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| Revenues . . . | 8,986 | 4,135 | 7,912 | 3,642 | 7,793 | 3,400 | 6,883 | 3,177 |
| Expenses | 6,151 | 2,545 | 5,589 | 2,236 | 5,172 | 2,077 | 5,058 | 2,061 |
| Depreciation, etc. & amort. . . . | 2,835 | 1,590 | 2,323 | 1,406 | 2,621 | 1,323 | 1,825 | 1,116 |
| Provisions | 288 | 143 | 264 | 123 | 238 | 104 | 224 | 106 |
| Other income | 1,161 | 951 | 895 | 882 | 1,006 | 825 | 633 | 715 |
| Income before taxes | 1,386 | 496 | 1,164 | 401 | 1,377 | 394 | 968 | 295 |

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FISHERIES AND MARINE SERVICE

Translation Series No. 4198

A manual of scallop culture methodology and management

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by K. Taguchi

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A MANUAL OF SCALLOP CULTURE

METHODOLOGY AND MANAGEMENT

March 1977

Kisaburo TAGUCHI

Overseas Fisheries Cooperation Foundation

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I. FOREWORD

(4)

Scallop culture is different from fish culture and has a number of characteristics as mentioned below.

1. The feed consists of vegetable plankton distributed in the natural environment, so that the provision of feed which accounts for over 50% of the operating cost in the case of fish culture is not required.
2. The construction of a pond at huge expense is not necessary.
3. Since there is no need to establish floating fish preserves which are vulnerable to waves, it is possible to make extensive use of the sea surface as suitable culture grounds.
4. The commercial product value is high, and it is a world-wide product.

Our country is the only country which has succeeded in the commercialization of scallop culture, and coupled with the fact of being blessed in terms of our natural environment as well as our socioeconomic environment, its output has grown more than tenfold in the past 10 years, the production in 1975 being approximately 110,000 tons which is the highest in the world.

On the other hand, looking at the scallop production pattern in the world, we find it is being caught throughout the world except for the tropics, but apart from a few countries such as the U.S. and Canada, the production in the various other countries is extremely low. Were culture techniques to be introduced in these countries, the production can well be surmised to increase.

Considering now the results of our country's achievement in rapid growth and the aforementioned characteristics of scallop culture along with the scallop production pattern in various countries of the world, the scallop culture techniques of our country are believed to be extremely significant as a matter for international technical cooperation.

Based on the foregoing considerations, this paper is aimed at serving as a manual for use in future international cooperation by summarizing the methodology

of scallop culture. At the same time, those matters essential for the formulation of business plans and revenue and expense forecasts are also discussed in terms of a model.

This paper has omitted the scientific aspects of the subject, there being many research reports and other related publications already published concerning this aspect.

II. OUTLINE OF BIOLOGICAL BASICS

(5)

1. Species and Distribution

Scallops and similar protozoa number roughly 300 species, the large majority of which are distributed at latitudes higher than 35 degrees latitude north or south. However, no distribution of commercial density has been seen north of 55 degrees north latitude.

The species which reflect an industrially-viable abundance are as listed below, their production levels being as given in Table II-1.

Japan

Patinopecten yessoensis (Scallop)
Pecten albicans (Cardium edule)

U.S. (Atlantic side)

Aequipecten irradians lamark (Bay scallop)
A. j. concentricus
Placopecten magellanicus (Giant scallop; Large sea scallop)

U.S. (Alaska)

Patinopecten caurinus

Europe

Pecten (Chlamys) opercularis (Queen scallop; Common scallop)
Pecten maximus (Scallop; Escallop; Great scallop)

Southern Hemisphere

Notovola meridionalis (Tasmanian scallop)
Equichlamys bifrons
Mimachlamys asperinumus (Southern Brocade)
Pecten novaezelandiae (New Zealand scallop)
Amusium balloti (South Sea Times)
Pecten alba (Southern Cardium edule)

Pecten yessoensis is distributed in Japan and the Soviet far eastern region. According to 1965 statistics, the Soviet Union has landed 3,500 tons, but these are surmised to be products of the Southern Kuriles.

Patinopecten curinus (Bay scallop) is reported to be distributed in the waters from the Alaskan-Canadian border to Kodiak Island, and its abundance has been said to rival that of Georges Bank on the Atlantic coast, but there are no landing records. (6)

Chlamys (*Argopecten*) *purpurate* is distributed from Valparaiso to the vicinity of Coquimbo in Chile, but commercial harvesting is currently prohibited.

Apart from these, scallops are also being caught on the Pacific side of northern Baja California in Mexico, primarily by the submerged fishing method, but the species is not known. Also, in Panama, *Aequipecten circularis* is being caught, approximately 900 tons representing 2,000,000 dollars being landed in 1972. The catch in both cases is exported to the U.S.

Several species are distributed in Australia and New Zealand.

The New Zealand species is *Pecten novaezelandiae*, which is distributed mainly in Tasman Bay and Golden Bay and is mixed in the catch during sea mussel dredging.

The species distributed in Australia are the following five:

| | | |
|-------------------------------|--------------------|------------------|
| <i>Amusium balloti</i> | (Saucer scallop) | Queensland State |
| <i>Pecten alba</i> | | Victoria State |
| <i>Mimachlamys asperrimus</i> | (Doughboy scallop) | Tasmania State |
| <i>Notovola meridionalis</i> | | " |
| <i>Equichlamys bifrons</i> | | " |

In the northwestern and western Atlantic, *Placopecten magella* (Sea-scallop) is distributed from off Cape Hatteras at 36°N to the Newfoundland offing at 50°N, with Georges Bank being the central dredging grounds. This species is currently being harvested by the U.S. and Canada.

In the offshore waters from New England to the Gulf of Mexico is distributed *Aequipecten irradians* called Bay scallop which the U.S. harvests. However, it is not being harvested in the Gulf of Mexico. In these waters is also distributed *Chlamys islandicus* called Iceland scallop, but it is rare.

