Woods Hole Oceanographic Institution

FACTORS LIMITING THE
DEVELOPMENT OF AQUACULTURE:
A JAPANESE EXPERIENCE

by

Yoshiaki Matsuda

April 1979

TECHNICAL REPORT

Prepared with funds from the Pew Memorial Trust and by the Department of Commerce, NOAA Office of Sea Grant under Grant #04-8-MO1-149, and the Institution's Marine Policy and Ocean Management Program.

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Approved for Distribution Robert W. Morse

Dr. Robert W. Morse
Associate Director and Dean of Graduate Studies

Abstract

An understanding of those factors which have limited the development of Japanese aquaculture may have some applications to the problems of aquaculture in developing countries. The history of aquaculture in Japan is reviewed from chronological, geographical, species and institutional points of view. Conclusions reached in this study reveal that throughout the history of Japan aquaculture development has been limited by variables which can be identified. The most important factor is the existence of leadership which coordinates supply and demand, environmental suitability, technical capability, legality, experience, infrastructure and social welfare incentives with economic feasibility. The development of aquaculture depends on simultaneous development of all these factors, not on the preponderance of any one of them. Within the framework of this generalization, issues pertaining to aquaculture development in developing countries could be handled by adaptation to local conditions.

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PREFACE

This research was prepared with funds from the Pew Memorial Trust and by the Department of Commerce, NOAA Office of Sea Grant under Grant # 04-8-M01-149, and the Woods Hole Oceanographic Institution's Marine Policy and Ocean Management Program. The author wishes to acknowledge Drs. Susan Peterson and Leah Smith for offering the opportunity, criticism and support; Mrs. Ann Martin for all her help in preparing this manuscript; and Miss Kaleroy Hatzikon, Mrs. Lynda Davis, Mrs. Jane Zentz, and Mrs. Ann Goodwin for typing this report. Special acknowledgment is extended to Drs. Clinton E. Atkinson and E. Evan Brown for critical review of the manuscript. The author hopes this effort will contribute to successful aquaculture management in developing countries and elsewhere.

INTRODUCTION

This exploratory study was designed to provide an understanding of those factors which have limited the development of Japanese aquaculture in the hope that it would have some applications to the problems of aquaculture in developing countries.

Many failures of international and government assistance for the development of aquaculture seem to have resulted from extreme and inflexible assumptions. For example, it is a popular assumption that whatever is successful and important to the developed nations is important to the developing nations and is transferable in toto (15).

Developing areas need not repeat failures that have been experienced repeatedly in developed areas. The history of aquaculture in Japan is rich in experiences from the chronological, geographical, species and institutional points of view. Thus, in Section 1, the overall history of aquaculture is reviewed. Further, the history has been approached from two standpoints in Sections 2 and 3: 1) structural change of geographical area, and 2) development of certain species management and institutions. A generalization of the Japanese experience in aquaculture development is attempted in Section 4.

Adaptation of this effort to various local conditions will play an important role in aquaculture development in developing countries.

SECTION 1. HISTORY OF AQUACULTURE IN JAPAN: AN OVERVIEW

Aquaculture as an industry in Japan is now in a state of dynamic evolution reflecting social, economic and political factors as well as ecological and technological ones. The major species involved are "Wakame" seaweeds (Undaria pinnatifida S.), laver (Porphyra tenera K.), tangle (Laminaria japonica A.), oyster (Ostrea gigas T.), pearl (Pinctada martensii D.), scallop (Pecten yessoensis J.), young yellowtail (Seriola quinqueradiata T. et S.), red snapper (Pagrus major T. et S.), prawn (Penaeus japonicus B.) for mariculture; and goldfish (Carassius auratus L.), fancy and common carps (Cyprinus carpio L.), eel (Anguilla japonica T.), rainbow trout (Salmo gairdnerii irideus G.) and "Ayu" fish (Plecoglossus altivelis T et S) for freshwater culture. The coast of Iwate is noted for "Wakame" seaweeds; Saga, Hyogo, Aichi and Mie for laver; Hokkaido for tangle and scallop; Hiroshima and Miyagi for oyster; Nagasaki, Mie and Ehime for pearl; Mie, Ehime, Nagasaki and Kagoshima for young yellowtail; Kumomoto, Nagaski and Mie for red snapper; and Kumamoto and Yamaguchi for prawn. In addition, Nara, Aichi and Tokyo are noted for goldfish culture; Niigata, Nagano and Tokyo for fancy carp; Iberagi, Nagano and Gunma for common carp; Shizuoka, Aichi, and Kochi for eel; Wahayama and Tokushima for "Ayu" fish; Osaka for crucian carp (Figure 1-1).

Within the total fisheries production, aquaculture production has been increasing (Figure 1-2). Until 1960 it accounted for less than 5% in quantity, a figure accompanied by 11.17% in value. Since this date the monetary value of aquaculture production has reached 17% of the total production (Figure 1-3). Further, when the comparison is limited to coastal fisheries, the number of aquaculture families forms more than 70% of the

	Species	Production*	Major Producing Areas
○	Young Yellowtail	10,000t	Mie (17,029), Ehime, Nagasaki Kagoshima, and Kochi
●	Red snapper	1,000t	Kumamoto (1,661), Nagasaki and Mie
⊕	Prawn	91t	Kumamoto (517), Yamaguchi and Kagoshima
□	Oyster	10,000t	Hiroshima (128,892), Miyagi, Okayama and Iwate
■	Scallop	5,000t	Hokkaido (40,587), Aomori and Iwate
⊠	Laver	25,000t	Saga (40,000), Hyogo, Aichi, Mie and Yamaguchi
△	Wakame	30,000t	Iwate (48,072 and Miyagi
▲	Tangle	4,786t	Hokkaido (16,685) and Iwate
✡	Pearl	7t	Nagasaki (10), Mie and Ehime
✸	Trout	1,000t	Nagano (3,780), Shizuoka and Tochigi
◇	Ayu	500t	Wakayama (1,535), Tokushima, Shiga
◆	Common Carp	2,500t	Ibaragi (5,943), Nagano and Gunma
⊖	Eel	2,000t	Shizuoka (18,400), Aichi and Kochi

* OVER

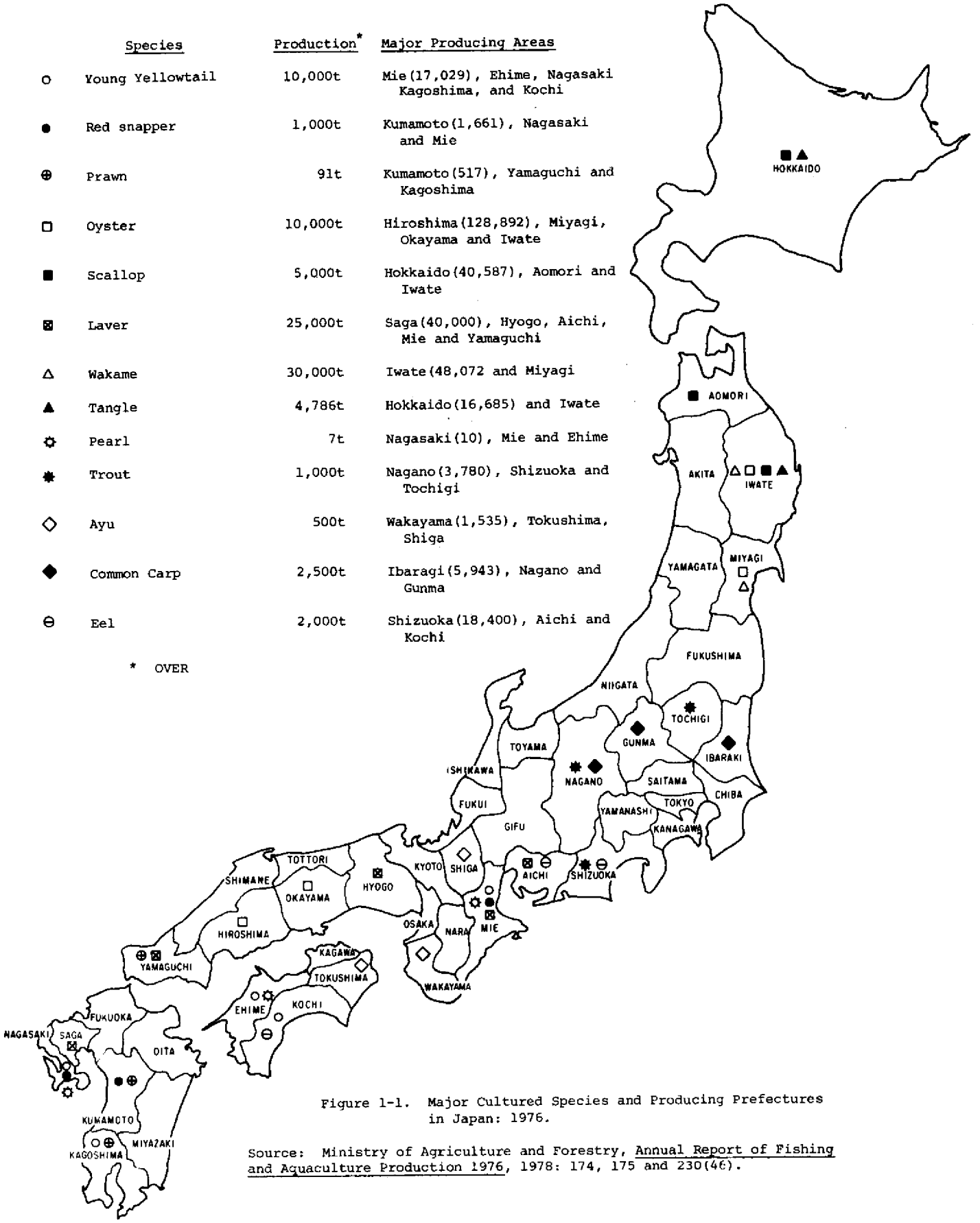

Figure 1-1. Major Cultured Species and Producing Prefectures in Japan: 1976.

Source: Ministry of Agriculture and Forestry, Annual Report of Fishing and Aquaculture Production 1976, 1978: 174, 175 and 230(46).

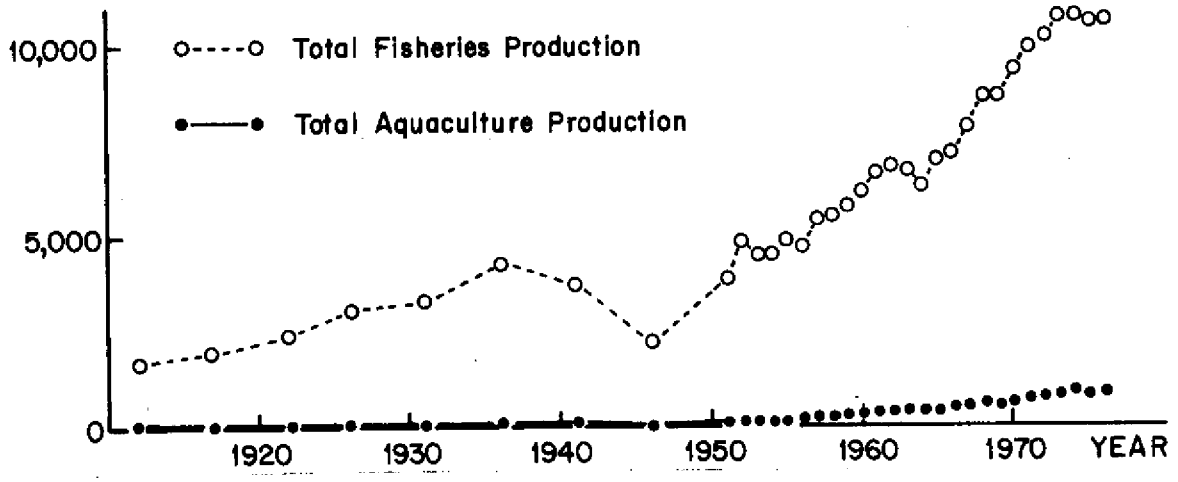

Figure 1-2. Fisheries Production in Japan: 1912-76 (Unit: 1,000t)

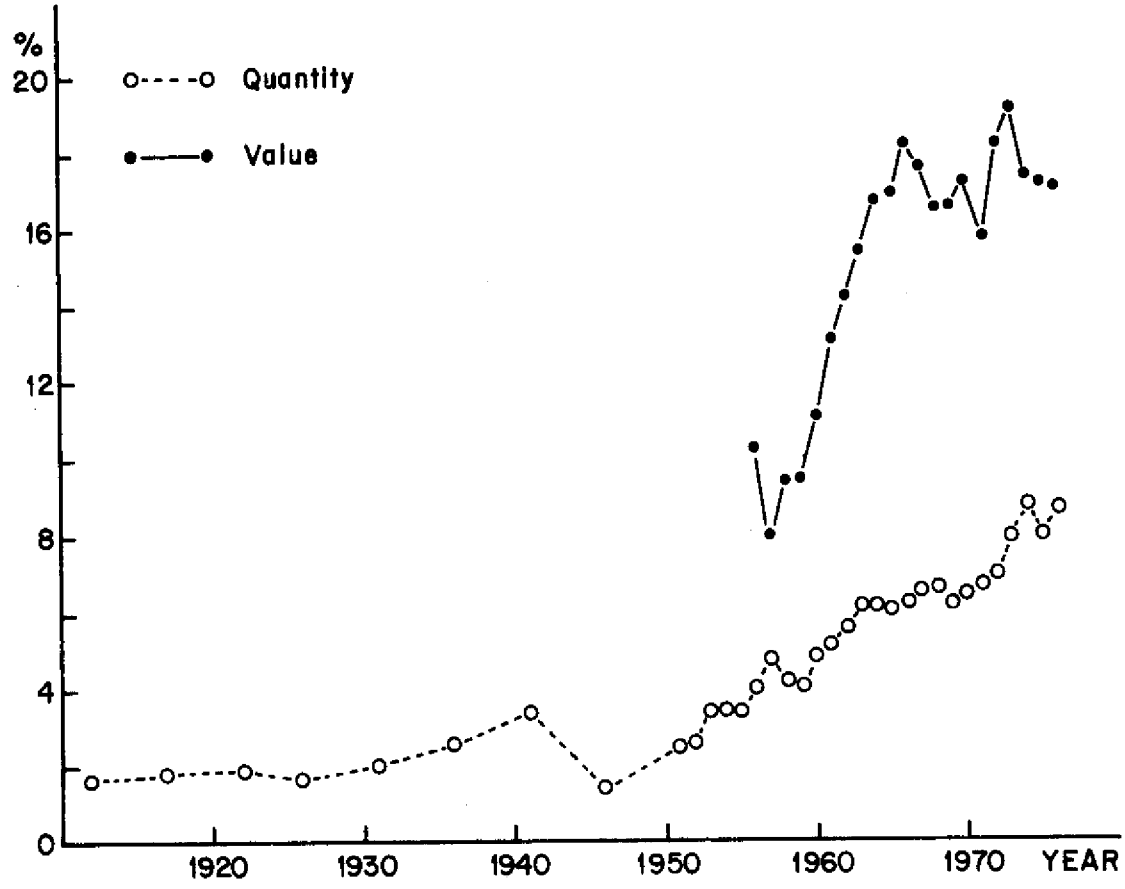

Figure 1-3. Aquaculture-Total Fisheries Production Ratios in Japan: 1912-76.

Sources: Suisansha, Fisheries Yearbook 1968, 1968; 1971, 1971; 1976, 1976(63) and Ministry of Agriculture and Forestry, Fisheries Statistics of Japan 1975, 1978(47).

total number of fisheries families (aquaculture families plus fishing families) in many fishing villages in Mie, Miyagi and Hiroshima prefectures (45).

The history of aquaculture in Japan is rich in various experiences of technology transfer and innovation, trial and error, and the evolutionary process. Transplantation and stocking have played an important role at the early stages of aquaculture. When aquaculture became extensive in a community, artificial reproduction, feeding, disease and destruction of aquacultural grounds due to over-cultivation and inadequate waste treatment consideration became important.

Japanese history reflects chronological phases in the history of aquaculture: pre-Tokugawa period, phase I (Tokugawa era: 1600-1868), phase II: (1868-1945), and phase III (after World War II). During the pre-Tokugawa period, common carp was first raised and became popular among the aristocrats. During the phase I period, oyster, laver, mullet, fancy carp, goldfish, and clams (Meretrix meretrix lusoria R. and Venerupis semidecussata R.) appeared as aquaculture species. During the Phase II period, salmon (Oncorhychus spp.) and trout, snapping turtle, eel, pearl, "Ayu" fish and yellowtail were added. All other aquaculture species were introduced during the phase III period (Table 1-1 and the Appendix).

