize the world's ocean resources. Historically, such changes have had immediate impact on nations which have fisheries long dependent on high-sea resources -- particularly true in the case of Japan.

A considerable portion of Japanese fisheries harvest was reaped from waters within the 200-mile limit of many other coastal countries.

For example, in 1972 the Japanese high-seas fisheries harvested a total of 9.4 million metric tons from the world oceans. Five million metric tons were produced in Japanese coastal waters, whereas 4.5 million metric tons were within so-called 200-mile zones (Table 1).

Table 1. Japanese catch by sea areas in 1972 (Nagasaki, 1974)

Area		Catch (million metric tons)
1.	Japanese coast	5.0
2.	So-called 200-mile zone	4.5
	a. Bering Sea and North Pacific	2.3
	b. Okhotsk Sea	1.1
	c. Japan Sea	0.26
	d. Yellow Sea, Korean, and Chinese coast	0.36
	e. Atlantic Ocean	0.26
	f. South Pacific	0.23
	g. Indian Ocean	0.03

From Table 1, it is obvious the Japanese fisheries have relied intensively upon fishing grounds within the 200-mile limit in northern waters. In 1976, 1.6 million metric tons were harvested within the U.S. jurisdictional zone and 1.8 million metric tons within the USSR zone. The Japanese coastal fishery catches such fish as tuna, skip-jack tuna, Pacific salmon, mackeral, jack mackeral, Pacific saury, anchovy, flatfish and others. The general yield for these species has been relatively stable during the last decades.

The Japanese fishery industry has exploited demersal fish in the Bering Sea since 1955, and have caught about 30 percent of the total landings in that area. The Japanese high-seas fishery has steadily developed a walleye pollack fishery since 1965. In 1972, a total of 1.92 million metric tons of demersal fish were harvested in the Bering Sea. About 84 percent were walleye pollack, *Theragra chalcogramma.*

Two-thirds of the pollack catch was processed into fish paste, which long has been a subsistence fish product in Japan. The remainder of the pollack catch was sold as fillet or made into fishmeal for poultry and fish culture industries.

Fifteen years ago, raw materials for fish paste were almost exhausted in the East and Yellow China Seas due to overfishing. However, new food technology made it possible to use the pollack meat as a raw material substituted for conventional fish species. Although it is not anticipated that the Japanese fishing in the U.S. 200-mile zone will be wholly closed, it is apparent the Japanese will loose status as a major exploiter of pelagic fish resources in the oceans. This situation imposes restraints on the Japanese high-seas fisheries and upon the Japanese people's demand for aquatic protein, which has traditionally satisfied their needs.

Another situation expediting aquaculture in Japan is a direct result of damage to the coastal environment. Japanese coastal fishing grounds and aquaculture farming areas are suffering from catastrophic deterioration due to industrial effluents, city sewage, oil spills from tankers and refineries, as well as deposition of heavy metals. Artificially induced red tides caused by industrial effluents are indirect pollution. Warm water effluent from atomic-energy power plants also is regarded as a pollutant. This pollution creates a large-scale hazard to fishing grounds throughout Japan.

The influence of pollution upon aquaculture enterprises can be divided into five categories: (1) Decrease in catch caused by interference of fishing operations; (2) Large-scale mortality of fish, growth retardation and driving of fish from their habitat; (3) Decrease of food organisms, destruction of spawning ground and nursery areas; (4) Decrease of commercial value due to accumulation of poisonous materials in fish products; and (5) Breakdown and corrosion of aquaculture facilities, fishing gear and fishing nets. In parallel with the development of fish culturing ventures, extensive damage of aquaculture production has been reported. Table 2 illustrates the extent of pollution damage to the aquaculture industry in a recent two-year period.

Table 2. Damage of aquaculture due to pollution in Japan (Anon. 1976)

Year	No. of cases	Damage	Major causes
1973	313	41.5×10^8 Yen (US $12.4 million)	1. Oil pollution (66 cases)
			2. Red tide (27 cases)
1974	471	285.0×10^8 Yen (US $94 million)	1. Oil pollution (91 cases)
			2. Red tide (30 cases)

* Exchange rate: US 1 dollar = 300 Yen.

It is alarming that the 1974 damage totals are almost equivalent to 12 percent of the value of the aquaculture harvest. Accumulated poisonous materials in fish and shellfish, such as mercury and PCB, subject both fishermen and consumers to grave health hazards. Much notoriety has already been evidenced in sea food products at Minamata, Kyushu Prefecture.