In the eastern part of the North Sea and the vicinity of Scotland in the northeastern Atlantic, *Pecten maximus* is distributed to some extent. This is currently being harvested by the U.K., France and Spain in the offshore waters of Ireland, the English Channel and Spain, but because of indiscriminate harvesting the resource is decreasing, and research on its culture method is being advanced in the U.K. and France. (7)

In the offshore waters of France and Spain the small bivalve *Chlamys varia* called Queen scallop and *C. opercularis* are abundant, but due to the high cost of shucking they are not being developed.

In addition, *Cardium edule* is distributed in Holland, U.K., France, Spain and Portugal, with the catch being in excess of 30,000 tons.

In the southwestern Atlantic, the two species of *Chlamys purpuratus* and *Pecten patria* are distributed in the offshore waters of Argentina but their catch is low.

Looking at the world's catch up until 1970 according to the catch statistics of the FAO (Table II-1), the world's leading producer is Canada, with the U.S. being second and Japan third. Both the U.S. and Canada, however, reflect a decreasing trend in their catch, while Japan, by virtue of cultivation begun from around 1965, has now become the world's leading producer with an output in excess of 100,000 tons in 1975.

2. Life Cycle

Quite a few of the Japanese-produced scallops (*Patinopecten yessoensis*) are of the hermaphroditic variety, but as a general rule they are dioecious. The gonads differ in colour between male and female, the ovary exhibiting an orange-reddish

Table II-1. Scallop catch statistics for the world

(8)

Unit: 1,000 tons

| | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 |
|--|-------|-------|-------|------|-------|------|------|
| Sea-scallop | | | | | | | |
| (<i>Pecten magellanicus</i>) | 126.0 | 126.0 | 131.0 | 90.0 | 109.0 | 90.0 | 78.0 |
| Canada (Northwest coast) | 62.0 | 46.8 | 68.7 | 50.0 | 54.7 | 50.8 | 48.4 |
| " (Newfoundland) | 0.7 | 0 | 0 | 0 | 0.4 | 1.2 | 0.5 |
| U.S. (North Atlantic) | 54.5 | 65.2 | 62.5 | 40.2 | 47.8 | 31.7 | 23.6 |
| " (Mid-Atlantic) | 8.9 | 14.2 | - | - | - | - | - |
| " (Northeast Pacific) | | | | 0 | 6.1 | 6.7 | 5.1 |
| Scallop | | | | | | | |
| (<i>Patinopecten yessoensis</i>) | 7.0 | 6.0 | 7.0 | 7.0 | 5.0 | 15.0 | 16.0 |
| Japan | 7.0 | 6.0 | 7.0 | 7.0 | 5.0 | 15.0 | 16.0 |
| Common-scallop | | | | | | | |
| (<i>Pecten maximus</i>) | 10.0 | 9.0 | 8.0 | 9.0 | 11.0 | 17.0 | 19.0 |
| France (Coquille) | 8.2 | 7.5 | 6.9 | 7.4 | 8.4 | 10.2 | 12.0 |
| Iceland | | | | | | 0.4 | 2.4 |
| Ireland | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Spain (Vieira) | 0.2 | 0.2 | 0 | 0.1 | 0 | 0 | 0 |
| U.K. | 1.0 | 0.7 | 0.8 | 1.1 | 2.9 | 5.9 | 4.4 |
| Scallops n.e.i. | | | | | | | |
| (<i>Pecten</i> spp.) | 14.9 | 19.3 | 32.5 | 29.1 | 20.9 | 21.9 | 23.1 |
| U.S. (Northwest Atlantic) (Bay scallop) | 1.7 | 1.6 | 5.1 | 2.6 | 2.6 | 5.3 | 0.9 |
| Spain (Zamburina) | 0 | 0.4 | 0.7 | 0.1 | 0.2 | 0.5 | 0.1 |
| U.K. (Queenies) | | | | | | | |
| U.S. (Mid-Atlantic) | 5.2 | 5.1 | 12.8 | 12.0 | 3.1 | 2.4 | 2.0 |
| (Calico-scallop) | - | - | 10.5 | 9.8 | 0.6 | 1.4 | 1.2 |
| (Bay-scallop) | 5.2 | 5.1 | 2.3 | 2.2 | 2.5 | 1.0 | 0.8 |
| Argentina (Vieyras) | 0.8 | 0.4 | 0.2 | 0.6 | 1.1 | 7.5 | 14.0 |
| Australia (Indian Ocean) | 6.7 | 11.0 | 13.1 | 13.4 | 13.6 | 5.2 | 3.1 |
| " (Pacific Ocean) | 0.3 | 0.2 | 0.3 | 0 | 0.1 | 0.3 | 2.3 |
| New Zealand | 0.2 | 0.6 | 0.3 | 0.4 | 0.2 | 0.7 | 0.7 |

colour and the spermary being yellowish-white. When parent scallops are taken out of the water, the shells open about 5 mm so that it is possible to see inside and distinguish their sex.

a. Spawning season

The spawning season in Mutsu Bay in Aomori Prefecture is from late March to mid-May, while in Uchiura Bay in Hokkaido, because the rise in water temperature is later than in Mutsu Bay, it is from mid-April to mid-May. (9)

The critical temperature for spawning is 8.0° - 8.5° C, and it is when the water temperature has suddenly increased that spawning takes place. In Uchiura Bay, since a rapid increase in water temperature occurs twice or so during the spawning season, spawning also occurs on about two separate occasions.

b. Growth

In the natural state, given a water temperature of 8° - 9° C, the blastula develops in about 40 hours after fertilization, with cilia developing and rotary motion commencing. In two days after fertilization it becomes a bursa, in four days it becomes a trochophore and surfaces, and by the 5th-6th day it turns into a veliger with a D-shaped shell forming.

By the 15th-16th day after birth the shell length becomes 120 μ (1/1,000 mm), and this is called the umbo stage. By the 40th day the shell length becomes 300 μ . This is called a mature larva. When this stage is reached, the larva becomes attached to something else.