1. Pre-Tokugawa Period: Before 1600

Some knowledge of the methods of raising carp in ponds was apparently introduced from China shortly after the end of the later Han dynesty, ca 220 A.D. (16). However, the arrival of carp culture in Japan is dated at 100 A.D. by Kaempfer (31) in his statement that during the sixtieth year of the eleventh Emperor, Suinin, fish ponds were first built in Japan. Suinin appears to have been the earliest figure in

Table 1-1. History of Aquaculture in Japan

PHASE	PERIOD	SPECIES INTRODUCED INTO AQUACULTURE
Pre Tokugawa Period	Before 1600	Common carp
Phase I	1600-1868	Oyster, laver, mullet, fancy carp, goldfish and clams.
Phase II	1868-1945	Salmon and trout, snapping turtle eel, pearl, "Ayu" fish, yellowtail, grass carp and silver carp.
Phase III	After 1945	Prawn, abalone, scallop, "Wakame" seaweeds, Tangle, octopus, globe fish, red snapper and sea bream.

Japanese history to have been interested in carp culture. Keiko, who followed Suinin as the ruler of Japan (280-316 A.D.), is also supposed to have had carp reared in his garden ponds. A certain Lord Kumawani of Oka reared many birds and fish (common carp) in his gardens and ponds, and presented quantities of them to the consort of Chuai, the second ruler following Keiko.

Common carp culture is such an easy procedure that once the technique was introduced, it rapidly became a common practice. However, Japan was so richly endowed with natural fish resources that this fish culture was non-utilitarian and a luxury. It was an activity engaged in by the Chinese, and at that time Chinese culture was fashionable in the upper classes in Japan. Ponds apparently were one of the first aspects of formal gardening to be introduced from the continent, and in such a pond the common carp found a home (67). In fact, landscape gardening may have a closer relationship to the development of carp culture than has been recognized. Many of the great landscape artists were Korean, or Chinese or Japanese trained on the continent, so the common carp may have been brought into Japan many times by these men coming or returning from abroad (70). The most significant indication of the future importance of fish culture to Japan was the preference for freshwater fish acquired by the people of Kyoto at an early date (29).

Before 1600 aquaculture as such did not exist except for pet fish (55). However, the phenomena of over-fishing and conservation efforts are recorded. There were closed seasons and prohibited methods for "Ayu" fishing in 675 A.D., and closed fishing areas for all fishing in the Kansai area in 689 A.D. In 724 A.D. the Emperor Shomu reminded the

Japanese of the Buddhist precept against killing; he changed Japanese eating habits for the next five centuries. During the 9th and 10th centuries common carp were raised as pet fish by the aristocrats. However, in the 13th century Shinran, a new Buddhist leader, proclaimed that people might eat fish because eating fish did not violate the Buddhist precept against killing. His ideas gradually changed people's eating habits again. In 1502 goldfish were first imported as pet fish from China by Sakai merchants.

2. Phase I: Tokugawa Era (1600-1868)

The Tokugawa era is characterized by the refinements of feudalism imposed by the Tokugawa Shogunate. The Shogunate took the drastic step of virtually closing Japan's doors to the outside world in 1639. In order to control feudal local lords, the Shogunate adopted the "Sankin-kotai" system, which forced local lords to build a mansion in Edo (now Tokyo) and to live there and in his local territory for alternate years. As the Shogunate had intended, this system was a heavy burden to local lords,who attempted to alleviate the problem by supporting local industries. Aquaculture was regarded as a potential local industry by some local lords, and the transplantation of various species was attempted in various parts of Japan (Appendix).

The growth of great new centers of population was characteristic of the Tokugawa era, and midway in the Tokugawa era a rising middle class of merchants began to weaken the position of the aristocracy. The newly rich among the commoners sought to express their rise in economic status by consuming goods which reflected their social aspirations. There was a marked increase in the use of richly colored silks, fine porcelain, lacquerware and other art goods, as well as of the more expensive foods.

The common carp was considered desirable, undoubtedly because of its association with the continental culture from which Japan has borrowed so much (16).

Further, the carp traditionally has been associated with Boys' Day, a festival celebrated by all Japanese families with male children. At this time, May fifth of each year, the "carp banner", a fish shaped streamer of cloth, is flown from a pole erected next to every house where the family has a son, and the flesh of the fish is eaten to solemnize the occasion (71). The Japanese believe that the carp is an extraordinarily courageous creature. It is a fish that ascends the swiftest streams, and when it is brought alive to the cleaning block, it does not quiver while being cut up for the table. Such behavior, reflecting portions of the warrior's code in Japan, may explain in part the Japanese appreciation of the carp.

After much trial and error, common carp culture settled in Niigata and Nagano prefectures, oyster at Hiroshima Bay, laver and clams in Tokyo Bay and goldfish at Yamatokooriyama, Nara prefecture.

Since 1773 the Miomote River (Niigata) has been regarded as a salmon spawning river by Takeiji Aotogi. In order to increase the salmon population, Sori Naito legislated the OTOMEGAWA-NO-SEI: closed season for salmon and salmon fry in the salmon spawning rivers in his territory of Murakami-hama, Niigata. In 1774 the Shogunate announced fisheries regulations. Fish, shellfish and seaweeds which do not migrate offshore, were regarded as the property of local fishing villages, while anyone was allowed to catch the fish which migrate offshore. In 1781 a conservation law on pearl oysters in Omura Bay, Nagasaki, was enacted (55).

The technique of cultivating carp in flooded rice paddies developed in 1845 (16). As early as 1854 efforts were made to propagate a native trout artifically, but this enterprise for cultivating cold-water fish met with no success (44). During the 1863-1868 period, Bunemon Yamada put 717,000 rocks into the sea to form artificial reefs in order to increase tangle production in Hidaka, Hokkaido. It was a great success (55).

Aquaculture in this period was a product of chance and was closely related to subsistence fisheries. It operated on a small scale and was prey to instability in production, traditional marketing, and lack of experience, resulting in the abandonment of many aquaculture grounds due to filling and other alternative uses.

3. Phase II: 1868-1945

After the long isolation, Perry arrived in his black ships in 1853. There was great turmoil for about a decade until the feudal system of the Tokugawa Shogunate collapsed in 1867, and full sovereignty was restored to the Emperor in the Meiji Restoration in 1868. Under the Emperor Meiji, the country set out to achieve in only a few decades what took centuries to develop in the West. The whole country embarked on the study and adoption of modern Western civilization with energy and enthusiasm.

In 1875 the government dispatched Minsei Sekizawa (later Director of Suisan-Denshusho: Fisheries School founded in 1887) to America to learn techniques pertaining to artificial fertilization and ocean ranching of salmon and trout techniques, which were first practiced in Japan the following year. In 1877 rainbow trout eggs were transplanted from Shasta, California, and grass carp and silver carp fingerlings were imported from

China the following year. The government also sent Shinnosuke Matsubara to Germany to learn German aquaculture techniques in 1880. In 1881 a Fishery Section was established in the Ministry of Agriculture and Commerce, later changed to the Fishery Bureau consisting of three sections of Fisheries, Fisheries Experiment and General Affairs in 1885 (55).

During the 1886-1929 period many laws were legislated. The relevant ones include the Fishermen's Association Quasi-Law in 1886, the First Fisheries Law in 1901, Co-operative Facilities Act for Agriculture and Fisheries Development in 1918, Salmon and Trout Culture Act in 1919 and the Prefectural Fisheries Experiment Station Act in 1929. As a result, a salmon hatchery---later the center for the salmon ranching program in Hokkaido--was established in Chitose, Hokkaido; trout farms such as Samegai (Shiga), Kawaguchi (Yamanashi), Fuji (Shizuoka) and Gassan (Yamagata) were founded; the salmon ranching business was rapidly adopted; and by 1931 almost two hundred trout and salmon hatcheries were in operation, pouring something like 450,000,000 fry into the lakes and rivers of Japan each year (72). Public agencies also sold carp fry to peasants with rice paddies and bought back from the same individuals the fish that were not yet large enough to be sold as food at harvest time. These carp were used to restock rivers and lakes (30). The production of freshwater species such as "Ayu" and eel, and marine species such as oyster, abalone, sea cucumber, tangle, Gelidium and Gloiopeltis was also promoted, and various kinds of artificial reefs were built at sea.

At the same time, numerous educational and research institutions

were established. These included the First Marine Laboratory at Aburatsubo, Kanagawa in 1885, Suisan-Denshu-Sho (later Tokyo University of Fisheries) in 1887, the First Fisheries Experiment Station at Isshiki, Aichi in 1891, Department of Fisheries at Sapporo Agricultural School (later Hokkaido University) in 1897, and Department of Fisheries at Tokyo University in 1909. Furthermore, the First National Aquacultural Conference was held in 1913.

During the era of the Russo-Japanese War (1904-1905), at the peak of the Industrial Revolution, the present pattern of fish culture around large centers of population developed (16). Although industrialization raised land rents in the vicinity of the cities, it did, of course, also increase the size of those cities and raised the standard of living of the city dwellers. Demand for status-foods such as eel and carp increased just at a time when the pisciculturists might otherwise have felt discouraged by the way the factories were driving them from the cities. Fortunately, by this time the railroad system of Japan was fairly well complete, and it was possible to ship fry or fingerlings and live food fish safely and rapidly by this new medium. Kurajiro Hattori had developed snapping turtle and eel culture during the 1866-1879 period, and began his commercial venture in Hamanako, Shizuoka, in 1899 (21). However, years were to pass before the problems of feeding the fish were solved adequately, and it was not until the wave of prosperity attending the Russo-Japanese War (1904-1905) that eel culture was developed sufficiently to permit rapid and large-scale expansion (14). The expansion of eel culture was due mainly to a favorable government food production policy, utilization of the waste products of the sericulture for which Japan was famous, pumping water, and a high demand for eel. This expansion also encouraged the development of fry fisheries and export

market among Japanese abroad. The rearing of carp, eel and mullet together in brackish ponds became popular.

Carp were already being reared in small ponds with running water, a method which began in 1896 (16). Apart from eel and carp culture, transplantation methods of laver seeds were developed in Chiba in 1879. Kokichi Mikimoto established a technique to produce cultured pearls (half-round pearls) in Shima, Mie, in 1893, while Tokichi Nishikawa and Tatsuhei Mise developed the technique to produce the round pearl in Omura Bay, Nagasaki in 1907. Sadayuki Wainai successfully produced land-locked sockeye salmon in Lake Towadoko, where no fish had lived. In 1909 the Shiga Fisheries Experiment Station proved the hypothesis that small Ayu in Lake Biwako could grow larger if adequate food were available, and Chiyomatsu Ishikawa transplanted Ayu to the Tama River in 1913 and showed that transplanted Ayu could grow as large as wild Ayu in various rivers.

The technique of harvesting round pearls from freshwater mussels was established by Shosei Fujita in 1924, while in 1931 Fukutaro Tange was the first to collect pearl oysters in Palau, later the largest pearl oyster fishing ground in the world. Furthermore, Shinsho Miyagi and Juzo Hori proved the economic feasibility of raft methods for oyster culture at Kanazawa Oyster Laboratory, Kanagawa in 1924, and oyster seeds were exported from Matsushima Bay to the United States. In addition, young yellowtails were first domesticated by Sakichi and Wasaburo Noami at Ado Pond, Kagawa in 1930 (55).

It appeared that aquaculture could be important to the Japanese economy. However, Japan's involvement in the Manchurian incident in 1931, in the China-Japanese incident in 1937, and in World War II in 1941 forced the aquaculture industry to conform with The National Emergency Act

in 1938. Pearls and eel were regarded as luxury goods, and were prohibited. The pearl industry was controlled by the government, and eel ponds were filled for rice, wheat and sweet potato production. Carp, laver and other aquaculture species were treated in the same way, with the exceptions of grass carp (Ctenopharyngodon idellus C. et V.) and silver carp (Hypophthalmichthys moritrix idellus C. et V.), for which approximately 3.7 million fingerlings were imported from China to meet the demand for food during the 1941-45 period (73).

Aquaculture during this period was the product of imitation, trial and error processes influenced by government intervention, and the devotion of volunteers to the industry. This industry that was born of different origins from the old subsistence coastal fisheries, has developed in the framework of capitalistic aquaculture.

4. Phase III: After World War II (1945-1978)

Immediately after the surrender of Japan, General MacArthur implemented a policy of occupation designed to reform the total structure of society and business, a restructuring which vitally affected aquaculture. In 1952 Japan regained its sovereign independence and, in 1956, was admitted to full membership as the 80th member state of the United Nations. The acceptance into the world community seemed to signal a revitalization, and the following decade was characterized by a degree of economic growth and development perhaps unprecedented in the history of any nation. In aquaculture there was a quick recovery of the pearl, oyster, and eel industries. At the same time that aquaculture became more important, water pollution became more severe.

General MacArthur contributed directly to the recovery of aquaculture by reconstruction of the pearl and oyster industries as well as other general development (55). The first five-year plan for pearl culture development started in Mie in 1947, and the export of oyster seeds from Matsushima Bay to the United States was resumed. By 1953 pearl production reached the highest level of production that had been achieved before the war; oyster production had reached that level by 1952.

However, eel was outside government price control at a time when most items were rationed. Domestic demand for eel as a luxury food was high, for use at receptions and banquets, but since demand exceeded supply, eel was very expensive. Investors put money into the eel business, and by 1953 the production of eel had reached levels as high as before the war (21).

Among the laws enacted during the 1948-56 period were the Fisheries Agency Acts and the Fisheries Cooperative Association Law in 1948, the Second Fisheries Law in 1950, the Law Promoting Reorganization of Cooperative Associations of Agriculture, Forestry and Fisheries as well as the Law Promoting Pearl Culture in 1951, and Financial Acts for Smaller Enterprises of Fisheries in 1952.

During the same period there was a growth of technological innovations. Synthetic fiber nets became available in 1950, and net culture began in 1952 (27). Artificial fertilization became possible experimentally for yellowtail in Megima, Kyushu, and rope culture for "Wakome" seaweeds began in Onagawa Bay, Miyagi, in 1954. Vertical hanging-style scallop culture was attempted in 1956. Eventually young yellowtail culture based on net culture was widespread (68),and rafts or ropes began to be used for commercial scallop ventures (22) and artificial culture

techniques were adopted for laver in 1958 (27). This was the period of preparation for modern aquaculture based on scientific knowledge, which characterized the following decades.

Japanese economic growth had some detrimental effects, including water pollution, which threatened aquaculture. Industrial pollution from Honshu-seishi (paper company) destroyed the laver culture grounds in Urayasu, Chiba, in 1958, and Water Pollution Control Acts were legislated in the same year (27). During the 1960-68 period additional laws were enacted: the Law Promoting Reorganization of Fisheries Co-operative Associations in 1960; the Third Fisheries Law in 1962; the Agricultural Pollution Control Act amended and the Law Promoting Inshore Fisheries in 1963; the Practical Fisheries Cooperative Extension Service Acts in 1966; the Law Promoting Adult Education in Fishermen's Villages and the Fisheries Disaster Relief Law, the Environmental Protection Law and the Law Promoting Amalgamation of Fishermen's Cooperative Associations in 1967; and the Fisheries Resource Conservation Law in 1968.

Nevertheless, the salmon in the Ishikari River, of which 1,480,000 were caught in 1892, 67,000 in 1958, 2,000 in 1969 and 380 in 1970, are decreasing rapidly because of pollution (57). During the 1961-68 period, 22 of 40 fishermen's cooperative associations in Chiba were forced to abandon their laver culture grounds in Tokyo Bay because of land-filling for industrial development. All laver culture grounds in Tokyo Bay were to be abandoned by 1975. (28) The"Minomata Disease", which results from mercury poisoning, and other PCB problems became national issues in 1968.

Waste water from paper companies became an issue in Tagonoura,

Iyomishima and Kawanoe, and cadmium pollution appeared in the Ariake Sea in 1970; red tide took its toll of fish farms in the Inland Sea in 1972; self-waste problems from fish farming became an issue in 1973; the bulk of the scallops were killed in Aomori, Iwate and Miyagi; and red tide again invaded fish farms in the Inland Sea in 1975 (66).

Water pollution and disease problems became severe and commonplace for the aquaculture industries. In addition to natural catastrophes such as the Isewan Typhoon in 1959, the Chile Tsunami in 1960, and unusual weather in 1964 and 1966, diseases severely damaged laver culture in 1968 and 1969, goldfish farms in 1968 and the eel industry in 1968. Eel and yellowtail industries suffered from the shortage of fingerlings, and a shortage of eel elvers in 1968 led to 245 tons of elver imports, which introduced new problems of disease. During 1968-1973 the national supply of eel elvers was extremely low, and imported elvers were essential to eel culture. In 1975 a shortage of yellowtail fingerlings occurred, resulting in high fingerling prices.