In some areas, national or prefectural laws regulate or prohibit the catching of the mercury-affected fishes including croaker, flatfish flounder, *Lepido-trigla sp.*, sea bass, gurnard, cuttle fish, *Malakichthys sp.*, hairtail, blanquill, *Nemipterus bathybus*, conger eel, hardtail, barracuda, flathead and *Therapon jarbua*. It is likely that sea bass, mullet, thread herring, mackerel, conger eel, *Leiognathus nuchalis*, eel, *Therapon oxyrhynchus* are regionally affected by PCB. Thus, aquaculturists are supporting reclaimation of coastal areas for fish farming.

The Japanese people long have been dependent on sea foods for their essential protein and vitamin intake. Traditional dietary preference for marine products, which appears to have originated from historical, geographical and religious complexities in that maritime nation, also is associated with Japan's rice eating habit.

The amount of animal protein in the 2,500 calories of total daily caloric intake was 13.9 percent (in 1974). The daily consumption of fish protein of

18g per day, per capita, is just about 50 percent of the 35g of the total animal protein consumed by the Japanese.

Although the modern way of life has diversified Japan's traditional food habit to the extent that hamburgers and fried chicken attract the younger generation in the urban areas, demand for marine products still is growing. Contemporary questionnaires exemplify such inveterate habits as the taste of plain fish, a variety of sea products, and seasonable kinds of fish.

Today consumers tend to favor high-priced marine products rather than low-priced ones like anchovy, sardine and mackerel, which long had been popularly marketed. Chosen from numerous species of aquatic organisms, shrimp and squid are highly relished foods either in the form of "Tempura" (deep fried) or in "Sashimi" (raw meats eaten with soybean sauce), whereas yellowtail, tuna and sea breams are a delicacy mainly in "Sashimi."

Laver or Nori (*Porphyra spp.*) is a popular appetizer at breakfast, Kombu (*Laminaria spp.*) and Wakame (*Undaria spp.*) are indispensable for Japanese soups and many other seasoned foods. Oyster, scallop, abalone and top shell (*Turbo spp.*) also are raw meat delicacies.

Many fish most esteemed draw highest prices in the fish market when sold raw. Some kinds of fish eggs, such as sea-urchin, salmon, herring and walleye pollack, are typical examples of the most sought-after and most expensive sea foods in Japan.

Sea squirt's natural flavor is appealing to rural peoples' taste. It virtually is impossible to exhaust the list of such food items and recipes, showing how Japanese utilize a great variety of marine resources for food.

To fill this growing demand, Japan has imported many kinds of fishes and seaweed, such as shrimp, tuna, oyster, cuttle fish, eel, fish eggs and laver. The value of imports is increasing annually. In 1974, a total of

320 billion Yen (US $1.1 billion), compared with 32.3 billion Yen in 1963, was paid to more than 60 countries. This is equivalent to almost 1.4 times the total value of aquaculture production.

As a consequence of such consumer demand, the target species in aquaculture naturally tend to be high-priced species of fish, shellfish and seaweed. In 10 ten years between 1964 and 1974, aquaculture production increased dramatically -- approximately a 240 percent increase in landings and a 320 percent increase in value, compared with only 5 percent increase for coastal fishery landings. In 1974, a total of 880,000 metric tons were produced in aquaculture. This figure is approximately 8 percent of the total national catch, while the value is as much as 18 percent (233 billion Yen or US $774.2 million).

Among the numerous kinds of organisms produced artificially, Nori or laver occupies 30 percent of the total harvest in weight (38 percent in value), followed by oyster 24 percent (7 percent) and the seaweed, *Undaria spp.* 17 percent (5 percent). Yellowtail, *Seriola quinqueradiata*, has been a fascinating target species for culturists since 1958, increasing to 11 percent in weight and 31 percent of the total value that year.

Sea breams (3,300 metric tons), horse mackerel and hardtail (200 metric tons) are other commercially important species of fish. Even though the harvest of 912 metric tons appears low, Kuruma shrimp, *Penaeus japonicus*, remains an important species in aquaculture. Northern waters produced more than 63,000 metric tons of scallop, 10,200 metric tons of seaweed *Laminaria spp.* and 5,000 metric tons of sea squirt, respectively. Fifty-four tons of octopus also were produced. About 110,000 people of a total 490,000 fishermen are engaged in aquaculture in Japan. Table 3 shows examples of the number of management groups (generally a fishing family) and the mean income earned in some representative aquaculture enterprises.