The suitable temperature range for growth is 6° - 20° C, with the optimum temperature being between 10° - 15° C. The suitable salinity range is between 30-40‰, with the optimum salinity being 37‰ which is slightly higher than in normal sea water.

c. Attached life - bottom life

The attached life lasts for 40-60 days and extends from early June until late July. During this period the shell length becomes 6-10 mm. The average growth

per day is 100-150 u.

When the shell length reaches 6-10 mm, it naturally detaches itself from the attached object and sinks to the sea-bed to enter into the bottom life.

The bottom life commences in late July - early August. Those which have lapsed one full year after birth are called bottom fry, those over one year up to two years are called young scallops, and those beyond that are called mature scallops.

The suitable temperature range for habitation is 5^o-23^oC, with the upper limit of the suitable salinity being 25‰ above 18.11 Cl‰ (pH 8.3) and the lower limit being 12.00-15.50 Cl‰. Below 5^oC or above 20^oC growth stops, and particularly at high temperatures there is a risk of death.

3. Reproduction

(10)

The egg count in mature females is around 100 million in two-year-olds and 170 million in 5-6 year-olds, and the spawning count from one female parent is deemed to be several tens of millions. In the natural state, however, fertilization is extremely difficult, and even with artificial insemination no more than 2-3 million turn out to be cultivable to seedlings, so that in nature it would be far less.

Next, the attachment of the seedlings to other objects is characterized by wide variations according to environmental factors, while the survival rate of the bottom-shifting fry is extremely low in the natural state, being 5-10% or lower.

Because of such characteristics, the reproductive rate of scallops in the natural state is extremely low, but it has happened that abnormally high births have been seen when there has been an abnormal increase in the spawning count or when a large number of attached fry have developed by virtue of a favourable environment or when the survival of bottom-shifting fry is high, giving rise to an abrupt increase in the catch.

Prior to 1965, scallop production in our country had been extremely unstable, characterized by the emergence of a sudden rise at intervals of 10-20 years, which

had been attributed to such abnormal births as described above.

The heart of the scallop culture technique currently being undertaken lies in helping the attachment of free-swimming fry, preventing the sinking of attached fry to the sea-bed and carrying out suspension culture in the sea for a fixed period so as to eliminate the high mortality rate.

4. Formation of Obstruction Ring

The year ring on the shell normally forms due to growth stagnation because of high temperatures in the summer. In Hokkaido, however, a lowering of the water temperature becomes the cause, it being formed due to growth stagnation from the

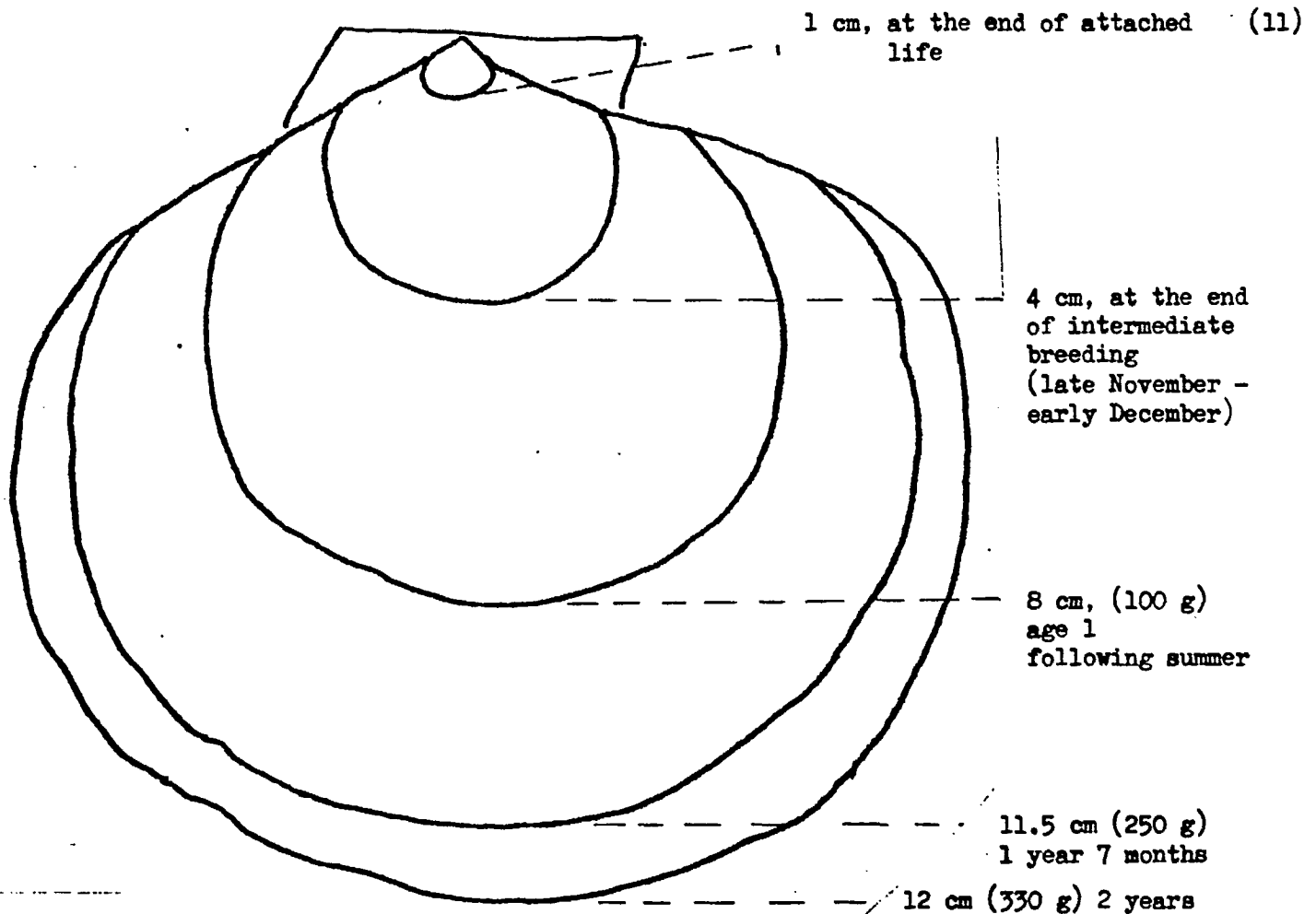


Fig. II-1. Obstruction rings appearing on the shell of a scallop (actual scale)

end of November until the following May.