Nevertheless, there was a vibrant growth in aquaculture development. (Figures 1-4 and 1-5). In 1962 the Inland Sea Ocean Ranching Center was established, with the objectives of development of mass production techniques of artificial mariculture seedlings to increase fisheries resources in coastal fishing grounds on a gigantic scale, and of education of fishermen to manage fisheries constructively. During the 1962-1976 period, artificial mass production techniques of larvae and fry of "Kuruma" shrimp, red snapper, blue crab and flounder were developed, and remarkable progress has been made in releasing and culturing these fry. In addition to the existing six centers already in operation in the Inland Sea area, 38 more centers were planned for all parts of Japan.

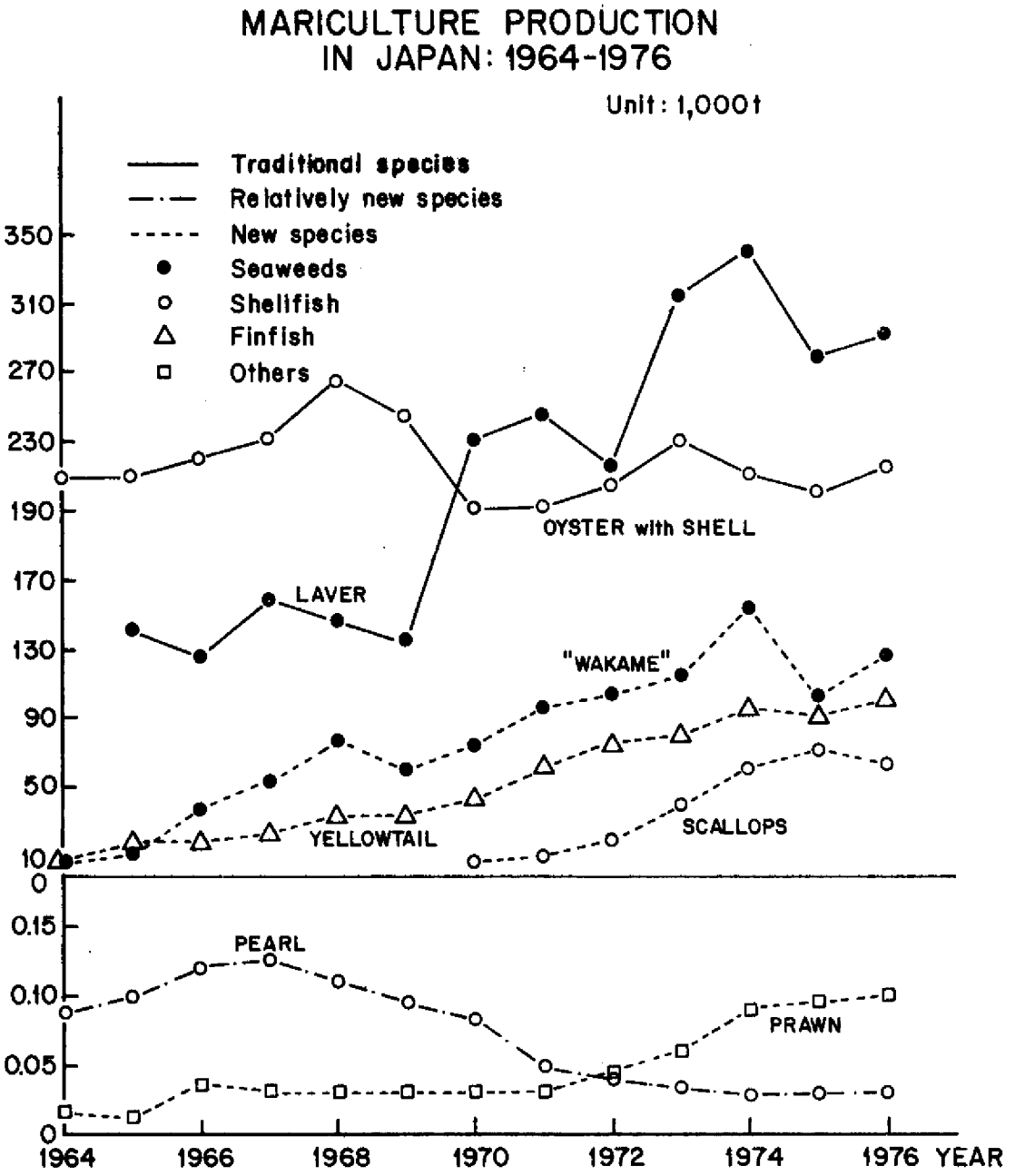

Figure 1-4

Sources: Suisansha, Fisheries Yearbook 1968, 1968; 1971, 1971; 1976, 1976(62) and Ministry of Agriculture, Forestry and Fisheries, Annual Report of Fishing and Aquaculture Statistics 1975, 1977 and 1976, 1978: 168-169(46).

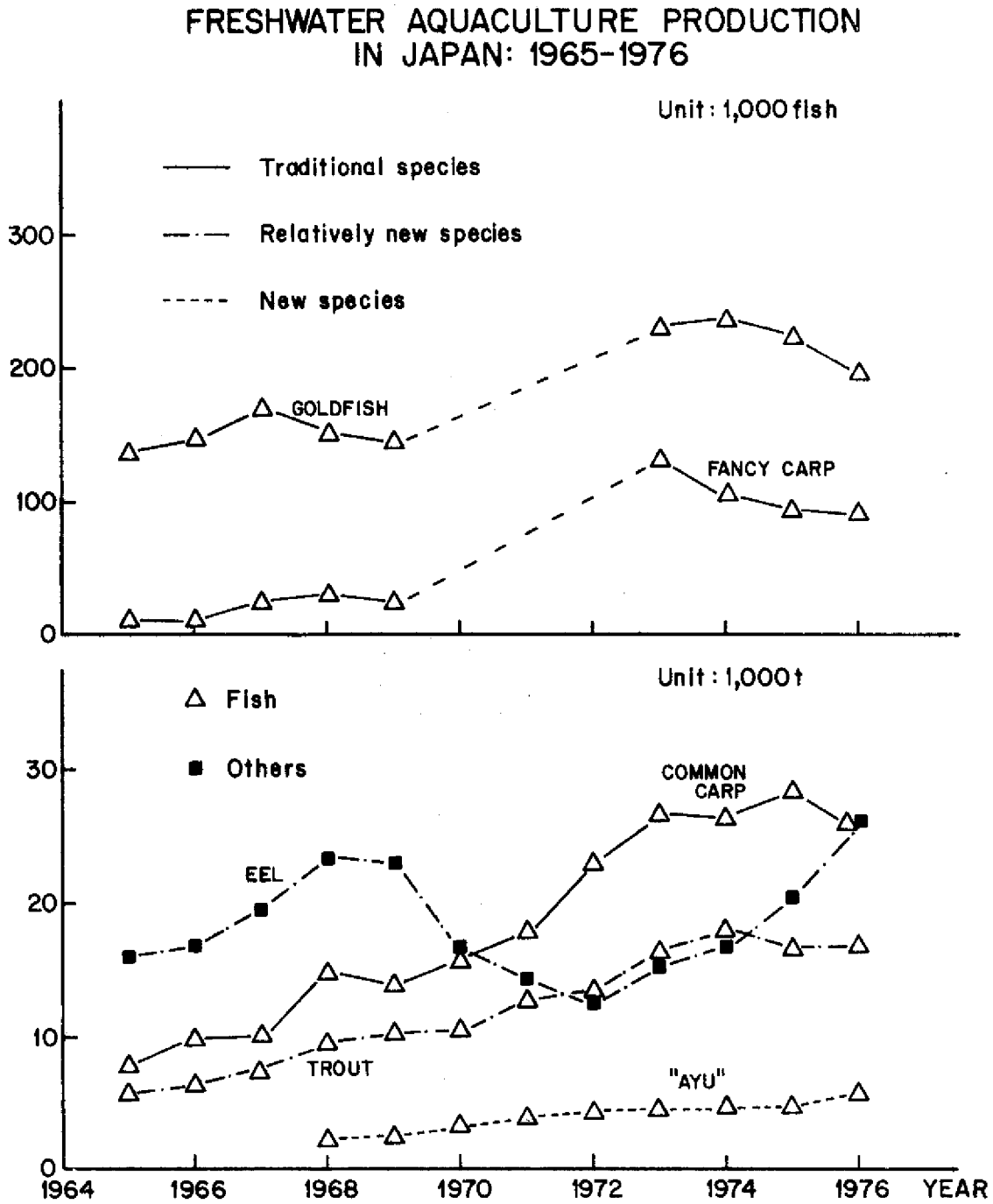

Figure 1-5

Sources: Ministry of Agriculture and Forestry, Annual Report of Fishing and Aquaculture Production 1975, 1977 and 1976, 1978: 208-209(46).

In addition, other technological improvements occurred in traditional species such as laver. "Beta-Nagashi" culture methods were developed in Miyagi in 1963, and double crops in laver production began, due to the invention of low temperature stocking nets in 1966. The technique for the artificial fertilization of eel was experimentally achieved in 1973. In 1975 salmon products in Hokkaido exceeded the highest production reached before the war. Further, the government legislated the Coastal Fishing Grounds Adjustment and Development Law in 1974. Based on this legislation, the Coastal Fishing Grounds Adjustment and Development Projects are under way. These projects intend to develop the inshore fishing grounds during the 1976-1982 period with the total expenditure of approximately .7 billion dollars. These projects include artificial reef construction, ocean ranching and environmental protection programs.

The declaration of a 200-mile economic zone by the United States, effective on March 1, 1977, and support by the U.N. Law of the Sea Conference participants for a 200-mile economic zone will result in a decrease of Japanese fish production of up to 4.6 million tons, nearly one-half of its production in 1976. The Japanese distant water fleet now will be prohibited from fishing in a number of areas formerly heavily fished. Approximately 50 percent of animal protein in the Japanese diet comes from marine products, and the demand for fish is extremely high. The Japanese fisheries are now forced to change their attitude toward fisheries.

SECTION 2. STRUCTURAL CHANGES IN RURAL VILLAGES DUE TO AQUACULTURE DEVELOPMENT

Aquaculture is accepted by local people only when the potential for income is shown to exceed that produced by existing industries. The history of aquaculture villages is classified into five cases (55):

1. Aquaculture starts as coastal fishing decline,
2. Aquaculture starts in areas where other industries, except for coastal fisheries, are dominant;
3. Aquaculture starts where fisheries do not exist;
4. New aquaculture ventures start where old aquaculture ventures already exist, resulting in competition or coexistence of different types of aquaculture;
5. Aquaculture is abandoned due to the influence of other industries.

The first case is most common among present aquaculture villages. Most laver and pearl culture projects have developed in caostal fishing villages which also support shellfishing and seaweed gathering, and yellowtail culture has developed where fish stocking techniques exist, such as live bait fish supply areas. Furthermore, merchants who are live fish transporters and middlemen tend to get involved in these aquaculture ventures.

The second case is quite rare, but exists. In Wagu and Hamajima, Mie, pelagic fisheries and pearl culture coexist. In this case, alien aquaculturists have brought capital and techniques to the villages, absorbed the local unemployed women as labor and developed a pearl culture industry. Another example is the yellowtail and "Kuruma" shrimp culture in the Seto Inland Sea area which developed after the local salt industry disappeared.

There are only a few examples of the third case: Muroyoshida, Aichi, changed from a rice production area to an eel culture area; Obama area, Shiga, changed from an agricultural area to a freshwater pearl culture area; and in 1955, alien pearl culturists established a new pearl culture area in Iki Island, where fisheries have never existed.

The fourth case is very common. Hiroshima Bay, once a laver and clam culture resort, is now the largest oyster culture area in Japan. Lake Hamanako, formerly a laver and oyster culture area now supports an eel and snapping turtle culture. The coexistence of pearl oyster and yellowtail cultures in Kochi and laver and pearl cultures in Ago and Gokasho Bays in Mie are other examples.

The fifth case is also common, and shows the dynamics of contemporary social change. Watari oysters in Mie lost their market to the Hiroshima and Matsushima oysters, so the oyster culturists of Watari have returned to traditional offshore fishing. Laver and clam culture grounds have disappeared from Tokyo Bay due to industrial development around the bay, and similar phenomena have occurred along Japan's coast.

According to Oshima (55), structural changes in rural villages due to aquaculture development are quantitatively demonstrated by changes in the "aquaculture- total fisheries family ratio"* and in types of

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* Aquaculture-Total fisheries family ration is expressed by:

$$\frac{\text{Number of Aquaculture families}}{\text{Number of Aquaculture families \& number of fishing families}} \times 100\%$$

aquaculture. The developments in the Tohoku region and Mie prefecture will be discussed, based on the first (1954) and second (1963) census results (55).

1. Tohoku Region: Miyagi and Iwate Coasts

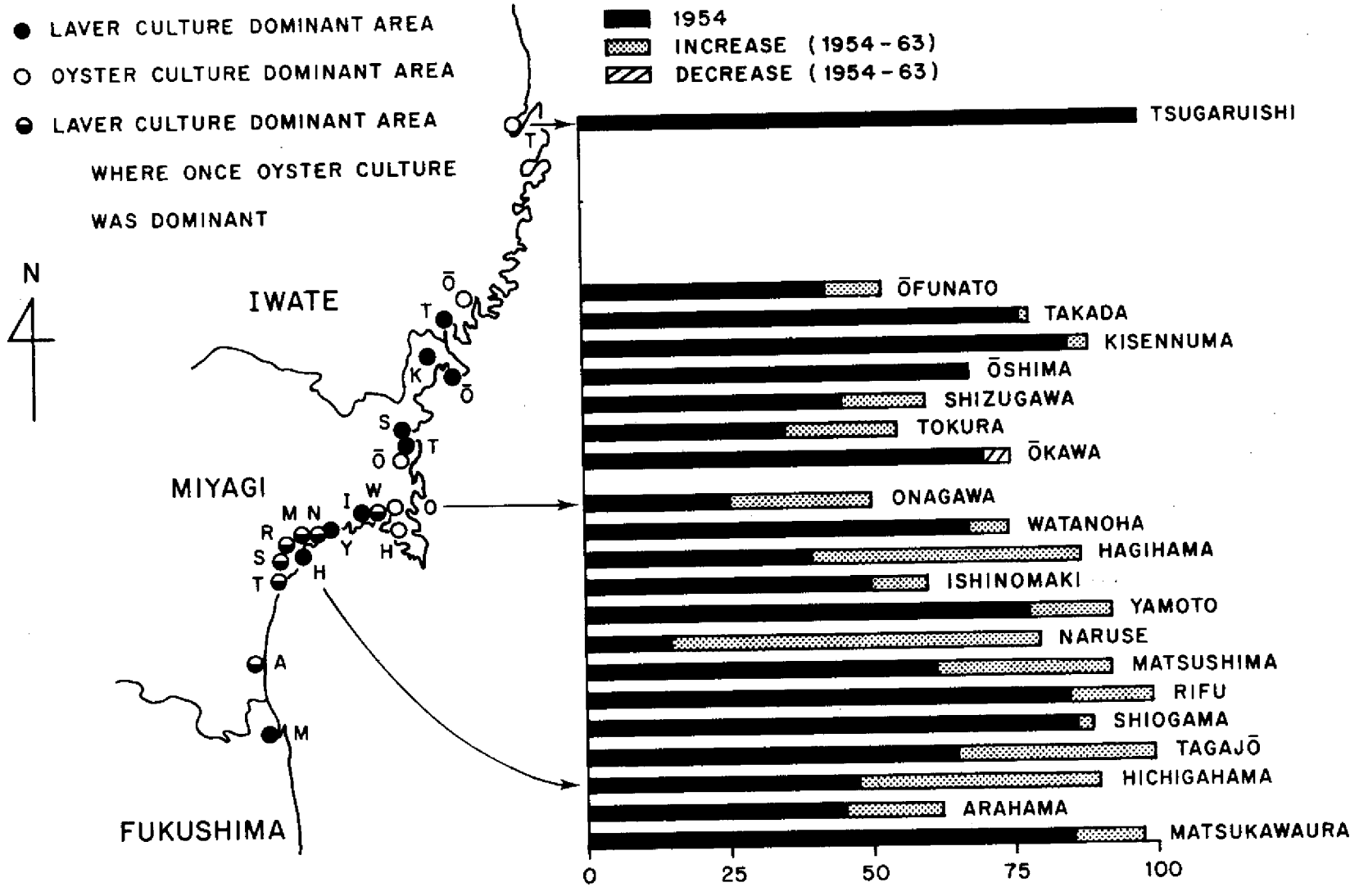
The coasts of Miyagi and Iwate traditionally have both an oyster and a laver culture. However, a stagnant demand for oyster and an increasing demand for laver during the 1954-1963 period gradually changed the character of the aquaculture from oyster to laver in many villages, Tsugaruishi, Watanoha, Maruse, Matsushima, Rifu, Shiogama, Tagajo and Arahama (Figure 2-1). Among them, Matsushima, Tagajo and Rifu showed 100% change. Where rough water made a change to laver culture difficult, the villages of Ofunato, Onagawa, and Hagihama adopted a Wakame seaweed culture.