Table 3. Main categories of aquaculture and mean income in Japan (Nohrinsho 1976)

Organism	No. of management groups		Annual income (million Yen)	
	1973	1975	1973	1975
Oyster	3,245	5,292	3.12	4.87
Laver	37,161	42,409	2.69	3.53
Wakame	9,562	-	1.11	-
Yellowtail	2,841	3,044	14.96	-
Scallop	2,888	-	2.62	-

Due to a relatively stable and growing consumer market and high prices, aquaculturists derive a good income in Japan. On the other hand, the most difficult problems aggravating these aquafarmers include high-cost feed materials for rearing, worsening water quality, disease and a large-scale mortality due to high-density commercial farming techniques (self-pollution) and red tides.

To avoid deterioration of water quality, culturing farms tend to shift from near-shore to offshore and from shallow water to deep water, seeking the cleanest and most favorable environment. They are being aided by deep-water net pens, wave-resistive construction and other related facilities.

In order to meet vigorous demands for marine products and to solve vital problems caused by over-exploitation, "200-mile zone" impact and coastal pollution, the Japanese government initiated a new coastal fishery development project in 1975. Although Japan has a long history of aquaculture, the present projects are expected to be a cornerstone in steadily and promptly turning aquaculture away from high-sea hunting type fisheries. The new projects, substantially boosted by about 667 million U.S. dollars in Japanese government subsidies, are designed to produce a total harvest of 410 thousand metric tons beyond the present harvest. In short, this nationwide plan aims ambitiously to reform the Japanese islands as a farming area. Japan has a 310,000 km^2 (120,000 $mi.^2$) continental shelf, which corresponds to 81 percent of the total area of the Japanese islands. At present, however, only 3.4 percent contributes to mariculture. Another 40 percent of the continental shelf is anticipated to be feasible for future aquaculture.

In the first phase, selected coastal waters are designated as suitable for fish farming, artificial recruitment areas or transplantation. After the plan is implemented there will be expansion or reestablishment of appropriate fish farming areas, feeding, nursery and spawning areas, construction of artificial fish habitats, wave-reducing facilities, rocky beach tilling, leveling of seabeds, and improvement of sea water flow and exterminating predators.

In general, the technical conditions for establishing suitable production target organisms in aquaculture must satisfy such conditions as: (1) The production of high-demand, high-value species; (2) Ecologically and oceanographically well-prepared habitats or farming sites; (3) Easy seeding techniques and seed supply; (4) Stable and sufficient feed material acquisition with low-cost and high-quality; and (5) Expertise in seeding, raising, culturing, protecting, releasing and harvesting the respective organisms.

The organisms listed in Table 4 show the important aquaculture target species in Japan. The target species, of course, differ locally, because natural, historical and socio-economical concerns vary from place to place. The target species, separated into categories according to seeding procedure, extent of management and culturing type, are as follows:

A. The species for which artificial seeding technique is established, or experimentally accomplished, using either artificial fertilization method, spats or spores collection.

B. The species for which seedings are made using naturally spawned eggs, spats, larvae or juveniles. After collecting, eggs or larvae can be raised either in enclosed habitats or protected culturing grounds.

C. Raising of fry or larvae is done under artifically controlled facilities.

D. The species for which early life stages are protected for a considerable period of time long enough to prevent predation or natural mortality, and to facilitate growth rate. Thereafter, they are released into the fishing grounds or natural habitats until harvesting time.

It can be seen that establishment of seeding techniques, mass production or mass collection of seeds, survey of nursery areas, timing of release and transportation, prey-predator relationships, survival rate, site selection for ranching, protection and artificial construction of nursery areas, are particularly important. Among the species listed, the Japanese government in 1975 gave priority to a total of 36 kinds of organisms as incentive farming species (asterisked organisms in Table 4).

Similar to the high-seas fishery development in Japan, the USSR also maintains high status in the world fisheries. Since it has been proven that high-sea fisheries provide the most successful and economic way to acquire animal protein resources, the Soviet Union since World War II has been devoted to exploiting the marine resources of the world oceans with several consecutive national plans.

In the Soviet Union, about 80 percent of the total fishery catch, 95 percent of the frozen fish and 41 percent of the canned fish, are produced by the Soviet high-seas fishing fleets. As seen in Table 5, the marine resources harvest is mainly from the Atlantic and Pacific Oceans.

Table 4. A list of target organisms in the Japanese aquaculture.