Apart from this, growth may be impeded due to parasites or disease or when man-made environmental changes occur, resulting in year-ring-like lines on the shell.

Fig. II-1 shows to actual scale the formation pattern of year rings on a scallop subjected to suspension culture in Mutsu Bay, along with its shell length at each period.

5. Feed Organisms

The principal feed organisms of scallops, according to a survey in Mutsu Bay, are the three types listed below.

1. Flagellata: *Monochrysis lutheri*
2. Diatomaceae (Bacillariophyta): *Phaeodactylus triconutum*
3. " : *Navicuta* sp.

6. Relationship between Life Cycle and Culture

As previously mentioned, the heart of the scallop culture technique lies (12) in artificial seedling collection and a fixed period of suspension culture, and the relationship between this and the life cycle is as given in Table II-2. The table depicts the situation in Mutsu Bay which differs from the situation in Hokkaido.

Table II-2. Relationship between the life cycle and culture process of scallops in Mutsu Bay (From Sugano, 1972)

| Life cycle segment | Period | Time | Label | Size | Habitat | Culture process |
|-----------------------------------|--------------|------------|------------------------|------------|-----------------------|------------------------|
| Female parent | | | | | At sea; sea-bed | |
| Spawning, fertilization, cleavage | March-April | 0-5 days | Current year scallop | 70-100 u | At sea; surface layer | Seedling collection |
| Free-swimming larva | April-May | 30-40 days | " | 100-400 u | At sea | |
| Fry - Attached fry | May-August | 4 months | " | 0.3-12 mm | At sea; sea-bed | Intermediate breeding |
| " - Bottom fry | Aug-Next Mar | 7-10 mths | " | 1-6 cm | At sea; sea-bed | Ground-scatter culture |
| Young scallop | Mar-Next Mar | 1 year | 1st yr scallop | 5-10 cm | " | Suspension culture |
| Mature scallop (female parent) | After April | Over 2 yrs | 2nd yr scallop & older | Over 10 cm | " | |

III. PRESENT STATE OF SCALLOP CULTURE IN OUR COUNTRY

(13)

1. Position Occupied by Scallop Culture in Surface Culture

Table III-1 shows the number of operators, production levels and production values in the surface culture industry in our country.

Table III-1. Number of operators, production levels (tons) and production values (millions of yen) in the surface culture industry

| | Year | Yellow-tail | Sea bream | Scallop | Oyster | Pearl | Laver | Seaweed | Kelp | Prawn |
|---------------------|------|-------------|-----------|---------|---------|--------|---------|---------|-------|-------|
| Number of operators | 1970 | 2,278 | 204 | 3,538 | 5,407 | 3,635 | 63,162 | 18,735 | 1,126 | 77 |
| | 71 | 2,675 | 278 | 5,572 | 5,536 | 2,962 | 55,942 | 19,315 | 1,539 | 75 |
| | 72 | 3,066 | 529 | 6,154 | 5,261 | 2,823 | 50,362 | 19,870 | 2,408 | 80 |
| | 73 | 3,246 | 745 | 8,090 | 5,355 | 2,526 | 47,733 | 20,804 | 3,034 | 83 |
| Production levels | 1971 | 61,743 | | 11,165 | 193,846 | 49 | 244,946 | 94,350 | | 306 |
| | 72 | 76,913 | | 23,162 | 217,373 | 42 | 217,906 | 105,678 | | 454 |
| | 73 | 80,269 | | 39,372 | 229,899 | 34 | 311,410 | 113,211 | | 653 |
| | 74 | 92,685 | | 62,673 | 210,583 | 30 | 339,314 | 153,762 | | 912 |
| Production values | 1971 | 34,255 | | 2,271 | 10,369 | 10,823 | 66,450 | 6,958 | | 1,120 |
| | 72 | 45,372 | | 4,089 | 12,189 | 13,893 | 76,948 | 8,397 | | 1,707 |
| | 73 | 45,235 | | 7,233 | 12,836 | 16,297 | 117,904 | 10,678 | | 2,749 |
| | 74 | 72,705 | | 11,838 | 16,511 | 14,473 | 88,070 | 11,134 | | 4,391 |

Source: 1976 Fisheries Statistical Index - Planning Section, Fisheries Administration Division, Fisheries Agency

In terms of the number of operators, if we exclude algae culture, the scallop culture operators are the most numerous, reaching some 8,000 in 1973. If we add the approximately 2,000 girder net fishermen involved with ground-scatter cultured scallops, the number exceeds 10,000, which is double the approximately 5,300 oyster culture operators in second place. (The girder net operators number 1,055 in Hokkaido and 1,094 in Aomori.)

In terms of 1974 production levels, however, the scallops were third at 62,000 tons following 210,000 tons of oysters and 92,000 tons of yellow-tail, while in terms of money value the scallops were fourth at 11.8 billion yen following the

yellow-tails at 72.7 billion yen, oysters at 16.5 billion yen and pearls at 14.5 billion yen. Furthermore, if we look at the production value per operator, again in 1974 it was 22.39 million yen for yellow-tails, 5.72 million yen for pearl culture and 3.09 million yen for oyster culture, whereas it was no more than 1.46 million yen for scallop culture.

Next, looking at the pattern of increase in the number of culture operators (14) during the four-year period of 1970-1973, there has been an increase by 1.4 times in yellow-tail culture, no change in oyster culture and a decrease to 0.7 in pearl culture. In contrast to this, scallop culture shows an increase by 2.3 times.

From the foregoing facts, it can be surmised that while scallop culture has undergone rapid development in recent years, it is attributable to an extremely large number of small-scale operators.