In most cases, the "aquaculture-total fisheries family ratio" increased from 1954-1963. This implies that the relative importance of aquaculture in these fishing communities increased. The only decline of "aquaculture-total fisheries family ratio" is observed in Okawa, where the number of fishing families increased while the number of aquaculture families was unchanged. In 1954 oyster culture was dominant in all 84 aquaculture families, but 12 of them changed to laver culture by 1963.

Although aquaculture generally gained in popularity in these rural villages, competition and/or coexistence between coastal fisheries and aquaculture industries and within the aquaculture industry existed.

2. Mie Prefecture

Mie is unique in the variety of aquaculture species which it



AQUACULTURE - TOTAL FISHERIES FAMILY RATIO IN TOHOKU AREA, JAPAN : 1954 - 1963

Figure 2-1

Source: Oshima, J., A Geographical Study of Aquaculture in Japan, University of Tokyo Press, Tokyo 1973, p.85(55).

supports within a small region, with laver, oyster and pearl the dominant species along the coast. Once oyster was one of the most important species in the area, and there was a noticeable growth in the culture during the 1929-30 period (Figure 2-2). It had been started by alien aquaculturists and developed without having any ties to the existing fishing industries. The production of oysters on rafts reached a peak in 1941, while natural production eventually declined due to overfishing that started in 1932.

Change in the "aquaculture-total fisheries family ratio" during the 1954-63 period is shown in Figure 2-3. In contrast to the rise of the pearl and laver cultures during this period, the decline of the fishing industry and the oyster culture is remarkable. There is a tendency toward monoculture in Kisozaki for laver, and Tategami, Shinmei and Gokasho for pearl. Uramura, Iihama, Matoya, Kou and Hikimoto were once important oyster areas, but except for Uramura the situation had changed drastically by 1963. Laver from the north, and original oyster and pearl from the south coexisted in Iihama, Mataya and Kou. Hikimoto changed from an oyster to a pearl oyster monoculture area.

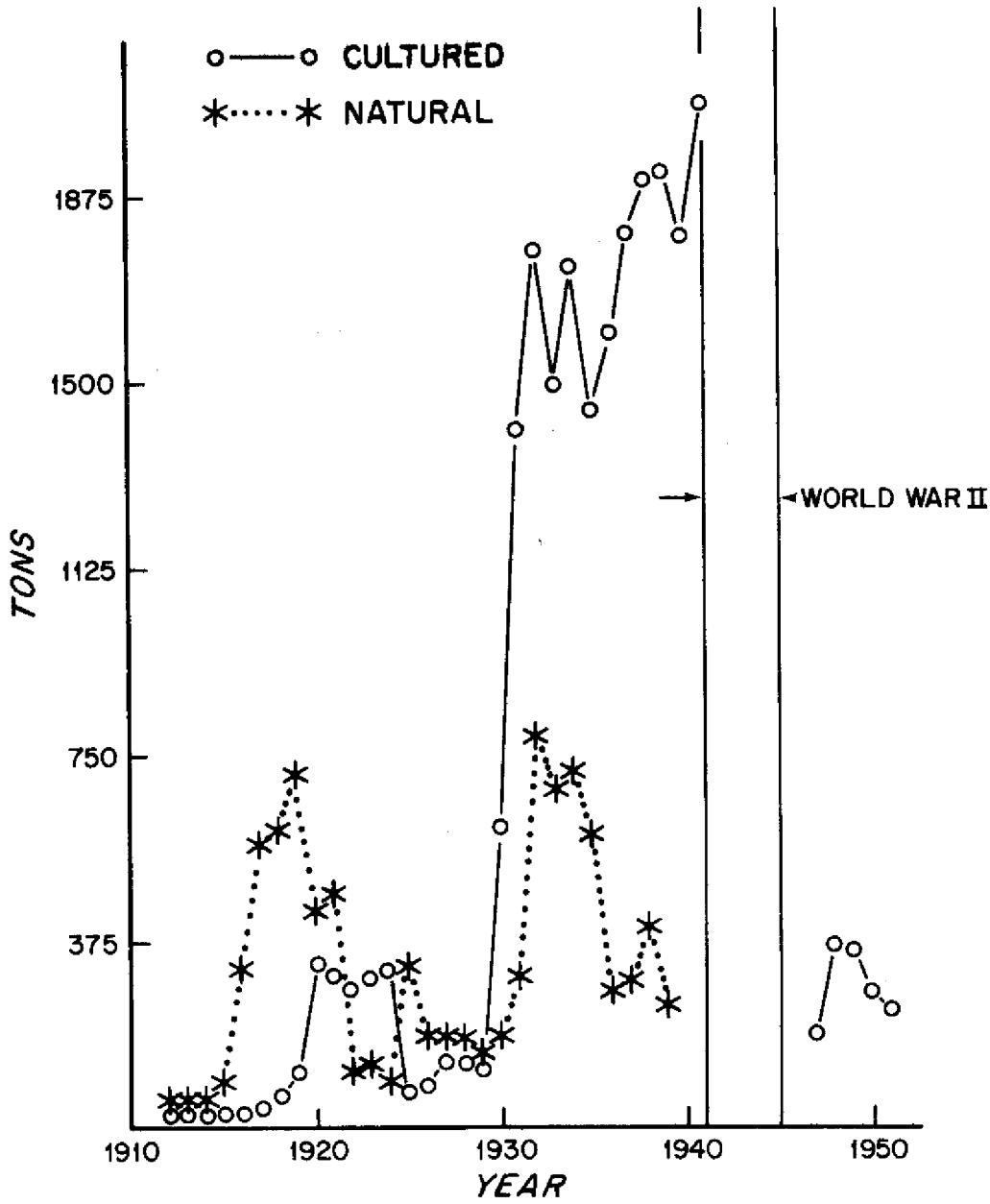


Figure 2-2

Source: Oshima, J., A Geographical Study of Aquaculture in Japan, University of Tokyo Press, Tokyo 1973, p.279(55).

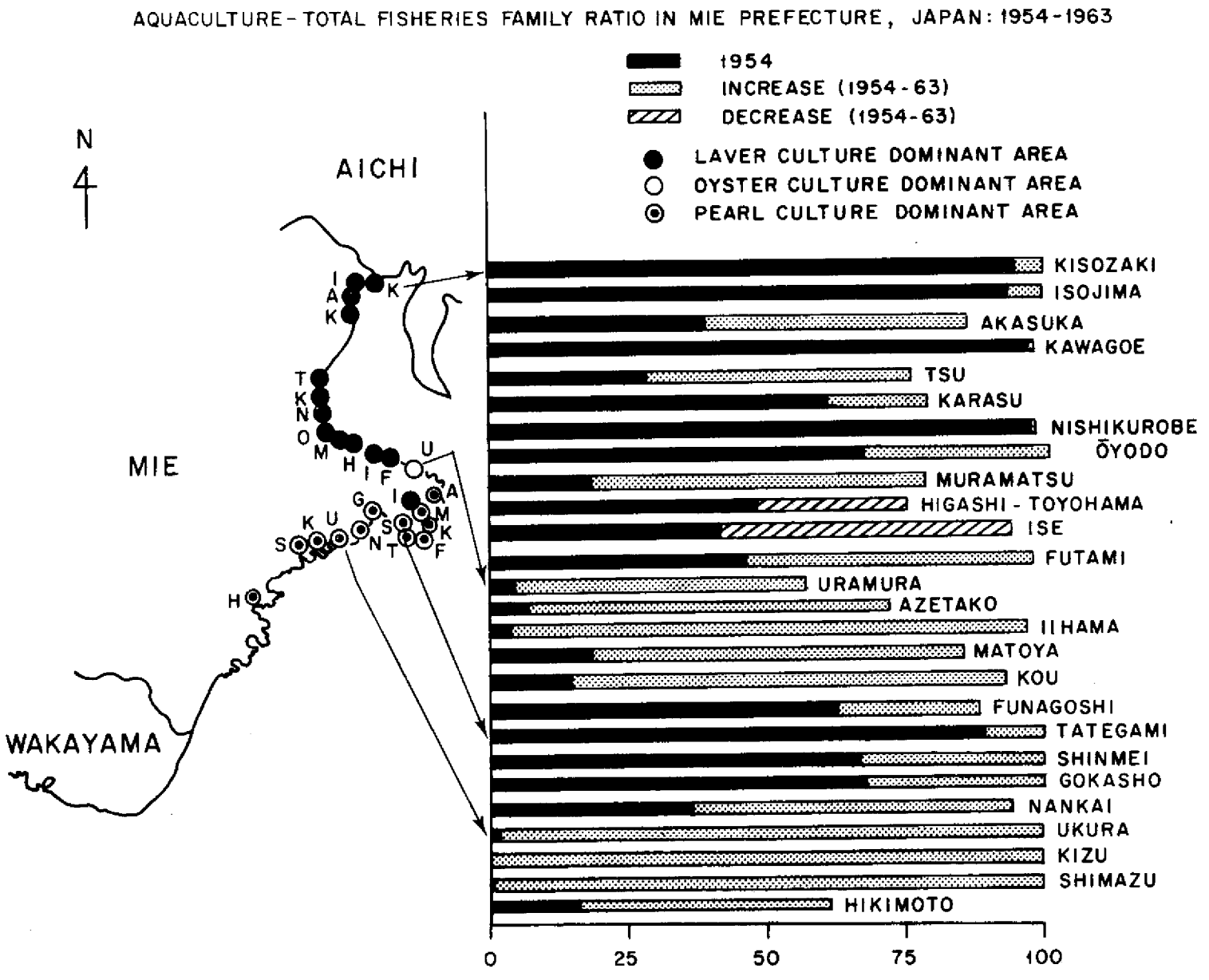


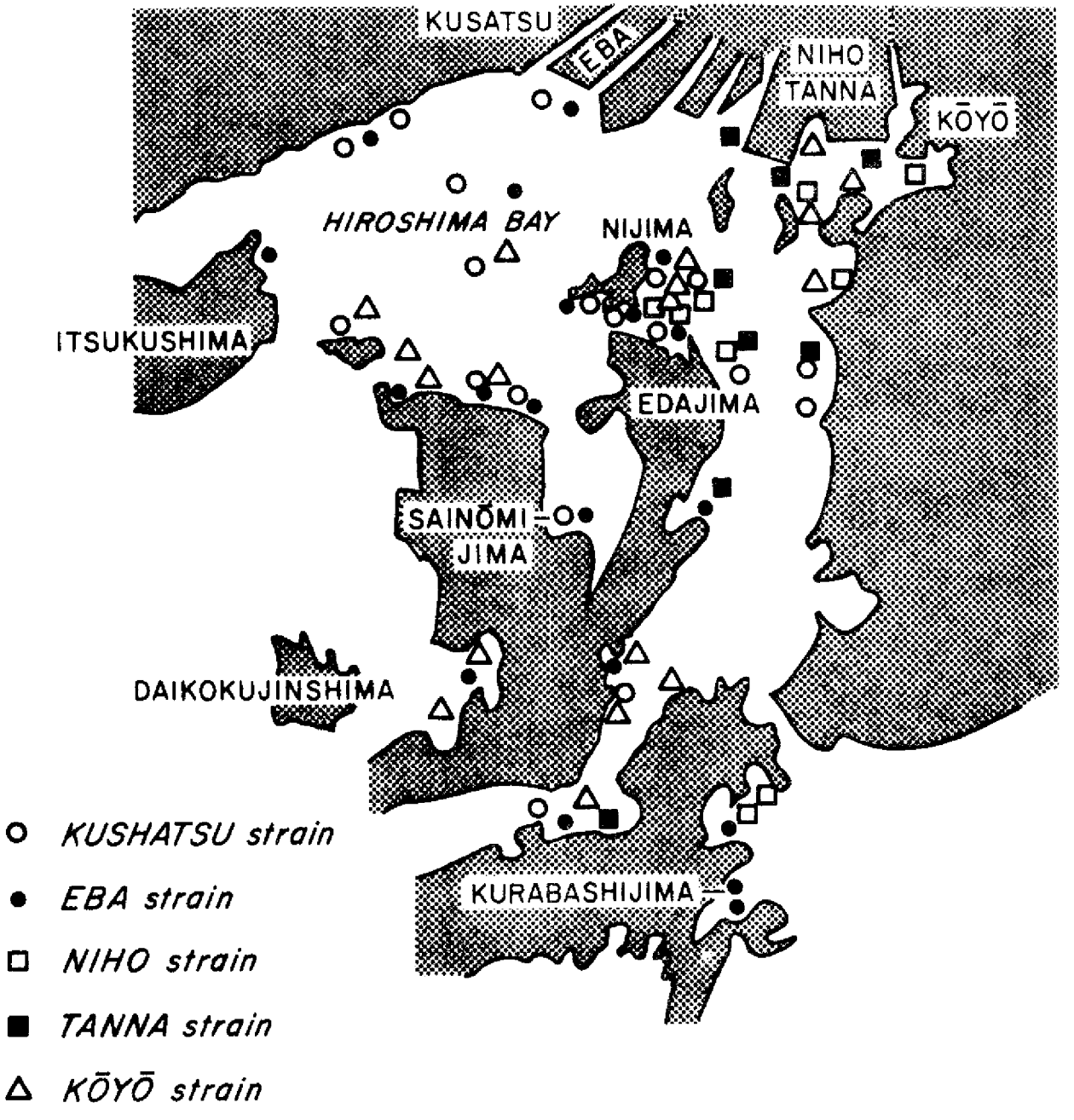
Figure 2-3. Aquaculture-Total Fisheries Family Ration in Mie Prefecture, Japan: 1954-1963.

Source: Oshima, J. A Geographical Study of Aquaculture in Japan, University of Tokyo Press, Tokyo 1973, p.101(55).

SECTION 3. CHARACTERISTICS OF AQUACULTURE DEVELOPMENT

1. Hiroshima's Oyster Marketing

Oyster culture villages in Hiroshima Bay were established during the 16th century and even today produce nearly 72% of the total oyster meat production in Japan (62). The oyster guilds, which market their products in Osaka, have played an important role throughout the history of this culture (55). The Kusatsu oyster guild received a license from the Tokugawa Shogunate in 1690. It consisted of 16 stocks of which one stock was a unit containing three people, 1.7 hectares of oyster grounds (including .4 hectares of Natsuageba: summer grounds, and .6 hectares of Miireba: winter grounds) and one oyster boat to market in Osaka. It was given a monopoly of oyster marketing in certain areas. Although similar oyster guilds were admitted in Hiroshima Bay, tireless competition among guilds to expand marketing territories continued for centuries. At present, the so-called Kusatsu, Eba, Niho, Tanna and Koyo strains are remnants of those guilds (Figure 3-1), but three different oyster production systems have succeeded in the small Hiroshima Bay. These are Kusatsu, Niho and Koyo methods, which suit the natural condition in each area. Paradoxically, this closed production and marketing network has given the Hiroshima oyster culture a great advantage over the oyster industry in other parts of Japan.



A MAP OF OYSTER CULTURE AREAS IN HIROSHIMA BAY, 1963

Figure 3-1

Source: Oshima, J. A Geographical Study of Aquaculture in Japan, University of Tokyo Press, Tokyo 1973,p.83(55).

2. Traditional vs. Modern Laver Culture

The name "Asakusa-nori" is familiar to the Japanese, but there now is no "Asakusa-nori" production area in Asakusa, Tokyo. Laver culture started in Asakusa in the 16th century, and it has been one of the favorite foods of the Japanese people ever since.

However, industrial growth since the war has blocked the development of laver culture in many parts of Japan. Fishermen completely abandoned culturing laver in Tokyo Bay and Toyohashi area in 1975; pollution problems have been serious in Chita and Atsumi Bay and the Yokkaichi area in Ise Bay.

Nevertheless, this industry is growing rapidly, holding approximately 40,000 enterprises, producing 339 tons (equivalant to 8.6 billion sheets), and earning nearly 300 million dollars gross income in 1974.

A historical review of cultured laver production in Japan is shown in Figure 3-2. There have been technological improvements in the basic field of production such as alga substrata, seedling methods and seed storing.