A. FISH

*	Yellowtail, *Seriola quinqueradiata*	B, C, D
*	Amberjack, *Seriola purpucascens*	B, C, D
*	Bonitos, *Sarda orientalis*	A
*	Frigate mackerel, *Auxis thazard*, and *A. tapeinosoma*	A
*	Sea bream, *Chrysophrys major*	A. C, D
*	Black sea bream, *Acanthopagrus schlegeli*	A, C, D
*	Sea bream, *Sparus sarba*	A
*	Sea bream, *Acanthopagrus latus*	A
*	False parrot fish, *Oplegnathus fasciatus*, and *O. punctatus*	A
*	Porgy, *Evynnis japonicus*	A, C, D
*	Chum salmon, *Oncorhynchus keta*	A, C, D
*	Pink salmon, *Oncorhynchus gorbutscha*	A, C, D
*	Cherry salmon, *Oncorhynchus masou*	A, C, D
*	Rainbow trout, *Salmon gairdneri irideus*	A, C, D
*	Scorpion, *Sebastiscus marmoratus*	A, D
*	Gray rockfish, *Sebastes inermis*	A, D
*	Greenling, *Hexagrammos otakii*	B, D
*	Triggerfish, *Stephanolepis cirrifer*	A, C
*	Hardtail, *Caranx delicatissimus*	B, C
*	Flounder, *Paralichthys olivaceus*	A, C, D
*	Stone flounder, *Kareius bicoloratus*	A, D
*	Flat fish, *Limanda herzensteini*, and *L. yokohamae*	A, D
*	Groblefish, *Fugu rubripes*	A
*	Bigeye tuna, *Thunnus obesus*	A, C
*	Horse mackerel, *Trachurus japonicus*	A
*	Common seabass, *Lateolabrax japonicus*, and *L. latus*	B, C
	Rabbit fish, *Siganus fusescens*	A, D
	Grouper, *Epinephelus akara*	A, D
	Halfbeak, *Hemirhampbus sajori*	A, B, C
	Parapristipoma trilineatus	A, D
	Sweet smelt, *Plecoglossus altivelis*	A, B, C
	Pond smelt, *Hypomerus olidus*	A, D
	Mullet, *Mugil cephalus*	B, C
	Mullet, *Lisa haematocheila*	A
	Girella punctata	B, D

Table 4. (continued)

	Sandfish, *Arctoscopus japonicus*	B
	Eel, *Anguilla japonica*	B, C
	Conger eel, *Conger myriater*	B, C
	Percoid fish, *Sillago sihama*	A
B.	SHELLFISH	
*	Japanese oyster, *Crassostrea gigas*	A, C,
*	Common scallop, *Pecten yessoensis*	A, B, C, D
*	Short-necked clam, *Tapes japonica*	B
*	Hard clam, *Meretrix lusoria*	B
*	Abalone, *Haliotis discus hannai*	A, C
*	Abalone, *Haliotis discus discus*	A, C
*	Common abalone, *Haliotis gigantea*	A, C
*	Abalone, *Haliotis sieboldii*	A, C
*	Abalone, *Haliotis japonica*	A, C
*	Hen clam, *Spisula sacchhlinensis*	A, B, C, D
*	Top shell, *Turbo cornutus*	A
*	Scallop, *Pecten albicans*	B, C
*	Scallop, *Chlamys nobilis*	B, C
	Pearl oyster, *Pinctada martensii*	B, C
	Ark shell, *Anadara subcrenata*	B
	Mussel, *Mytilus crassitesta*	B
	Bay mussel, *Mytilus edulis*	B
	Hen clam, *Mactra sulcataria*	B
	Jackknife clam, *Sinonovacula constricta*	B
	Ark shell, *Anadara broughtoni*	B
	Ivory shell, *Babylonia japonica*	B
C.	CEPHALOPOD	
*	Common octopus, *Octopus vulgaris*	A, D
	Monkou Ika, *Sepia esculenta*	A, B, D
	Cuttlefish, *Sepioteuthis lessoniana*	A, B, C
D.	CRUSTACEANS	
*	Kuruma shrimp, *Penaeous japonicus*	A, B, C
*	Blue crab, *Neptunus trituberculatus*	A, C, D
*	Spiny lobster, *Panulirus japonicus*	A, B, C

Table 4 (continued)