2. Regional Distribution of Operators

According to the 5th Fisheries Census of October 1, 1973, scallop culture is being undertaken in 14 prefectures as shown in Table III-2 but predominantly in the four prefectures of Hokkaido, Aomori, Iwate and Miyagi. Within Hokkaido itself, it is centred in the four counties of Abashiri, Iburi, Oshima and Shiribeshi.

What should be noted here is the fact that within Honshu it is also being undertaken in Mie, Ishikawa and Fukui Prefectures, while in Hokkaido it is not expanding in Kushiro, Hidaka and Rumoi. This means that the topography of the coast governs the possibility of culture.

3. Production Pattern

Looking at the shift in production levels in the four predominant prefectures during the eight-year period of 1967-1975, as shown in Table III-3 in 1975 Hokkaido had 47% of the national production while Aomori had 42%. If we look at the shift during the eight years, the production in Aomori (Mutsu Bay) expanded by 27 times in contrast to an eight-fold increase in Hokkaido. This fact implies that the sea environment in Mutsu Bay was well suited to scallop culture and that the socio-

economic conditions such as the relationship with other types of fisheries or existing fisheries were conducive to making this possible.

Next, in scallop culture there are two methods consisting of an extensive method based on the ground-scattering of seedlings and an intensive method by suspension, but the production increase seems to have been largely dependent upon the development of suspension culture (see Fig. III-1).

4. Pattern of Expansion of Suspension Culture Facilities

(15)

Looking at the pattern of development of suspension-type culture in terms of the pattern of increase in the number of facilities and in the harvest per unit area, the pattern for Hokkaido has been summarized in Table III-4.

The suspension culture facility is of the stretched-rope type, and the total length of stretched ropes in Hokkaido has grown from 445 km in 1970 to 1,926 km in 1973, an increase of 4.3 times in just three years. During this period the number of operators has also multiplied by 2.5 times, so that the stretched rope length per operator has grown by 1.7 times in three years from 655 m in 1970 to 1,130 m in 1973.

In addition, while no significant change can be seen in the harvest per 1 m length of girder rope (trunk rope of the stretched rope), whether it is because the layout spacing of the girder ropes has been reduced so as to raise the number of girder ropes per unit area or whatever, the harvest per unit area has increased by 2.6 times in three years. This is clear from the fact that the operating area per m of girder rope has shrunk to less than half in the three-year period.

The national scallop production level, as shown in Table III-3, has reached 113,000 tons in 1975 which is 13.7 times the 1967 level. Such a rapid increase in production has a dampening effect relative to the rise in various commodity prices, and from the management aspect this is one of the reasons for concentrated culture (increase in the number of suspended baskets per unit area). Tables III-5 and III-6 show respectively the prices in the Tokyo and Sapporo central wholesale markets.

Table III-2. Number of scallop culture operators nation-wide by prefecture
(5th Fisheries Census of October 1, 1973)

(16)

| | Total number | Main business | Side business | | | Number of cultured scallops (1,000) | Average per operator (1,000) |
|-----------------------------|--------------|---------------|---------------|----------|-------------------|-------------------------------------|------------------------------|
| | | | Other culture | Catching | Culture, catching | | |
| Nation-wide | 7,222 | 907 | 704 | 1,716 | 3,895 | 852,876 | 118 |
| Hokkaido | 1,663 | 147 | 151 | 609 | 756 | 337,036 | 202 |
| Aomori | 1,681 | 733 | 53 | 783 | 112 | 414,457 | 246 |
| Iwate | 2,894 | 24 | 215 | 289 | 2,366 | 66,265 | 22 |
| Miyagi | 861 | 1 | 245 | 2 | 613 | 33,696 | 39 |
| Chiba | 2 | 0 | 1 | 0 | 1 | 57 | 28 |
| Shizuoka | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| Mie | 30 | 1 | 28 | 0 | 1 | 399 | 13 |
| Ehime | 2 | 0 | 1 | 0 | 1 | 123 | 61 |
| Toyama | 2 | 0 | 1 | 0 | 1 | 28 | 14 |
| Ishikawa | 39 | 0 | 4 | 21 | 14 | 212 | 5 |
| Fukui | 34 | 0 | 3 | 10 | 21 | 539 | 15 |
| Kyoto | 2 | 0 | 0 | 1 | 1 | 3 | 1 |
| Shimane | 3 | 1 | 1 | 0 | 0 | 40 | 13 |
| Kagawa | 8 | 0 | 1 | 1 | 6 | 20 | 2 |
| By counties within Hokkaido | | | | | | | |
| Abashiri | 316 | 85 | 36 | 118 | 77 | 135,567 | 429 |
| Kushiro | 32 | 0 | 1 | 12 | 19 | 946 | 29 |
| Hidaka | 1 | 0 | 1 | 0 | 0 | 5 | 5 |
| Iburi | 439 | 21 | 31 | 105 | 282 | 103,298 | 235 |
| Oshima | 714 | 38 | 80 | 223 | 373 | 93,933 | 131 |
| Rumoi | 12 | 0 | 1 | 11 | 0 | 469 | 39 |
| Shiribeshi | 149 | 3 | 1 | 140 | 5 | 2,818 | 18 |

Table III-3. Shift in nation-wide scallop production level
(Includes planned figures; unit: tons)