The development of synthetic fiber encouraged net laver culture in 1950, and laver culturists have taken advantage of synthetic fibers ever since. They developed "Ami-hibi" early in the 1950's and "Ukinagashi" and "Betanagashi" in the 1960's, resulting in an expansion of laver culture grounds throughout Japan's coast. Artificial culture techniques developed late in the 1950's, providing

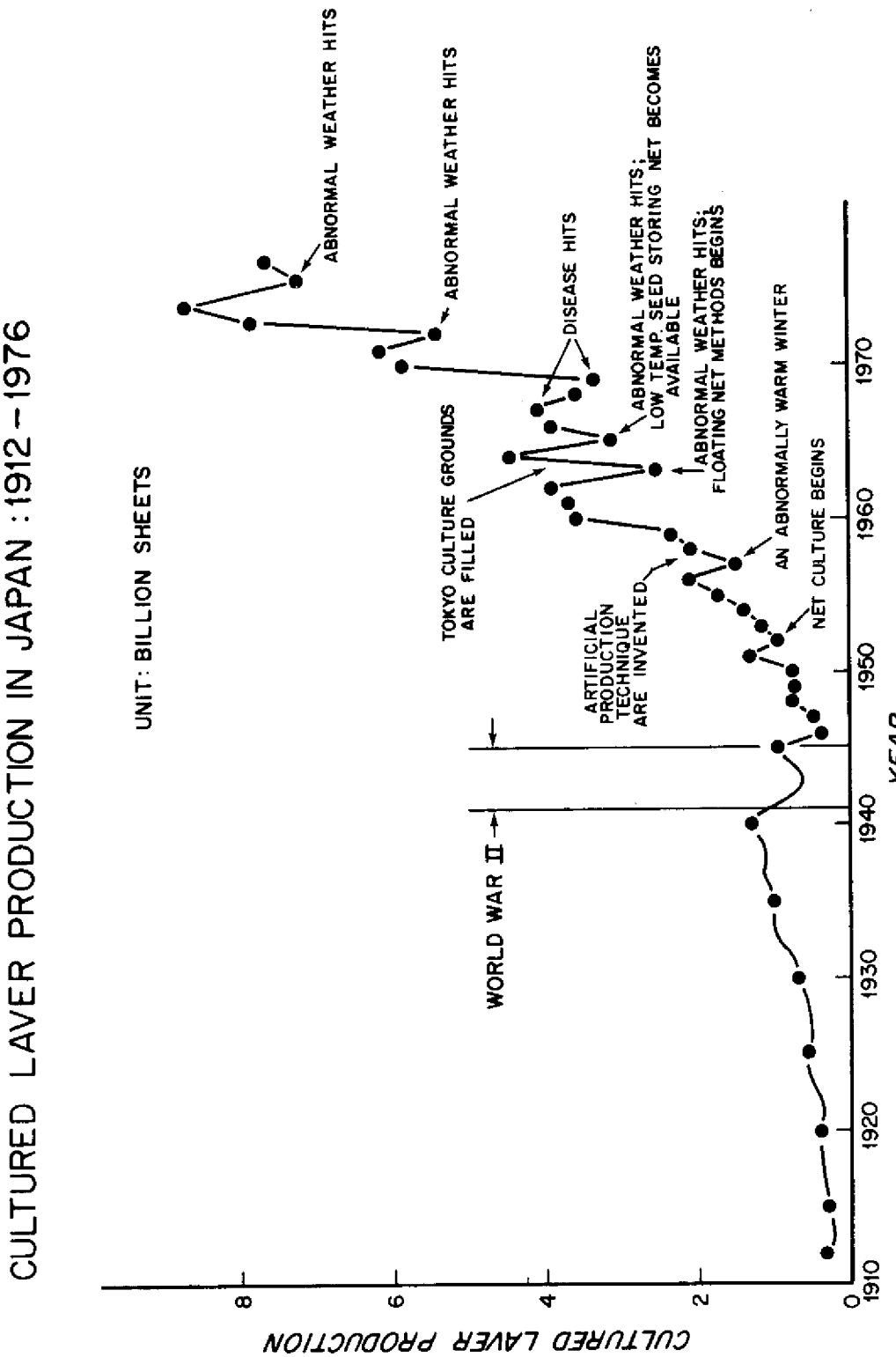


Figure 3-2

Sources: Complied from Japanese Federation of Laver and Shell Fisheries Cooperatives, The First Twenty Years of Japanese Federation of Laver and Shell Fisheries Cooperatives, 1969, pp.8(29); The Ministery of Agriculture and Forestry. Annual Report of Fishing and Aquaculture Production Statistics 1975, 1977, p.172(49); and The Ministry of Agriculture, Forestry and Fisheries, Fisheries Statistics of Japan 1976, 1978, p.17 (47).

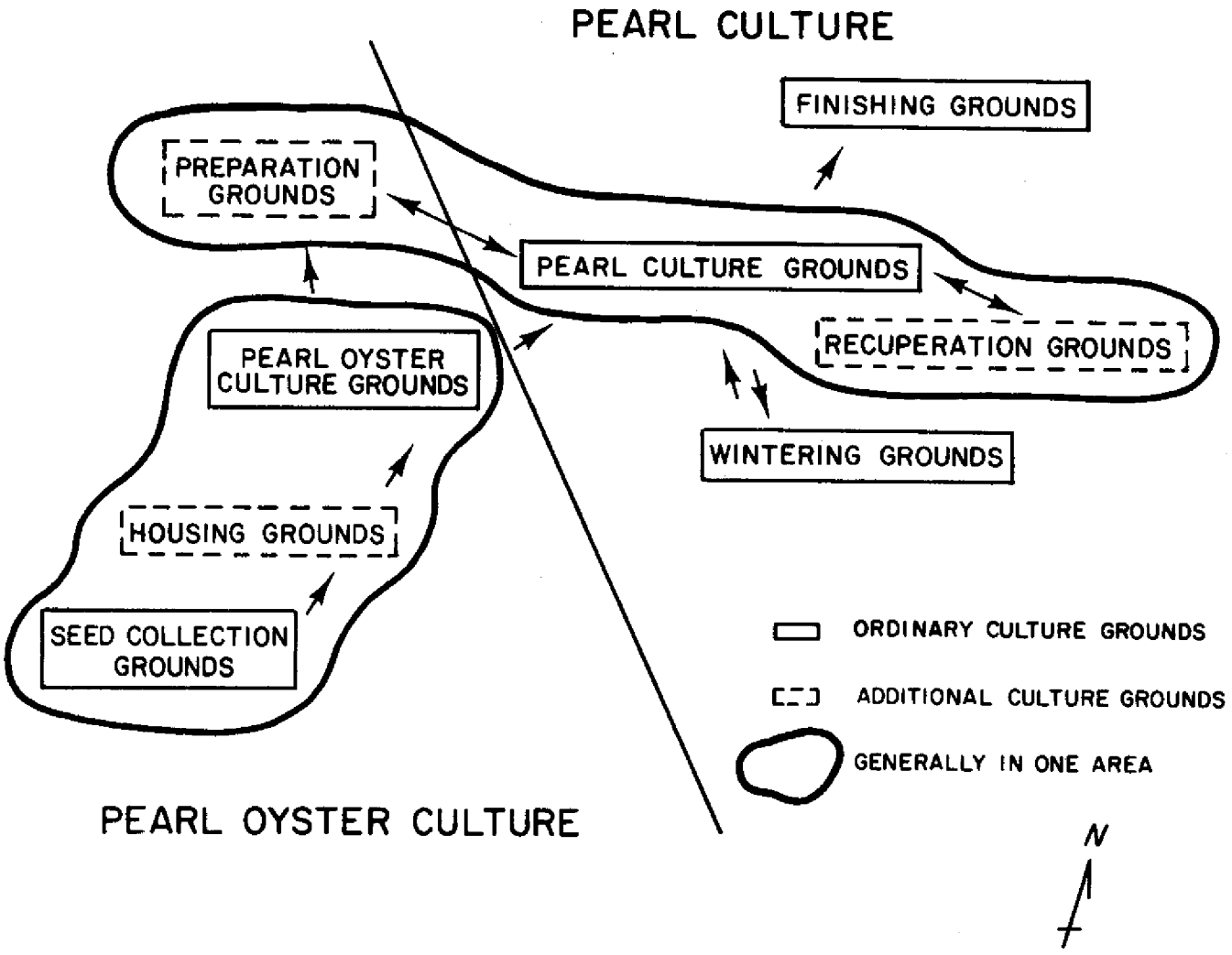
stability to the laver culture. The invention of low temperature seed storing methods in the 1960's doubled the crops in a year and increased the productivity per area. In addition, labor-intensive technology in production and processing methods has been fully exploited.

However, despite the expansion of laver culture grounds and the increase of total production, the number of enterprises has been decreasing rapidly. More than 60,000 enterprises were engaged in this industry in 1970; there were about 34,000 in 1976. Today the laver industry tends to be highly professional, large in scale, highly mechanized and more competitive than any other industry.

3. Pearl Culture: Behind the World Commodity

Within less than a century, labor-intensive technology has created a unique world industry of pearl culture in Japan. This industry has competed successfully with other sophisticated, mechanized and capital-intensive big industries since the war, yet the industry has declined since 1966 due to a decline in the growth of demand. The gross earnings of this industry were approximately 100 million dollars in 1966 and 50 million dollars in 1974.

This industry developed a unique transplantation technique keyed to stage of growth (Figure 3-3): spat collection, pearl oyster culture, pearl culture, wintering and finishing grounds. Even today, the pearl industry depends on natural spat. Sukumo Bay in Kochi is one of the best spat collection grounds. No one except fishermen along the Sukumo



A MODEL OF PEARL CULTURE GROUNDS

Figure 3-3

Source: Oshima, J. A Geographical Study of Aquaculture in Japan, University of Tokyo Press, Tokyo 1973, p.166 (55).

Bay is allowed to collect pearl oyster spat in this area. However, these fishermen have never fostered aquaculture ventures except for Minatoura and Mozu, where cooperatives have developed. Most of the spat is sold to the adjacent prefecture, Ehime, where cooperatives have developed. Ironically, Ehime pearl oysters are better than the Sukumo pearl oysters; the Sukumo crop develops from the poor quality spat which remain after the first sale by untrained subsistence aquaculturists. Thus, the economy of Sukumo is always unstable.

The amount of skilled labor for the pearl operations correlates directly to the amount and quality of pearl production. The man-female ratio was 16:84 in Mie and 53:47 in Nagasaki in 1954. In Mie the lack of competition for skilled labor results in ease of transition for workers from other industries to the pearl industries; the alternate industries are Ago Bay, agriculture; Matoya Bay and Toba, oysters and laver; and Gokasho Bay, pelagic fisheries.

According to the Ehime Prefectural Course on pearl culture in 1957, any one enterprise is prohibited from operating both pearl oyster culture and pearl culture, except for fisheries cooperatives. No enterprise is allowed to control pearl oyster culture, and pearl culture is allowed as a joint venture between free enterprise and fisheries cooperatives. The fisheries cooperatives in Ehime have taken advantage of free enterprise to learn operation techniques and acquire capital, and are rooted in the rural communities. Since 1963 some fisheries cooperatives which have developed enough managerial skill and capital have been allowed to transfer

to pearl culture ventures.

4. Young Yellowtail Culture: Fingerlings, Feed and Marketing

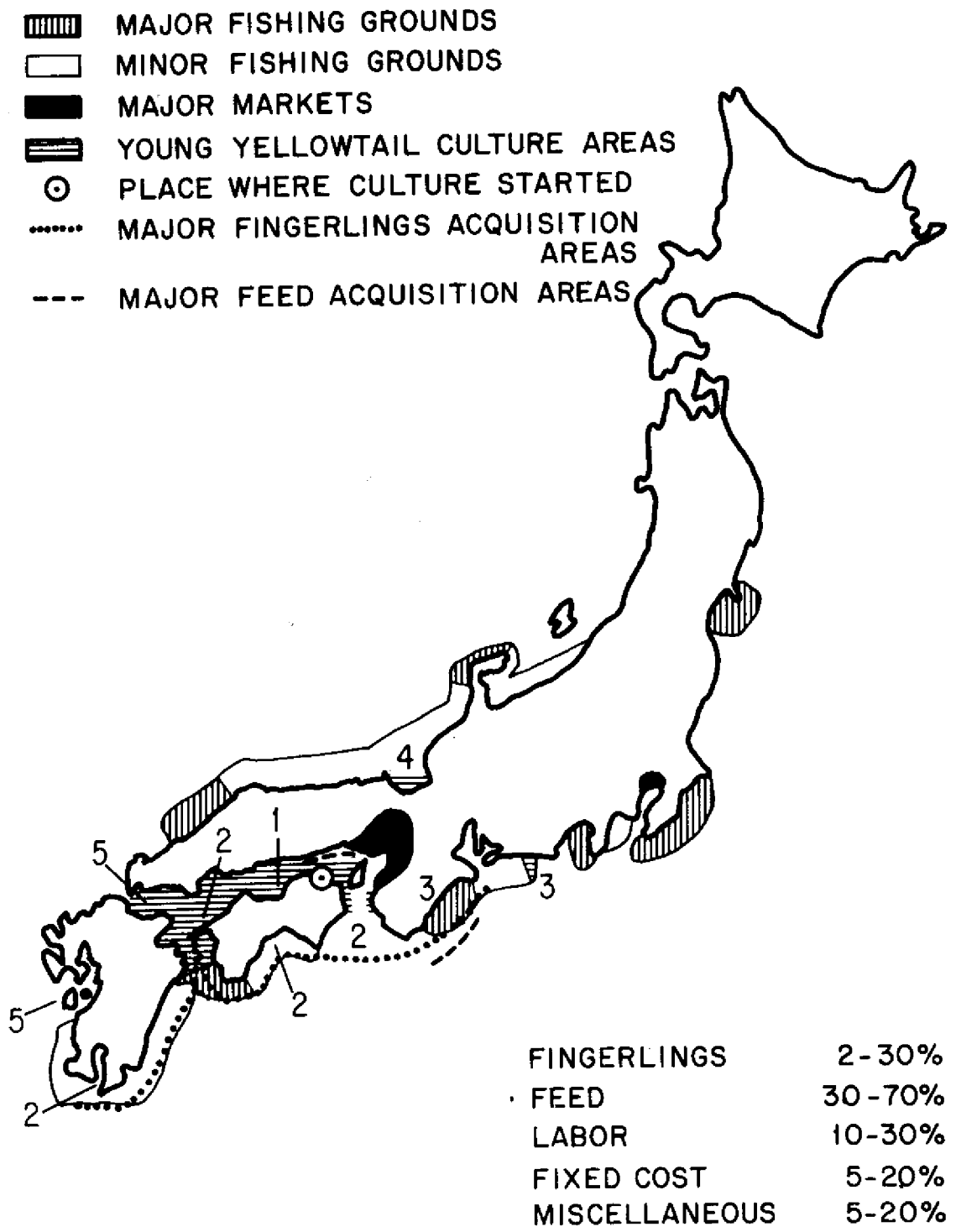
Yellowtail fishing grounds are shown in Figure 3-4. Neither the original grounds of the yellowtail culture nor the present most popular yellowtail culture area are in the yellowtail fishing grounds. This characteristic of yellowtail culture has developed because of the need for close ties with the market. Markets for this fish are very limited in Kansai, and this is the only justification for yellowtail culture in the Seto Inland Sea.

In order to be successful, yellowtail culturists must consider fingerlings, feed and marketing. Kagoshima, Kochi, Wakayama and Mie have the advantage of natural fingerlings, while Ehime, Hyogo and Mie have the benefit of natural feed. On the other hand, Hyogo, Kagawa, Osaka and Okayama have a great advantage from the marketing point of view. Thus, no one place combines all three aspects.

According to Oshima (55) yellowtail culture is classified into five different types. These are:

(1) East Inland Sea Type (Hyogo, Kagawa, Osaka and Okayama)--takes advantage of marketing strength in the Kansai market, tends to large-scale operations and emphasizes young yellowtail sales before winter;

(2) South Sea Types (Wakayama, Tokushima, Kochi Ehime, and Miyazaki)--take advantage of fingerlings acquisition and emphasize two-year yellowtail sales in Kansai markets;



YELLOWTAIL SITUATION IN JAPAN

Figure 3-4

Source: Oshima, J., A Geographical Study of Aquaculture in Japan, Univeristy of Tokyo Press, Tokyo, 1973, p.212(55).

(3) Shizuoka Type (Shizuoka, Aichi and Mie)---emphasizes two-year yellowtail sales in Tokyo markets in polyculture with amberjack and Hardtail;

(4) Wakasa Bay Type (Fukui and Kyoto)---emphasizes short-term stocking from large fingerlings to marketing size in Kansai markets and sales whenever the price is high;

(5) Local Types (Hiroshima, Yamaguchi and Kumamoto)---emphasize sales to local markets and tend to small-scale operation, though the number of operations is extremely large.

Thus, the yellowtail culture is unique because of the significant effect on the culture by market conditions.

5. Salmon Ocean Ranching

Historically chum and pink salmon have been important to the Japanese. Chum salmon has been dominant along the coasts of Hokkaido and Northern Honshu. According to Atkinson (13), efforts to conserve salmon have a long history. In 1716, for example, a samurai named Buheji Aoto placed mature salmon in a fenced area of a stream to protect them while spawning and to preserve their eggs from natural enemies and adverse stream conditions -- a primitive artificial spawning channel. From all accounts, the salmon runs increased through his efforts, and the program continued for more than 200 years. In another stream, the Gekko River, adult salmon were caught in the lower reaches of the stream and

transported by bamboo basket to the headwaters where conditions were more favorable for spawning and survival of the young. At the same time (about 1800), a local administration prohibited the taking of young salmon in the Naka River in order to conserve the stock.