*	Prawn, *Pandalus kessleri*	B, D
	Neptunus pelagicus	A, D
	Prawn, *Metapenaeus monoceres*	A, B
	Prawn, *Penaeus orientalis*	A, B, C
	Prawn, *Penaeus monodon*	B
	Squilla, *Squilla oratoria*	B, D
	Botan shrimp, *Pandalus nipponensis*	B, D
	Crab, *Erimacrus isenbeckll*	B, D
E. OTHER ANIMALS		
*	Sea urchin, *Strongylocentrotus intermedius*	B, C, D
*	Sea urchin, *Strongylocentrotus nudus*	B, C, D
*	Horse-dung sea urchin, *Hemicentrotus pulcherrimus*	B, C, D
*	Red sea urchin, *Pseudocentrotus depressus*	B, C, D
*	Purple sea urchin, *Anthocidaris crassispina*	B, C, D
	Sea cucumber, *Stichopus japonicus*	B, C, D
*	Sea squirt, *Halocynthia roretzi*	B, C
F. SEAWEEDS		
*	Laver "Nori", *Porphyra spp.*	A. B. C
*	"Wakame" *Undaria spp.*	A, B, C
*	"Konbu," *Laminaria spp.*	A, B, C
*	Agar-agar, *Gelidium spp.*	A, B, C

Approximately 80 percent of the harvest from a total of 9.62 million metric tons in 1973 was obtained from these two oceans. The catch from the Pacific Ocean, with Okhotsk, Japan and Bering Seas and Gulf of Alaska as the main fishing waters, reached as high as 30 percent of the national total catch. These areas provide the following percentages of the total national landing: Pacific salmon with 90; rockfish, 80; herring, 50; flat fish, 70; Arctic cod, 85; Pacific saury, 80; crab, 100; black cod, 100; shrimp, 100; mollusca, 50; and seaweed, 50.

Table 5. The USSR's catch by sea areas (Anon. 1975-1977)

Fishing area	Catch (million metric tons)
1. Inland waters (Caspian Sea and others)	0.85
2. Ocean	7.77
a. Atlantic Ocean	4.87
b. Mediterranean, Black and Azov Seas	0.29
c. Indian Ocean	0.44
d. Pacific Ocean	2.8

Far eastern waters teem with ample resources of crustacean, cephalopods, bivalves, echinodermata, and seaweed. In detail, shrimps and crabs are found in abundance in the Okhotsk and Bering Seas, while squid and octopus are abundant in the Japan Sea, Aleutian and Kurile waters, sea urchin and sea cucumber in the Japan Sea, and oyster and scallop in Sakhaline and Primorskaya. They all have enormous potential for aquaculture.

The goal of the ninth five-year national economic development plan of the Soviet Union which ended in 1975 is reported to have been nearly reached according to obtainable Russian information. The main accomplishments during the five years were as follows: (1) A catch of about nine million metric tons in 1975. This indicates a 31.3 percent increase of catch over the five years; (2) The processing of 4.5 million metric tons of marine products which is a 32.4 percent increase in value; (3) The production of 2.3 billion metric tons of canned fish (52.7 percent increase); (4) The production of 65 thousand metric tons of fish meal, and (5) A 28 percent increase of yield in inland fish culture, raised by a total of 135 fish farms. One hundred-twenty billion fish fry belonging to 40 species were released. Such successful accomplishments of the ninth five-year national plan finally has led to the desired level of marine product consumption by the Russians. The average consumption rate of fish and marine products, 18.2 kg/year/person, which has been recommended by the Soviet Academy of Medical Science, was attained in 1976.

The Soviet Union's new five-year national plan set forth in 1976 still addresses the importance of fishery products as a ready source of animal protein. According to the proposed plan, the projects focus on the following goals by 1980: (1) A 30-32 percent increase of marine products, as compared with an increase of total food production of 26-28 percent and meat and milk production increase of 20-22 percent. A greater diversity of fishery products with higher quality than now are available also are emphasized; (2) Production of fish from national fish hatcheries is to be increased 1.7 times over the present level; (3) Development of additional fish markets and fish consumers.

With the purpose of extending consumption of marine products, a nationwide campaign was organized in 1970 in the Soviet Union. A total of 180 chain stores, restaurants, fish markets, and cafeterias were opened in more than 70 cities and have served a variety of sea foods, canned products, frozen fish, fillet, smoked fish and others. Such stores are called "Okean" (which literally means ocean in English).

During the years 1976-1978, more than 330 new "Okean" stores will be established. An experimental once-a-week "Fish Day" presently being tried in several regions will be extended in an effort to intensify consumption of sea foods over a wide area. This plan is intended to develop new consumers, particularly in Central Asia, Caucasus, Azerbaijan, Glusia, and Armenia, where people have not received marine products before.