(17)

| | | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975* |
|------------------|----------|-------|-------|--------|--------|--------|--------|--------|--------|---------|
| Hokkaido | Natural | 4,766 | 3,327 | 7,263 | 9,390 | 7,766 | 7,555 | 9,512 | 11,774 | 16,540 |
| | Cultured | 1,547 | 1,441 | 2,969 | 3,332 | 5,107 | 7,715 | 14,876 | 21,856 | 35,360 |
| | Total | 6,313 | 4,768 | 10,232 | 12,722 | 12,873 | 15,270 | 24,388 | 33,630 | 51,900 |
| Aomori | Natural | 1,781 | 1,125 | 5,936 | 11,770 | 7,635 | 14,233 | 14,530 | 17,497 | 20,350 |
| | Cultured | - | - | 200 | 2,600 | 1,500 | 9,524 | 16,343 | 29,426 | 27,429 |
| | Total | 1,781 | 1,125 | 6,136 | 14,370 | 9,135 | 23,757 | 30,873 | 46,923 | 47,779 |
| Miyagi | Natural | - | - | - | - | - | - | - | - | - |
| | Cultured | 96 | 181 | 492 | 1,160 | 1,500 | 1,900 | 1,000 | 1,420 | 1,920 |
| | Total | 96 | 181 | 492 | 1,160 | 1,500 | 1,900 | 1,000 | 1,420 | 1,920 |
| Iwate | Natural | - | - | - | - | - | - | - | - | - |
| | Cultured | 100 | 130 | 400 | 1,200 | 6,561 | 4,366 | 6,000 | 6,042 | 11,704 |
| | Total | 100 | 130 | 400 | 1,200 | 6,561 | 4,366 | 6,000 | 6,042 | 11,704 |
| Grand Total | Natural | 6,547 | 4,452 | 13,199 | 21,160 | 15,401 | 21,788 | 24,042 | 29,271 | 36,890 |
| | Cultured | 1,743 | 1,752 | 4,061 | 8,292 | 14,668 | 23,505 | 38,219 | 58,744 | 76,714 |
| | Total | 8,290 | 6,204 | 17,260 | 29,452 | 30,069 | 45,239 | 62,261 | 88,015 | 113,303 |
| Rate of Increase | % | 100 | 74 | 208 | 355 | 362 | 546 | 751 | 1,061 | 1,367 |

Note: *: Estimated volume; Natural: Ground-scattered culture; Cultured: Suspension culture; Rate of increase: 1967 taken as 100.

Sources: Hokkaido Prefectural Fisheries Division; Hokkaido Fisheries Association; Aomori Prefectural Fisheries Administration Section; Iwate Prefectural Fisheries Association; Statistical Information Division, Economic Bureau, Ministry of Agriculture and Forestry.

Table III-4. Pattern of development of scallop suspension culture in Hokkaido

| Year | Number of operators (A) | Total length of stretched ropes km (B) | Operated area 1000 m ² (C) | Stretched rope length per operator (B/A) m | Harvest with shell (D) ton | Harvest per m of stretched rope (D/B) kg/m | Harvest per square m (D/C) kg/m ² | Area per m of stretched rope (C/B) m ² |
|------|----------------------------|--|---|--|-------------------------------|--|--|---|
| 1970 | 680 | 445 | 6,330 | 655 | 3,291 | 7.4 | 0.52 | 14.2 |
| 71 | 911 | 707 | 9,653 | 788 | 5,624 | 7.9 | 0.58 | 13.6 |
| 72 | 1256 | 1,096 | 6,701 | 874 | 7,513 | 6.8 | 1.12 | 6.1 |
| 73 | 1694 | 1,926 | 11,626 | 1,130 | 16,266 | 8.4 | 1.39 | 6.0 |

(D/C for 1973 in terms of scallop count is generally around 8 scallops while by ground-scatter it is around 6 scallops per m².)

Table III-5. Average price of boiled scallops at Tokyo Central Market

(18)

| Year | Volume of supply (tons) | Sales value (1000 yen) | Unit price per kg |
|------|-------------------------|------------------------|-------------------|
| 1971 | 613 | 486,048 | 792 yen |
| 72 | 1,125 | 743,500 | 660 |
| 73 | 1,434 | 999,447 | 697 |
| 74 | 3,560 | 2,710,001 | 761 |

Note: Yield rate of boiled scallops is 27% of weight with shell.

Table III-6. Shift in scallop prices at Sapporo Central Wholesale Market
(From the Market Annual Report)

| Year | Shucked scallops | | | Scallops in shell | | |
|------|------------------|------------------------|-------------------|-------------------|------------------------|-------------------|
| | Volume kg | Cash value 1000 yen | Unit price yen | Volume kg | Cash value 1000 yen | Unit price yen |
| 1968 | 368 | 184,674 | 502 | 20 | 4,362 | 218 |
| 69 | 418 | 226,685 | 542 | 30 | 6,447 | 215 |
| 70 | 488 | 321,471 | 659 | 51 | 14,138 | 275 |
| 71 | 629 | 415,183 | 659 | 131 | 32,221 | 245 |
| 72 | 712 | 485,483 | 678 | 292 | 76,851 | 263 |
| 73 | 948 | 679,621 | 716 | 731 | 209,291 | 286 |
| 74 | 2,020 | 1,270,580 | 629 | 764 | 210,100 | 275 |

Note: Yield rate of shucked scallops is 30% of that with shell.

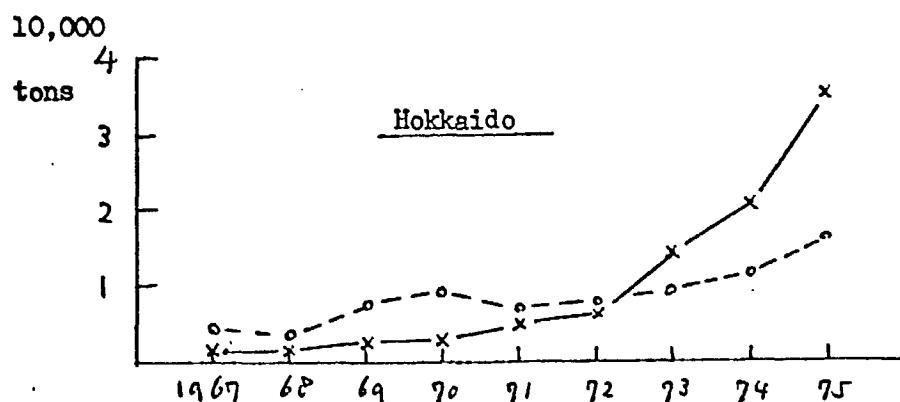
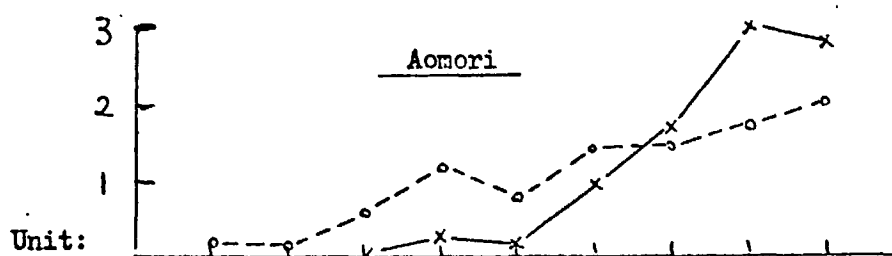


Fig. III-1.