Shortly after the beginning of the Meiji period in 1868, Mr. U.S. Treat, a member of a group of 45 agricultural experts from the United States invited by the Hokkaido government, attempted to rear salmon in a crude hatchery in Sapporo in 1877, but without success--the eggs died due to cold weather and drifting snow. The federal government in Tokyo had established a hatchery in Shinjiku (a suburb of Tokyo) in the previous year (1876), but the eggs were eaten by rats or destroyed by fungus so that few, if any, hatched. Because of the many difficulities encountered in these early attempts to rear salmon and a lack of public interest and administrative support, this initial salmon hatchery program was short-lived and finally abandoned in 1880.

It was not until 1888 that the first permanent hatchery was built at Chitose, Hokkaido, following closely the design and related information obtained by Kazutaka Ito after several months of study at the U.S. Federal Hatchery at Bucksport, Maine, and subsequent visits to the Columbia and Fraser Rivers. According to Kobayashi (35 & 36), 50 salmon hatcheries were in operation in Hokkaido. Most of them, however, were sponsored by private funds, and fishermen abandoned their programs when catches were low. In 1934 the local government of Hokkaido disposed of the malfunctioning salmon hatcheries in Hokkaido. Since then the government has played a major role in the salmon ocean ranching program. Following World War II

the production of many of the hatcheries in Japan was marginal, the methods obsolete and the basic, scientific information needed to understand the behavior and survival of salmon was lacking. The salmon hatcheries were in almost complete disrepair, and the program had little financial support and no encouragement from the occupation forces (13).

The Fisheries Resource Conservation Law in 1952 transferred control of these Hokkaido salmon hatcheries from the Hokkaido provincial government to the national government (35). However, a decrease in supply and an increase in demand for salmon, and growing restrictions on high seas salmon fishing imposed by the Japan-Soviet and the Japan-Canada-United States fisheries commissions, have generated considerable local pressure to expand the work beyond the scope and means of the national program. Accordingly, in 1967 the Fisheries Department of the Hokkaido provincial government, in close cooperation with the national government, began to propagate salmon at Mori. Five of these hatcheries and 53 private hatcheries are now in operation (11 & 13). In Honshu a national subsidy for salmon ocean ranching has been provided since 1956. Although the programs here have never been centralized as in Hokkaido, set net salmon fishermen in Iwate prefecture have began to realize the benefits from ocean ranching and voluntarily have contributed 1% of the value of their total salmon catch to promote research since 1974 (20).

At present, 195 hatcheries including 42 government operations are operating, with a stocking capacity of more than 600 million fry (11 & 13). There have been major research efforts on how to decrease mortality and improve the return rate. The number of chum salmon fry

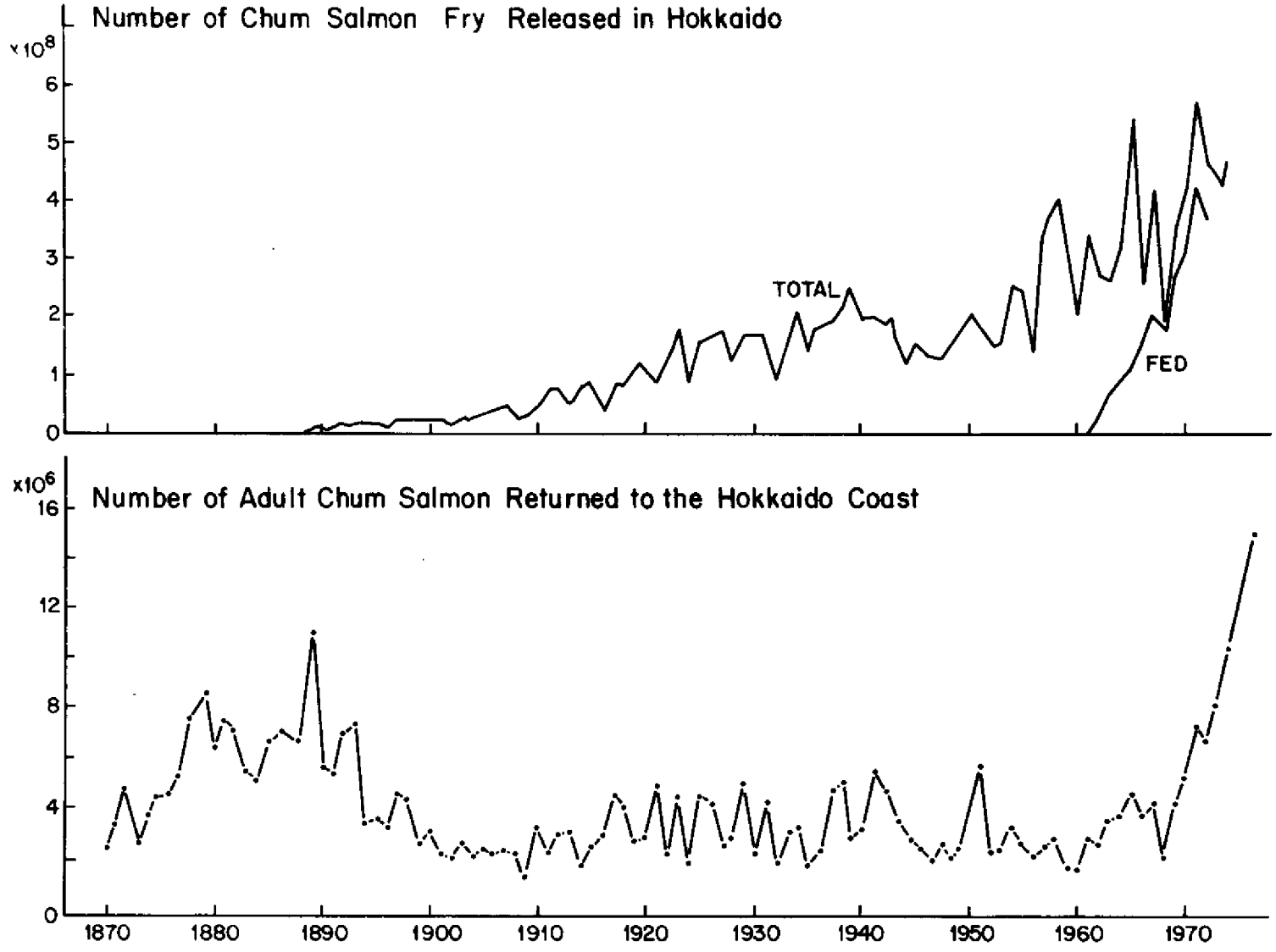


Figure 3-5. Number of Chum Salmon Fry. Released in and Adults Returned to Hokkaido: 1870-1975.

Sources: Anonyomous, Fish Farming in Japan, Japan Fisheries Association, Tokyo, 1975: p.9(6) and Y. Aoki, Salmon Ocean Ranching in the World, Japanese Salmon and Trout Resources Conservation Association, Tokyo 1976, p.7(11).

released and adults returned to the Hokkaido coast during the 1870-1975 period is shown in Figure 3-5. Although the salmon catch along the Hokkaido coast has fluctuated widely, the carrying capacity of salmon is regarded as 11 million fish, the amount recorded in 1889. Since then the salmon catch has decreased due to increased fishing efforts, and has fluctuated between 1 and 5 million fish. Despite the fact that the number of hatchery salmon fry released has incraased, the effects of this increase did not materialize until recently. However, the rate of catch has increased rapidly since 1970, and reached more than 15 million fish in 1975 (11). This is far beyond the presumed carrying capacity of that area, and is attributable to the release of fry or fingerlings beginning in 1960. It is generally accepted that a 2% return rate is possible.

6. The Seto Inland Sea Ocean Ranching Center and Beyond

The Seto Inland Sea Ocean Ranching Center has, in addition to salmon ocean ranching, developed methods to enhance the Japanese ocean resources in general. The Seto Inland Sea Ocean Ranching Association consists of a corporate juridical director and 28 representatives of 14 prefectural governments and 14 prefectural federations of fishery co-operatives. Since 1962 it has sponsored the production of artificial fingerlings for ocean ranching, as mandated by the national government. This is an experiment to increase the fisheries resources on a gigantic scale. Since it involves many prefectures, some with conflicting interests, in waters of complicated characteristics covering as large an area as 18,000 sq. km., the project is regarded as a thumbnail sketch of all the coastal fishing of Japan, or as one big fish family area, even though it

has been affected by reclamation and water pollution from the extension of coastal industrial areas. Efforts have been made to partially control such important fishery resources as prawn, sea bream, blue crabs, etc.

It has been more than 15 years since the project was started. Six branches under the Seto Inland Sea Ocean Ranching Center are in operation, Yashima, Hakata, Kamiura, Tamano, Shibushi and Komame branches. Mass production technology of artificial larvae or fingerlings of prawn, sea bream, rock cod, gray rock cod, blue crab, etc. has been developed, and there has been remarkable progress in the release and control of such artifically grown species. The center also has been responsible for extension education.

Basic assumptions of the program are the following:

(1) The level of the natural stock of renewable resources could shift upward to the carrying capacity of the environment if the recruitment of resources were artifically enhanced.

(2) The level of utilization of primary productivity in the oceans could shift upward if the critical stages of useful species were rtificially protected.

According to Hiyama' (18), in Oumi Bay, Yamaguchi, the average rate of the commercial catch of released prawn larvae during the 1972-1974 period was 1.6%. This rate increased to 5.8% when the larvae were first released in a predator-free artificial tidal land. The Seto Inland Sea Ocean Ranching Center has supplied the 14 prefectures with 154 million prawn, 2.2 million sea bream, 20 million blue crabs, 1 million

flounder and 2 million rock cod young each year (63).

After a pronounced increase of prawn farming, this project was to be extended throughout Japan, beginning with the prefectures facing the Japan Sea. However, this new project was not given the status of a nationally commissioned work because of a shift of emphasis from experimentation to application (12). However, the national government will pay 75% of the expenses necessary for establishing ocean ranching centers in the prefectures, and the rest of funds will be provided by the prefectural governments. Orginally, these facilities were to be provided with 250 million yen ($.83 million*) each, but since 1975 the amount has been increased to 325 million yen ($1.08 million*). During the 1973-78 period 16 centers were established and 22 more centers will be established in the near future (6).

Artificial mass production techniques of many important species have been developed, but the Ocean Ranching program is still confronted by numerous problems. These include difficulties of investigating survival rates of young release for most species, development of predator-free and nutrient rich semi-artificial nursing grounds, protection of the young from predators in the natural environment, economic feasibility, property rights and management problems, including compatibility with existing fisheries. While the ocean ranchers must expend a large amount to produce larvae and release them into the ocean while they are frail, aquaculturists can catch healthy fingerlings of sea bream or yellowtail from the ocean and culture them, and fishermen can catch those released fingerlings.

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*Exchange rate: $1.00 = 300 yen (1976 rate) is adopted.

7. The Government's Promotion of Coastal Fisheries and The National Federation of Fishery Cooperatives

Since 1962 the growth of government activities to promote coastal fisheries has been remarkable. Empahsis has shifted from hunting or gathering fisheries to fisheries coupled with aquaculture. This is symbolized by the passage of the Law Promoting Coastal Fisheries of 1963 and the following activities, including the First and Second Coastal Fisheries Structural Improvement Programs (Table 3-1) and the Coastal Fishing Ground Adjustment and Development Law of 1974 which provide massive government subsidy and finance (Table 3-2).

The First Coastal Fisheries Structural Improvement Program (1962-1970) is unprecedented not only because this reflects the first interest the government has ever shown in coastal fisheries throughout the long history of Japan (41), but also because the program attempts to shift the coastal fisheries policy from fishing and gathering to the culture of fisheries. Under the program 42 areas have been provided with a total expenditure of 63.9 billion yen ($177.50 million*),including 15.8 billion yen ($43.89 million*) of national government subsidy and 20.3 billion yen ($56.39 million*) of national government finance. Rapid rates of growth of laver, "Wakame",yellowtail and scallop culture are attributable to this program (54).

The Second Coastal Fisheries Structural Improvement Program (1971-1983) corresponds to an expansion of demand for coastal fisheries products and emphasizes the production policy, including the Shallow

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* Exchange rate: $1.00 = 360 yen is adopted.

Table 3-1 Subsidy for Culturing Fisheries in Japan: 1952-1973

Unit = 1,000 yen

Activities	Fisheries Facilities Modernization				Fishing Ground Improvement					Artificial Reef Construction		Aquaculture Ground Construction		Ocean Ranching Ground Construction	Exchange Rates
Project / Year	Stocking Facilities	Environmental Protection Facilities	Artificial Fry Supply Facilities	Storage Facilities	Recycling Reef Construction	Water Break	Sea-water Circulation Improvement	Bottom Soil Conditioning	Nursing Facilities	Standard Artificial Reef	Large-scale Artificial Reef	Aquaculture Ground Construction	Shallow Sea Development	Large-scale Ocean Ranching	yen / U.S.$
1952					33,490			18,403	900						360
1953					32,931			11,300	8,633						360
1954					33,100			10,600	9,697	27,347					360
1955			5,400		42,110			3,000	9,497	44,382					360
1956			1,601		52,498			1,921	42,917	41,587					360
1957			5,125		84,318		7,206	2,933	6,844	59,527					360
1958			2,255		80,767		6,438	4,255	1,296	60,870	31,765				360
1959			7,037		61,294		9,743		1,250	50,470	41,189				360
1960			9,289		63,147		16,066			58,639	42,084				360
1961			18,617		89,536		15,045			99,163	82,852				360
1962	22,324	1,744	68,342	3,032	127,821		46,100	12,982		252,930	179,637				360
1963	165,899	3,254	54,116	37,312	157,663		40,925	20,760		187,025	361,914				360
1964	193,696	11,092	68,261	37,863	148,064		40,347	56,960		186,804	378,211				360
1965	287,654	10,928	85,808	53,410	160,975		38,322	46,033		178,915	435,361		12,000		360
1966	221,723	2,944	119,558	23,916	180,417		43,382	19,621		206,989	506,003		18,981		360
1967	193,029	3,502	87,658	34,888	210,276		43,488	4,895		224,289	568,977		12,601		360
1968	109,160	6,218	49,520	54,216	259,768		23,679	30,724		275,132	587,323		24,754		360
1969	82,558	3,000	91,613	51,975	249,562		67,074	53,960		302,324	607,621		35,824		360
1970	65,589	5,264	48,112	55,486	271,702		4,821	30,782		362,334	607,638		254,236		360
1971	116,628		22,192	36,729	373,328	18,000			21,894	256,943	700,349	45,000	510,717		360
1972	171,561	3,616	43,746	70,954	413,145	13,500		49,036		335,909	771,166	129,999	824,563	14,340	328
1973	136,142	2,512	94,338	133,321	447,200					354,908	890,236	344,000	789,437	33,773	338
Total	1,765,963	54,074	882,588	593,102	3,573,112	31,500	402,636	378,165	102,928	3,566,487	6,792,326	518,999	2,432,555	48,113	

Source: Kyuki, B. 1976. Subsidy. In: Yasuo Oshima et al (ed.), Tsukuru Gyogyo (Culturing Fisheries). Norin Statistical Association, Tokyo, p. 42-43 (40).

Table 3-2 The Coastal Fishing Ground Adjustment and Development Program in Japan: The First Stage 1976-1982 *

Classification		Total Projects Project Cost	National Fund	Content of Projects	Size of Project per Ground	
Construction of artificial rocks to attract fish	Big artificial rockery	86.00	51.67	Artificial rockery made of durabled material to supplement natural ones	Honshu Others	$3,300m^3$ $5,000m^3$
	Construction of rockery fishing ground	133.33	98.67	Independent artificial rockery group made of durable material		$5,000m^3$
Construction of fishing farms	Construction of young fish farms	39.00	23.33	Protection of young fish by construction of artificial shallows weed ground		$1 million
	Construction of big fishing farms	202.00	121.33	Protection of egg laying young fish by constructing egg-laying rockery, artificial rockery, etc.		$1 million
Construction of culture farms	Construction of fishing grounds	43.67	22.00	Construction, development of culture farms by wave-fighting banks, dredging, etc.		$1.67 million
	Development of fishing grounds in shallows	77.67	39.00			$1.67 million
Maintenance and protection of Fishing ground environment	Non-public	13.00	6.67	Removal of wastes		$0.04 million
	Public	16.33	11.00	Dredging, covering ground with earth brought over		$0.33 million
Survey for development and improvement of coastal fishing grounds		1.67	1.67	Survey for development of material, structure, technology by national institutions		
Total		612.67	375.34			
Contingency Budget		54.00				
Grand Total		666.67				

* Exchange rate: $1.00 = 300 yen (1976 rate)
Source: Anonymous, 1975. Fish Farming in Japan. Japan Fisheries Association, p. 31 (6).