In view of such a trend, the necessity of development in aquaculture, as well as in untapped deep-sea fisheries, is being emphasized in the Soviet Union. At present, 130 national fish farming stations in the Azov Sea, White Sea, Baltic Sea, Caspian Sea, and Far East are involved in the culture of many organisms including sturgeon, salmon, oyster, scallop, mussel, and seaweed.

In the Far East, there are 23 hatcheries engaged in Pacific salmon culture in Kamchatka, Sakhaline, and Primorskaya. The Soviet Union has a long history and expertise in transplantation and acclimatization of fish species to develop new fisheries in appropriate places.

The 1960's transplantation of pink salmon eggs from the Far East to the Balenz Sea and White Sea resulted in the successful return of 90,000 spawners. In 1970, chum and pink salmon eggs were transplanted to the Baltic Sea. Except for sturgeon and salmonid species, there has been no other industrialized aquaculture established in the USSR; but Russia is facing the necessity of a culture-based fishery. Experimental farming stations have raised scallop at the production rate of 10-20 tons/hectare in southern Primorskaya. *Laminaria spp*. was also experimentally cultured and 60-70 ton/hectare was harvested. Sea urchin culture now is on an experimental scale. Salmon, herring, shrimp, crab, sea cucumber and agar-agar are planned to be pursued as important target species for future aquaculture in the Far East.

The prognosis of the status of aquaculture attracts our attention. As recognized in the above, the expectation from aquaculture by Japan and the USSR is quite immense.

Dr. P. A. Moiseev has predicted aquatic production of both countries after 25 years (Table 6). In his estimation, the Japanese conventional fisheries will be supplemented by culture-based fisheries, and that 40 percent of the total aquatic production will be obtained from aquaculture and bioamelization by the year 2000, though at present 90 percent of the aquatic production is carried by offshore and coastal fisheries. Unlike Japan, the Soviet Union will continue the ocean exploitation for more than 25 years, but at the same time aquaculture will share up to 17 percent of the total aquatic production by the end of this century.

Table 6. Type of fishery versus catch in metric tons (Moiseev 1976)

	U S S R		J A P A N	
Type of Fishery	1974	2000	1974	2000
Total catch	9.2	15.0	11.1	15.0
1. Inland fisheries	1.0	1.5	0.1	0.2
2. Freshwater fisheries	0.5	1.0	0.1	0.2
3. Mariculture and selective breading	-	2.5	0.9	6.0
4. Ocean fisheries	8.4	10.0	9.7	8.6
a. coastal fisheries	3.2	5.0	2.7	3.0
b. offshore fisheries	4.7	2.0	5.7	2.6
c. epipelagic and bathypelagic fishery	0.5	3.0	1.3	3.0

Unit: million metric ton

We have already perceived the impetus to develop aquaculture. We have discussed examples which corroborate that the artificial propagation of aquatic organisms in northern waters does work. There are possible areas for aquaculture throughout the northern Pacific region -- i.e., northern Japan Sea, Hokkaido, Okhotsk, Kamchatka, Sakhaline, and Primorskaya though at present the target species for aquaculture with high commercial value are quite few. These subarctic regions in the latitude higher than $40^{o}N$ are similar to the above regions in climate, oceanographic conditions and marine community.

Among them, high aquatic productivity which is attributed to high nutrient supply, seasonal convection, and low water temperature of sea water and severe climatic conditions are marked characteristics. Alaskan water conditions are similar. Thus, there are mutual problems in the future of aquaculture in Alaska, northern Japan, Hokkaido, and the Far East of the USSR. The exchange of reliable information with respect to aquaculture technology in the northern waters of the Pacific region would be quite beneficial.

The growth of aquaculture in many countries has been full of trial and error. It is apparent there is no easy way to establish successful aquaculture within a short period of time.

To develop aquaculture in Alaska (other than salmon ranching) I believe we need some experimental aquaculture pilot farms with objectives being to develop basic and applied research in Alaskan water. Choice of appropriate target species, site selection, and the development of culturing techniques will be the primary missions. Since most boreal species have a slow growth rate, an investigation on how to hasten the growth of boreal species by controlling biological and environmental factors should be given priority.

Genetic studies are also necessary to select and establish appropriate stocks which produce gene pools possessing fast growth rates and a high fecundity in cold water.

Concurrently, another essential problem to be studied is how to utilize in aquaculture the formidable physical energies from currents, tides, and winds, as well as from geothermal energies. The future of aquaculture is great in northern waters. The establishment of aquaculture technologies and concepts

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