Shift in production level of scallops by suspension culture and ground-scattered culture in Hokkaido and Aomori (1967-1975)

o---o Ground-scattered culture
x---x Suspension culture

IV. CULTURE METHODOLOGY (SEEDLING PRODUCTION)

(19)

Scallop (*Patinopecten yessoensis*) culture in our country is being undertaken mainly in the four prefectures of Hokkaido, Aomori, Iwate and Miyagi. Depending on such differences as the topography of the sea area being used as the culture grounds, the sea environment, and the conditions governing the cooperative fishing rights for scallop culture, etc., there are certain differences in the culture methodology between regions. In particular, while the differences in sea conditions reflected by the water depth, water temperature, tides and waves may not change the fundamental method of culture, they do lead to changes in the structure of facilities and various work procedures, thereby impacting on the required facilities and equipment.

Because of these factors, we shall in subsequent chapters discuss in some detail the operations in Hokkaido's Uchiura Bay as a method of culture in strongly oceanic waters, and the operations in Mutsu Bay in Aomori Prefecture as a method in typically shallow bay waters.

1. Fundamental Methodology

Basically, the method of culture entails collecting with a seedling collector mature larvae (free-swimming larvae) which have developed from natural spawning, putting them into a breeding basket and breeding them until they attain a shell length of around 3 cm (called intermediate breeding), and then either ground-sowing them in the fishing grounds (breeding grounds) and letting them grow naturally or putting them into a breeding basket for suspension culture until they become adults.

Artificial seedling collection which involves the whole process of artificial spawning, fertilization and larva breeding, is not being carried out as an enterprise. The reason for this is that the method of collecting free-swimming larvae developed from natural spawning has been technically perfected such that not only can the required volume of seedlings for both ground-sowing culture and suspension culture be sufficiently provided by the collection of naturally-spawned free-swimming larvae but their transplantation to areas where no seedlings can be collected altogether is

also possible.

Nevertheless, considering that artificial seedling collection may become necessary in the event that natural seedling collection becomes difficult, a seedling production technique based on artificial spawning on an experimental scale has been perfected at the Aomori Prefectural Fisheries Propagation Centre, with this technique being utilized in various biological studies. Even in this case, however, artificial breeding consists of the period until the end of attached life when the shell length grows to about 1 cm or so, the subsequent breeding being identical to the industrial case whereby the seedlings are placed in a breeding basket and suspended in the sea for breeding in a natural environment. (20)

2. Artificial Seedling Production

a. Method of artificial spawning

Although artificial spawning on an industrial scale is not being carried out, to provide for the event of difficulty in collecting naturally-produced seedlings a method of seedling collection based on artificial spawning has been devised as follows.

Naturally-produced parent scallops are collected in March and sexually identified by looking at the colour of their gonads through the 5 mm opening which occurs. The females have orange-reddish ovaries while the males have yellowish-white spermaries.

Any miscellaneous substances attached to the shell are thoroughly washed with sea water and eliminated.

Spawning tanks are prepared so as to accommodate each sex separately at the rate of one parent scallop per tank.

The structure of the spawning tank is as depicted in Fig. IV-1. Joining transparent pieces of 2-4 mm thick polyethylene plates to form a tank 21 cm wide, 25 cm deep and 26 cm long, a drainage tube is installed at the upper end using a pipe of 1 cm inner diameter.

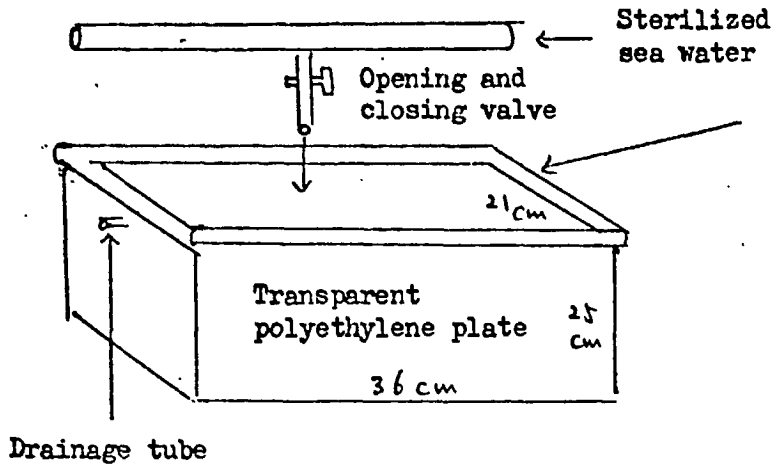


Fig. IV-1. Spawning tank

Reinforcement by polyethylene pipe

As tank water, sea water passed through a set of ultraviolet sterilizing lamps is used and introduced from above the spawning tank.

The intake volume is set so that there will be a steady trickle into each tank from a vinyl tube of around 1 cm diameter.

The vinyl intake tube must be isolated from the water surface in the tank. (21)

The tank water should be maintained at a temperature of 12°-15°C.

Each set of sterilizing lamps (seven units for approximately 100,000 yen) will be capable of providing water to about 20 spawning tanks.

The spawning tanks and sterilizing lamps are arranged as shown in Fig. IV-2. While the tanks are depicted in a single layer in the figure, more space saving can be achieved by arranging them in 2-3 layers (see Photo IV-1).