Sea Development Project. The program has been conducted in 108 areas throughout Japan, directed mainly at fisheries culture. The total expenditure will be 141.4 billion yen ($392.78 million*), of which 40 billion yen ($111.11 million*) will be subsidized and 44.8 billion yen ($124.44 million*) fiananced by the national government. Based on a plan of two years for a survey and four years for the implementation period, 12 areas will be chosen every year.

The Coastal Fishing Ground Adjustment and Development Law of 1974 calls for the further expansion of culture fisheries covering 120,000 sq. km. of the continental shelf area around Japan. The first stage of the plan applies to the 1976-1982 period. A total appropriation of about 200 billion yen ($666.67 million**) was asked for.

In addition to these government activities supporting coastal fisheries development, the role of the National Federation of Fisheries Cooperatives should not be forgotten. The Federation was established in 1952, but its roots stem from 1933 when fishing cooperatives were allowed to undertake economic activities and leaders were convinced that the cooperative movement was essential to liberate fishermen from mounting debts and unscrupulous merchants. The cooperative movement survived a poor start, negligible political power, and the Japanese involvement in wars. From the beginning, leaders such as Tatsuo Kinoshita and Takatoshi Ando were strong advocates of the legislative function of the cooperative movement. In 1957 a fishery policy planning section was established in the Federation to strengthen the legislative function. This was important because fisheries policy tended to be overlooked by the prevailing

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* Exchange Rate: $1.00 = 360 yen.

** Exchange Rate: $1.00 = 300 yen (1976 rate).

agricultural policy in Japan because the small population involved wielded little political power. The Fishery Policy Planning Section in the Federation surveyed the facts about fishing villages, fishermen, and coastal fisheries, analyzed, and planned realistic policy, and asked for legislation. Along with increasing economic activities and fishermen's support, this section has evolved into the Fisheries Policy Planning Division, which consists of three sections: Fisheries Policy Planning, Pollution Counter Planning and Communication and Advertisement. The political power of the National Federation of Fisheries Cooperatives is no longer ignored.

According to Okamoto (54), the Federation requested the government to consider their coastal Fisheries Promotion Strategy in 1957. Correspondingly, the Liberal Democratic Party and the Socialist Party announced their policies concerning coastal fisheries promotion. In 1958 a fisheries system evaluation committee was established and discussed issues about counter plans for improvement of the coastal fisheries system. Then the Evaluation Committee for Basic Problems in Agriculture, Forestry, and Fisheries was established , and the results, known as the Basic Problems of and Counter Plans for Fisheries in 1960, was sent to the prime minister. Based on this study, the Fishery Agency made a legislative proposal. However, this proposal did not take into account the Federation's recommendations, so that it encountered strong opposition. After two years negotiation and compromise, the revised proposal was discussed at the 40th and 41st National Diet Session of 1962 and 1963, but it was not passed because of different views on implementation by the Liberal Democratic Party and the Socialist Party. The Federation held a national conference on

this matter, reviewed the issues, revised them, and asked for early legislation. As a result, the revised proposal was discussed at the 43rd National Diet Session of 1963, and the Coastal Fisheries Promotion Law Subcommittee was established in the Agriculture, Forestry and Fisheries Committee in the House of Representatives. Finally, the Law Promoting Coastal Fisheries was enacted in July 1963.

It was also demanded, mostly by the National Federation of Fishery Cooperatives, that coastal fishing grounds should be adjusted and developed by national finance and investment on a large scale. In compliance with this request, at the 72nd National Diet Session of 1974 the Coastal Fishing Ground Adjustment and Development Law was enacted and implemented (6).

SECTION 4: SUMMARY AND CONCLUSIONS

The history of aquaculture in Japan is a process of dynamic evolution that reflects social , economic and political aspects as well as ecological and technological facets. The history of Japanese aquaculture may be divided into four chronological phases: Pre-condition (before 1600), Phase I (1600-1868), Phase II (1868-1945), and Phase III (1945-1978).

Despite the early introduction of fish culture into Japan, the rearing of fish was at first of relatively small importance, and its development was modest. This may be attributed to limited supply and demand, quasi-legal prohibition of eating fish, and a lack of leadership interested in aquaculture development. There was also little experience.

Oyster, laver, mullet, fancy carp and goldfish appeared as aquaculture species during the Phase I period. Despite the fact that the climate was favorable for the general practice of aquaculture, development was slow because experience and technical capability were still limited, and the deamnd for cultured species was low.

During the Phase II period, salmon and trout, eel, pearl, and "Ayu" fish were added to the Japanese aquaculture species. The experience of leadership in both public and private sectors encouraged aquaculture development as did the general development schemes. Under a favorable legal environment for aquaculture, experience and technical capability increased. Furthermore, the demand for aquaculture products increased, due not only to a rapid population increase and urbanization, but also to expansion in demands for export, particularly in the eel and pearl industries. By 1930 all the basic conditions for a large expansion

in aquaculture were developed. However, Japan's war involvement destroyed most of the aquaculture potential. The government, through its legal power, could wipe out all the aquaculture achievements of the previous years.

After World War II, yellowtail, globe fish, red snapper, tangle and more were introduced as aquaculture species. Immediately after the war, the aquaculture industry began a process of recovery along with general reconstruction. Again, the legal climate had become favorable for aquaculture development. Infrastructure such as transportation and communication systems had quickly recovered. By 1960 aquaculture experience had been accumulated and technical capability increased rapidly. The demand for aquaculture species was also strong, resulting in high economic feasibility. During the following decade, which was characterized by rapid economic growth leading to a rise of living standards, there was an unprecedented growth of aquaculture resulting from increased demand for aquaculture species, favorable legal conditions, and increased experience, technical capability and infrastructure. However, the pearl culture, which had been the first to recover after the war, showed signs of decline in the middle 1960's due to a decline in demand. In addition, the aquaculture industry has been confronted by environmental suitability problems due to water pollution. On the other hand, issues pertaining to pollution control in the Japanese Diet in 1970, legislation of the Coastal Fishing Grounds Adjustment and Development Law of 1974, and declaration of a 200-mile economic zone by the Japanese government on July 1, 1977, have been creating a new climate favorable for aquaculture.

Aquaculture development was accepted by local people in rural villages only when the income from it exceeded that from existing industries. Aquaculture villages are classified into five cases in which 1) aquaculture starts as coastal fishing declines; 2) aquaculture starts where other industries except for coastal fisheries are dominant; 3) aquaculture starts where fisheries do not exist; 4) new aquaculture ventures start where old aquaculture ventures exist, resulting in competition or coexistence of different types of aquaculture; and 5) aquaculture is abandoned due to the influence of other industries.

Although economic feasibility is of prime importance for aquaculture development, when aquaculture is one of several alternatives, it tends to be adopted by people who are engaged in jobs similar or familiar to the venture. Thus, to increase the probability of success, some kind of quasi-experience may be important. New aquaculturists may play an important role in rural aquaculture development, providing leadership, capital, experience and techniques, and absorbing local unemployed labor. In Japan there has been limited substitutability among different aquaculture ventures such as oyster and laver or pearl. The prime factor leading to the decision making must be profitability, due mainly to change in demand. Thus, an aquaculture venture faces competition not only with the same kind of venture, but also with other kinds of ventures.

In the Tohoku region where the prime factor for change may be profitability, environmental suitability is also a factor limiting the choice of alternatives. On the other hand, in Mie novice aquaculturists

developed the oyster industry in 1930 using new technological methods. However, the prosperity of the oyster industry was abruptly terminated in 1941 due to the Japanese involvement in World War II. Despite General MacArthur's support for the oyster industry, this industry in Mie did not grow after the war because its market was limited to a weak domestic market, and it was absorbed by the Hiroshima oyster market. On the other hand, pearl and laver industries expanded remarkably due to a large demand for pearls in the United States and for laver in the domestic market. Environmental suitability separated laver culture dominant areas from pearl culture dominant areas.

Each species, project and organization, has a unique history. In Hiroshima the legalities governing the market practice of oyster guilds in the 16th century dictated the present Japanese oyster industry. Competition among the guilds over the centuries to expand marketing territories has created the best techniques for oyster culture, taking into account environmental suitability and economic feasibility.

Cultured laver enjoys a strong domestic demand because it has been one of the favorite foods of the Japanese. However, industrial development following the war has imperiled the environmental suitability for laver culture. Nevertheless, this industry has been growing rapidly because of the existence of leadership, successive technical improvements and accumulating experience in addition to the steady demand. The existence of leadership has taken advantage of the legal

protection provided by cooperatives and of the technical capabilities made available by research and extension services. The laver industry is one which promises to expand in Japan.

Until recently pearls were in demand. Private leadership established the techniques for production of cultured pearls during the late 18th and the early 19th centuries. Learning these techniques, however, requires at least three years. Thus, the amount of skilled labor for pearl operations determines the amount and quality of pearl production. In addition, the different stages of growth of pearls require different environments for the best commercial production. Thus this industry has had to search for the best environments suitable for pearl culture compatible with the stages of growth, and have finally developed a unique transportation strategy. This industry also depends on the collection of natural spat. This dependency on natural spat has led to legal restrictions limiting entry to the collection of pearl oyster spat. Most of these fishermen who have the legal privilege of collecting pearl oyster spat have not developed aquaculture ventures and have suffered from economic instability, while other fishermen who are leaders but lack the privilege have developed cooperatives, produced high quality pearl oysters and created economic stability. After the war, General MacArthur encouraged the reconstruction of the pearl industry. The first five-year plan for pearl culture development began as early as in 1947. In Ehime a unique legal environment was created in 1957, and here the best pearl oysters in Japan have been produced. Yet the industry has declined since 1966 due to a decrease in demand.

If the market is limited, environmental suitability alone is not sufficient justification for an economic venture. Yellowtail culturists must consider fingerlings, feed and market. However, no one place is satisfactory from all three points of view. Thus, competition and experience have created unique combinations of environmental suitability, infrastructure and economic feasibility.

In salmon culture nearly all the critical variables are supportive, leadership exists, the environment is suitable, primary propagation techniques have been established, demand for the fish is high, and there has been strong government support and long experience. However, salmon ocean ranching was marginal until the recent introduction of fed fry and fingerlings. Thus, it was a small technical problem that limited the gigantic salmon ocean ranching activities for many decades.

Even though Japan has been regarded as one of the most advanced countries in aquaculture, it has shown an inability to develop effective nursing and predator elimination techniques that has limited various ocean ranching programs. Legality, economic feasibility and compatibility with existing fisheries will bring further complications to the problem. Further, the present ocean ranching programs are faced with basic problems: Can ocean ranching be a substitute for natural fertility in the ocean? and if we could protect the natural fry during critical stages from adverse physical conditions and predators, why is ocean ranching necessary?

Except in emergency situations, changes in the legal framework

come about where there is public and established support and are achieved through the persistent and organized efforts of those concerned. Without leadership, the National Federation of Fisheries Cooperatives was meaningless, and coastal fishermen in Japan had to continue their struggle against poverty at the mercy of unscrupulous merchants.

The choice of fishing grounds for aquaculture depends not only on natural factors but also on artificial factors. In the short run, capital efficiency from aquaculture ventures appears to be less than in other fisheries, although in the long run it is greater than in other fisheries. For this reason, aquaculture is basically of greater interest to merchants than to traditional fishermen. In fact, many have entered this industry from fields other than fishing. Furthermore, the industry tends to be more money oriented and accepts big business investments. Aquaculture requires both skilled and unskilled labor, while most aquaculture grounds are located in very rural areas. Thus, labor management has a great impact on the success of the venture. Demand expansion schemes are not easy tasks, and only enterprises with firm marketing roots have achieved success.

The aquaculture industry exists in relation not only to conventional fisheries but to other industries. It faces competition from land filling, water pollution, and availability of fishing grounds, labor and capital. In addition, in Japan the impact of World War II on aquaculture was very severe. On the other hand, new aquaculture grounds were created by the construction of man-made lakes resulting from hydroelectric power development.

Within the aquaculture industry over-culturing, over-production, fishing grounds depreciation and disease have been problems, as well as the availability of natural spat and fingerlings, feed availability and marketing. Whenever an aquaculture venture appears to be profitable, many imitators appear and create a boom, resulting in over-culturing, over-production, fishing grounds depreciation and disease, which eventually kill the industry. Thus, overall managerial skills of aquaculture and fisheries administration play an important role in aquaculture.

In conclusion, throughout the history of Japan aquaculture development has been limited by supply and demand, environmental suitability, technical capability, legality, experience, infrastructure, existence of leadership, economic feasibility and social welfare incentives. Among them, the most important factor is the existence of leadership as the co-ordinator. However, the development of aquaculture depends on simultaneous development of all these factors, not on the preponderance of any one factor. Within the framework of this generalization, issues pertaining to aquaculture development in developing countries could be handled by adapting them to local conditions. Further research, discussion and experiences in these matters are needed.

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Appendix - - - History of Aquaculture in Japan

G: Government efforts
P: Private efforts

Year	Species	References
		Pre-Tokugawa Period: Before 1600
100	Common carp	Fish ponds are first built in Japan (16).
280-316	Common carp	Emperor "Keikō" rears carp in his garden ponds (16).
280-316	Common carp	A certain lord Kumawani of Oka raises fish in his pond and presents quantities of them to the consort of Emperor "Chūai" (16).
675	"Ayu" fish	Conservation efforts such as closed season and prohibited methods are first practiced to maintain "Ayu" population (55).
689	All species	Closed fishing areas are specified in Kansai area (55).
724	All species	The Buddhist precept against killing, is emphasized by the Emperor Shōmu and changes Japanese eating habits (55).
900-1000	Common carp	Raised as pet fish among the nobles (55).
1081-83	Gelidium	Transplanted from Kamitsujima to Izu-Shirakawa (Shizuoka) (55).
1300-50	All species	Shinran, a new Buddhism leader, proclaims eating fish is outside the Buddhist precept against killing (55).
1502	Goldfish	Imported first from China by Sakai merchant (55).
1582	Shirauo	Transplanted from Mikawa-Washizuka (Shizuoka) to Edo (Tokyo) by Ieyasu Tokugawa (55).
1590	Crucian carp	Transplanted from Lake Biwako (Shiga) to Lake Sawako (Nagamo) by Shikibu Hineno (55).

Phase I: Tokugawa Era (1600-1868)

Year	Species	References
1619	Oyster	Transplanted from Wakayama to Hiroshima by Nagashige Asano (55).
1623	Common carp	Cultured first in Niigata-Kanbaragun (55).
1655-58	Shirauo & haya	Transplanted from Osaka to Tosa-Yoshinogawa (Kōchi) by Kengan Nonaka (55).
1658-61	Haya & trout	Transplanted from Ise-Miyakawa (Mie) to Tosa-Yoshinogawa (Kōchi) by Kenzan Nonaka (55).
1658-61	Crucian carp	Transplanted from Lake Biwako (Shiga) to Tosa-Kandagawa (Kōchi) by Kenzan Nonaka (55).
1658-61	Clam	Transplanted from Edo to Tosa Bay (Kōchi) by Kenzan Nonaka (55).
1673-80	Laver	Transplanted from Edo to Hiroshima Bay (55).
1673-83	Laver	Laver culture begins in Tokyo Bay (28).
1684-87	Laver	Transplanted from Edo-Asakusa to Ōmori-Shinagawa (55).
1684-87	Oyster	Transplanted from Aki (Hiroshima) to Ibaragi Yatsukawaura (55).
1688-1703	Shirauo	Transplanted from Edo to Hitachi-Katanuma (Iberegi) (55).
1716	Salmon	Buheji Aoto places mature salmon in a fenced area of a stream to protect them while spawning and their eggs are protected from natural enemies (13).
1724	Goldfish	Transplanted from Yamanashi to Yamato-Kooriyama (Nara) by Yoshishige Yanagizawa (55).
1764-71	Eel	Transplanted from various places to Dewa (Akita) (55).
1764-71	Common carp	Transplanted from Yamashiroyodo (Kyoto) to Shinano-Matsushiro (Nagano) (55).
1774	All species	Tokugawa government decides on fisheries policy. As a result, fish, shellfish and seaweeds which do not migrate offshore are regarded as the property of local fishing villages,while all are allowed to catch fish which migrate offshore. (55).
1780	Fancy carp	Raised in Koshi-gun, Niigota (39).

Year	Species	References
1781-89	Pearl	A conservation law on pearl oyster in Omura Bay is legislated and practiced (55).
1781-89	Common carp	Transplanted from various places to Yamato (Osaka) (55).
1789	Freshwater shrimp	Transplanted from Kai-Suruga (Yamanashi) to Lake Suwako by Isaburō Miyasaka (55).
1800	Salmon	Conservation efforts are recorded in the Gekko River and the Naka River (13).
1821	Laver	Transplanted from Edo to Kazusa-Ōhori (Chiba) (55).
1821	Laver	Transplanted from Edo to Tōmi-Maisaka (Shizuoka) by Matahachi Isuda (55).
1822	Salmon	Since 1773 the Miomote River (Niigata) has been regarded as the salmon spawning river by Taheiji Aotogi. In order to increase salmon population, Sōri Naitō legislates OTOMEGAWA-NO-SEI: Closed season for salmon and salmon fries in the salmon spawning rivers in his territorial area (55).
1845	Common carp	The technique of cultivating carp in flooded rice paddies is introduced (16).
1854	Native trout	Efforts to propagate a native trout artificially exist, but this enterprise for cultivating cold-water fish fails (44).
1854-59	Clam	Transplanted from various places to Toyama by Chūnagon Maeda (55).
1863-68	Kelp	Bunemon Yamada puts 717,000 rocks in the sea to form artificial reefs in order to fix kelp. (55).
1866	Snapping turtle	Kurajirō Hattori succeeds in snapping turtle culture in Tokyo (p) (55).
1868	General	The Edo era ends.
		Phase II: 1868-1945
1875	Salmon & trout	Meiji government dispatches Minsei Sekizawa to America to learn techniques for artificial fertilization and ocean ranching of salmon and trout (G) (55).

Year	Species	References
1876	Salmon	Artificial fertilization and ocean ranching of salmon is first practiced in Aoyagi, Ibarazi (G) (55).
1876-80	Salmon	A hatchery is established in Shinjiku (A suburb of Tokyo), but this program is ended in 1880 (13).
1877	Rainbow trout	Transplanted from Shasta, California to Yuki fish farm in Nishitama (G) (55).
1877	Salmon	Mr. Treat attempts to rear salmon in Sapporo without success (G) (13).
1878	Grass carp & silver carp	Fingerlings are imported from China and delivered to Tokyo, Nagasaki and Hyogo (G) (73).
1879	Eel	Kurajirō Hattori first cultures eel in Fukagawa, Tokyo (p) (21).
1879	Laver	Laver seeds attached to seed collectors are transplanted from China and Kanagawa to Ōmori and Shinagawa by Takejirō Hirano (p) (28).
1880	All species	The government sends Shinnosuke Matsubara to Germany to learn German aquaculture techniques (G) (55).
1880	General	The first lecture on fisheries science is taught at the Sapporo Agricultural School (Later Hokkaido University) (G) (69).
1881	General	A Fisheries Section is established in the Ministry of Agriculture and Commerce, and overfishing is prohibited (G) (55).
1885	General	The Fisheries Section is raised to the Fisheries Bureau including three sections of Fisheries, Fisheries Experiment and General Affairs (G) (55).
1885	General	The First Marine Laboratory is built at Aburatsubo, Kanagawa (G) (55).
1886	General	The Fishermen's Association Quasi-Law is legislated (G) (38).
1887	General	Suisan-Denshū-Sho (later Tokyo University of Fisheries) is established (G) (55).

Year	Species	References
1888	Salmon	The first permanent hatchery is built at Chitose, Hokkaido, following closely the design and related information obtained by Kazutaka Itō after several months of study in the United States (G) (13).
1891	General	The first national survey on fisheries is conducted (G) (55).
1891	General	The Aichi Fisheries Experiment Station, the first Fisheries Experiment Station, is built at Isshiki-cho, Aichi (G) (55).
1891	Eel and common carp	Senuemon Harada begins policulture of eel and common carp at his improved pond in Shizuoka (p) (21).
1893	Pearl	Kōkichi Mikimoto establishes the technique of producing cultured pearls (half-round pearl) in Shima, Mie (p) (55).
1893	Eel, common carp & mullet	Shizuoka Fisheries Experiment Station is established and engages in an experimental policulture of eel, common carp and mullet (G) (21).
1893-94	Eel	Hikohachiro Terada cultures eel successfully in Fukuda, Shizuoka (p) (21).
1896	Eel	Hachisaburo Okumura starts an eel culture venture in Kamino-Nitta, Aichi (p) (21).
1897	General	Department of Fisheries is established at the Sapporo Agricultural School (G) (55).
1897	Eel	Kurajiro Hattori builds his eel ponds on the coast of Lake Hamanako, Shizuoka and begins an eel culture business in 1899 (p) (21).
1899	Eel	Manzō Yoko builds eel ponds in Izojima, Mie (p) (23).
1900	Snapping turtle	Snapping turtles are cultured in Maisaka, Shizuoka by Kurajiro Hattori (p) (32).
1901	General	The First Fisheries Law is legislated (G) (38).
1903	Sockeye salmon	Sockeye salmon are successfully landlocked for the first time in Lake Towadako by Sadayaki Wainai (p) (55).
1904	Leather carp	Transplanted from Germany (G) (39).

Year	Species	References
1904-05	Common carp	Public agencies sell carp fry to peasants with rice paddies and buy back from the same individuals the fish that are not large enough to be sold as food at harvest time. These carp are used to stock rivers and lakes (G) (16).
1907	Pearl	Tōkichi Nishikawa and Tatsuhei Mise establish the technique producing round pearls in Ōmura Bay, Nagasaki (p) (55).
1909	General	Department of Fisheries is established at Tokyo University (G) (55).
1909	"Ayu" fish	Shiga Fisheries Experiment Station proves the hypothesis that small "Ayu" in Lake Biwako should grow larger if adequate food is available (G) (59).
1909	Eel	Kuwana County Fish Farm is established and engages in eel culture experiments (G) (21).
1913	General	The First National Aquaculture Conference is held (G) (55).
1913	"Ayu" fish	Biwako "Ayu" is transplanted to Tama River by Chiyomatsu Ishikawa and grows as large as wild "Ayu" in various rivers (p) (48).
1918	General	A subsidy system for cooperative facilities for agriculture and fisheries development is established (G) (60).
1919	Salmon & trout	A subsidy system for salmon and trout culture is established (G) (55).
1919	Trout	Trout farms such as Samegai (Shiga), Kawaguchi (Yamanashi), Fuji (Shizuoka)and Gassan (Yamagata) are fully equipped by government subsidy (G) (55).
1919	Salmon	Supported by government subsidy, salmon ranching programs are rapidly adopted (G) (55).
1919	General	A subsidy system for creating farm land is established. Fish ponds are built by farmers in areas where they have dug out the soil to build ridges between rice fields (G & p) (21).
1921	General	The Public Water Reclamation Act is enacted. Each new fish pond is not subject to further tax if the owner paid the license fee of 3% of the present value of land (G) (21).

Year	Species	References
1924	Freshwater pearl	Shosei Fujita establishes the technique to harvest round pearls from freshwater mussel (p) (55).
1924	Oyster	Raft culture proved to be successful by Shinsho Miyagi and Juzo Hori at Kanazawa Oyster Laboratory, Kanagawa (p) (55).
1925	Oyster	Oyster spat are first exported from Matsushima Bay to the United States (p) (55).
1929	General	The Prefectural Fisheries Experiment Station Act is enacted (G) (38).
1929-30	Eel	Fingerling shortage damages the industry (21).
1930	Yellowtail	Young yellowtail are first cultured by Sakichi and Wasaburo Noami at Ado pond, Kagawa (p) (55).
1931	Salmon & trout	Almost two hundred trout and salmon hatcheries are in operation pouring something like 450 million fry into the lakes and rivers each year (72).
1931	Pearl oyster	Fukutaro Tange first collects pearl oyster in Palau (later the largest pearl oyster fishing ground in the world) (p) (55).
1931	Eel	Canned "Kabayaki (eel teriyaki)" is exported for Japanese in the United States, Mexico and South America (p) (21).
1932	Freshwater species	Production of freshwater aquaculture species such as "Ayu" and eel is promoted (G) (55).
1932	Eel	Licensing system for eel elver fisheries is adopted in Aichi (G) (21).
1933	Marine Species	Production of mariculture species such as oyster, abalone, sea cucumber, kelp, Gelidium and Gloiopeltia is promoted, and various kinds of artificial reefs are built in the sea (G) (55).
1933	Eel	Licensing system for eel elver fisheries is adopted in Shizuoka (G) (21).
1934	Eel	Markets expand to Hokkaido and Kyushu (p) (21).
1934	Eel	The first eel culturists' cooperative (Gyoden-Kumiai) is established (p) (21).

Year	Species	References
1934	Scallop	Toraichiro-Kinoshita establishes an artificial spat collection method in Lake Saramako (68).
1935	Wakame	The Kanto-shu Fisheries Experiment Station develops raft and rope culture methods, resulting in the establishment of the Kanto-shu Shallow Sea Culture Inc. (G & P) (68).
1935	Eel	Overproduction of eel becomes an issue among eel culturists. Representatives from Aichi, Mie and Shizuoka discuss short working hours and diet for eel (p) (21).
1937	Eel	Shizuoka Fisheries Experiment Station conducts research of aerators for eel ponds (G) (21).
1938	General	The National Emergency Act is enacted (G) (33).
1940	Kelp	Iwate Fisheries Experiment Station develops rope spat collectors and a vertical hanging culture method (G) (68).
1940	Pearl & eel	Pearls are regarded as luxury goods, so the pearl industry is prohibited by the government from the production of pearls. Eel is also regarded a luxury, resulting in reclamation of eel ponds for rice, wheat and sweet potato production (G) (55).
1941-45	Grass carp & silver carp	To meet demand for food, approximately 3.7 million fingerlings are imported and delivered to more than 20 prefectures (G) (73).
1942	General	The Government Control Act of Fisheries is passed (G) (33).
1945	General	World War II ends (G) (33).
	Phase III: After World War II (1945-1977)	
1946	Pearl & Oyster	General MacArthur directs the occupation policy, emphasizing reconstruction of pearl and oyster industries (G) (55).
1947	Pearl	The first five-year plan for pearl culture development starts in Mie (G) (55).

Year	Species	References
1947	Oyster	Oyster spat export from Matsushima Bay to the United States resumes (p) (55).
1948	Laver	The National Laver Culturists Association (later the Japanese Federation of Laver and Shell Fisheries Cooperatives). The issues are sales tax exemption for laver, prohibition of laver imports from Korea, and water pollution control (p) (27).
1948	General	The Fisheries Agency Act is enacted (G) (23).
1948	General	The Fisheries Cooperative Association Law is promulgated (g) (24).
1950	General	The Second Fisheries Law is enacted (G) (25).
1950	General	Synthetic fiber nets become available (p) (27).
1951	General	The Law Promoting Reorganization of Cooperative Associations of Agriculture, Forestry and Fisheries is passed (G) (60).
1951	Laver	Laver culture grounds are filled in Sogo-cho, Chiba for the industrial development (p) (27).
1951	Pearl	The Law Promoting Pearl Culture is passed (G) (55).
1951	General	The Fisheries Resources Conservation Law is enacted (G) (35).
1952	General	The Financial Act for Small Enterprises of Fisheries is passed (G) (26).
1952	Laver	Net culture begins (p) (28).
1952	Eel	Electric aerator is adopted and increases production (p) (21).
1952	Oyster	The production achieves the highest record since before the war (p) (55).
1953	Eel & Pearl	The production achieves the highest record since before the war (p) (21,55).
1953-54	General	Yokkaichi Coast fish with oily smell become an issue (p) (61).
1954	Yellowtail	Artificial fertilization by Michizu (p) (17).

Year	Species	References
1956	General	The "Minomata disease" problem begins (p) (61).
1958	Laver	Industrial pollution from Honshu-seishi (paper company) destroys laver culture grounds in Urayasu, Chiba (p) (22).
1958	Scallop	Commercial culture using raft or rope begins (p) (22).
1958	Pearl	Pearl oyster industry becomes independent from pearl culture industry (p) (55).
1958	Laver	Use of artificial fry begins (G) (27).
1958	General	The Water Pollution Control Act is passed (G) (27).
1959	General	Isewan Typhoon hits Tōkai area (33).
1960	General	Chile Tsunami hits Tōhoku area (33).
1960	General	The Law Promoting Reorganization of Fisheries Cooperative Associations is passed (G) (41).
1961-68	Laver	Half (20) of the Fishermen's Cooperative Associations abandon their laver culture grounds in Chiba due to filling for industrial development (P) (28).
1961-62	Oyster	Massive mortality is recorded in Matsushama Bay due to industrial pollution (p) (61).
1962	General	The Seto Inland Sea Ocean Ranching Center is established (G&P) (6).
1962	General	The Third Fisheries Law is enacted (G) (41).
1962	General	Massive fish kill in Mikuni and Kanazu, Fukui, due to industrial pollution (p &G) (61).
1962	General	Massive fish and shellfish kill in the Ariake Sea due to the PCP pollution (p) (61).
1962	General	From November 1961 to October 1962, 74 incidents of water pollution results in massive fish kills in Shoji and Miyamoto (61).
1963	Laver	All laver culture grounds in Tokyo are closed due to reclamation for industrial development (p) (28).
1963	General	The Agricultural Pollution Act is amended (G) (41).

Year	Species	References
1963	General	The Law Promoting Coastal Fisheries is passed (G) (41).
1963	Laver	The "Beta-Nagashi" culture method develops in Miyagi (G & P) (28).
1964	Eel	Taste control of cultured eel meats becomes possible through manipulation of feeds (p) (21).
1964	Laver	Abnormally warm weather damages industry (p) (27).
1966	Laver	Abnormally warm weather damages the industry (p) (27).
1966	Laver	Low temperature stocking net becomes available and doubles crops (G & P) (27).
1966	General	The practical Cooperative Extension Service Act of Fisheries is enacted (G) (41).
1967	General	The Law Promoting Adult Education in Fishermen's Villages is passed (G) (41).
1967	General	The Environmental Protection Act is passed (G) (41).
1967	General	The Law Promoting Smaller Fisheries Enterprises is passed (G) (41).
1967	General	The Law Promoting Amalgamation of Fishermen's Cooperative Associations is passed (G) (41).
1967	General	The Fisheries Disaster Relief Law is promulgated (G) (41).
1967-71	General	The Niigata "Minomata" Disease problem becomes an issue (p) (49).
1968	Laver	Disease damages the industry (p) (27).
1968	General	The Fisheries Resources Conservation Law is enacted (G) (41).
1968-73	Eel	A shortage of elvers is supplemented by 245 tons of elver imports for the 1969-73 period (p) (4).
1969	Eel	Disease damages the industry (p) (3).
1969	Goldfish	Disease damages the goldfish farms in Tokyo (p) (2).

Year	Species	References
1970	General	The First World Conference on Pollution is held in Tokyo, and foreign participants learn the facts of "Minomata" disease and other pollution problems in Japan. As a result pollution problems become a national issue (49)
1971	General	The Fisheries Law is amended (G) (53).
1973	Eel	Artificial fertilization by Klichiro Yamamoto (G) (5).
1971-72	General	A volunteer organization surveys the facts on the Seto Inland Sea Pollution and publishes the Report on the Seto Inland Sea Pollution (p) (19).
1971-73	Goldfish & fancy carp	The "ANAAKI (Hole)" disease damanges the industry (p) (65).
1972	Yellowtail	Red tide appears in fish farms in the Seto Inland Sea and kills 14 million fish (p) (37 and 66).
1973	General	The Seto Inland Sea pollution becomes a national issue (G) (64).
1973	Eel	Imported elvers are still vital for the industry, but disease problems are unsolved (p) (63).
1973	Yellowtail	Self-waste problems from fish farms become an issue (p) (34).
1973	All species	Disease kills 9,000 tons of cultured species and costs 9 billion yen. (p) (9).
1973	General	The Fisheries Cooperative Association Law is amended (G) (52).
1974	All species	The Coastal Fishing Grounds Adjustment and Development Law is enacted (G) (40).
1974	Fancy carp	Unknown disease appears among the fingerlings (p) (51).
1974	Rainbow trout	The IHN damages the industry (p) (74).
1975	Scallop	The bulk of scallops in Aomori, Iwate and Miyagi are killed (p) (7).

Year	Species	References
1975	Yellowtail	Red tide appears in fish farms in the Inland Sea and kills 200,000 fish (p) (66).
1975	Yellowtail	Shortage of fingerlings damages the industry (p) (75).
1975	Salmon	Salmon production in Hokkaido is the highest in history (11).
1976	General	The 22nd National Conference of Fisher youths is held in Tokyo (p) (8).
1977	General	Japanese government declares a 200-mile economic zone (G) (58).
1977	Yellowtail	Red tide appears at fish farms in the Seto Inland Sea and kills 3.3 million fish (p) (10).
1978	Yellowtail	Red tide recurs in fish farms and kills 1 million fish (p).
1978	Scallop	Scallops in the Funka Bay are enjoined from the market because of red tide toxin contracted from cultured scallops.