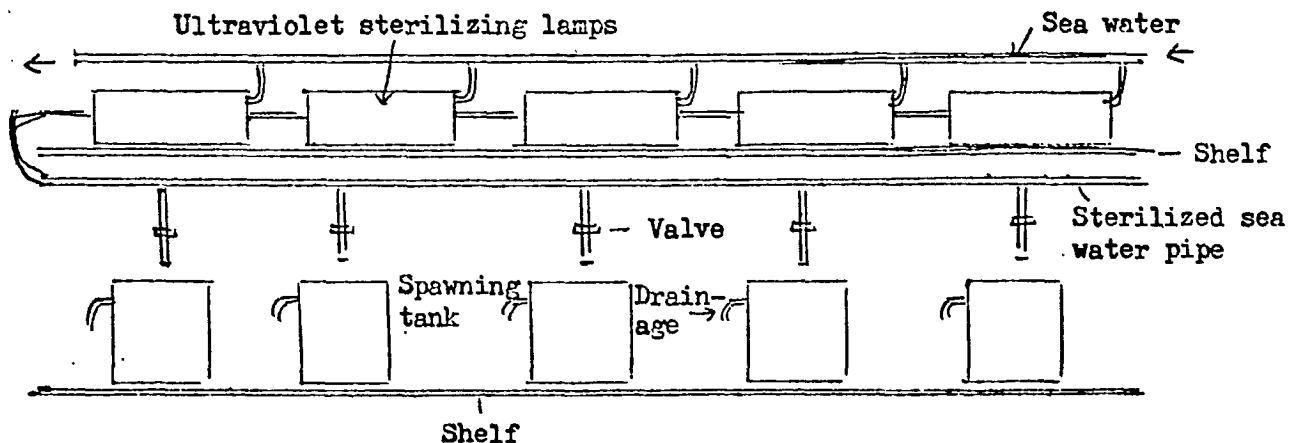


Fig. IV-2. Layout of spawning tanks and sterilizing lamps



Photo IV-1. Spawning tanks

Upper layer is ultraviolet sterilizing apparatus.

In the case of natural spawning, a sudden rise in water temperature becomes (22) the trigger for inducing spawning, but when ultraviolet-sterilized water is used, the sterilized sea water itself has the effect of inducing spawning, thereby obviating any need to worry about water temperature.

Putting the parent scallop into the spawning tank and letting sterilized sea water flow in, before long the female will start laying eggs and the male will begin discharging sperm. Once the egg laying or seminal discharge has been completed, the parent scallop is removed from the spawning tank. Next, with respect to the eggs, 1 cc of its sea water is extracted with a pipette and the number of eggs contained therein is calculated to determine the total egg count in the tank, and similarly with respect to the spermatozoa the sperm count per cc is calculated using a blood count plate. Then pouring the sea water containing the sperm discharge into the tank containing the eggs so as to achieve a ratio of 10-15 spermatozoa per egg, fertilization is allowed to take place. During fertilization the trickle of sea water is stopped.

As fertilization is completed, the fertilized eggs will sink to the bottom of the tank while the unfertilized eggs will not sink. The required time for this interval is approximately one hour.

At most one hour after fertilization, the spawning tank is tilted so as to pour out the supernatant sea water. The extent of discharge should be such that approximately 1 L of water at the bottom remains. This is in order to eliminate the unfertilized eggs and surplus spermatozoa. Repeating this supernatant exchange 5-10 times by pouring in sea water, once the unfertilized eggs and spermatozoa are completely eliminated, the tank is again filled with sea water and left alone. After a lapse of 65 hours or so, the fertilized eggs will hatch and the newborn larvae enter free-swimming life. During this period the water in the tank is left completely alone, with no aeration nor feeding. Those eggs which do not surface after a lapse of 65 hours are discarded using a siphon.

The number of free-swimming larvae which can be obtained by the foregoing method is in the order of 2 million - 3 million per female on the average.

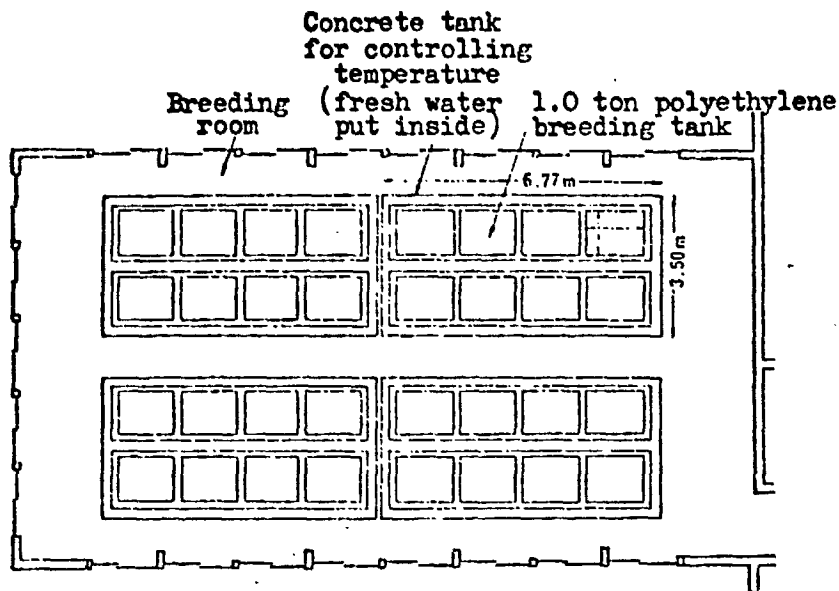
b. Method of breeding free-swimming larvae

The free-swimming larvae born in the spawning tank correspond to trochophores, and until they pass through the veliger stage and umbo stage and attain a shell length of 300 μ when they become attached to other substances, the free-swimming larvae are transferred to a free-swimming larva breeding tank for breeding.

The structure of the free-swimming larva breeding room is depicted in Fig. IV-3, with the structure being capable of temperature control, aeration and exchange of the breeding water.

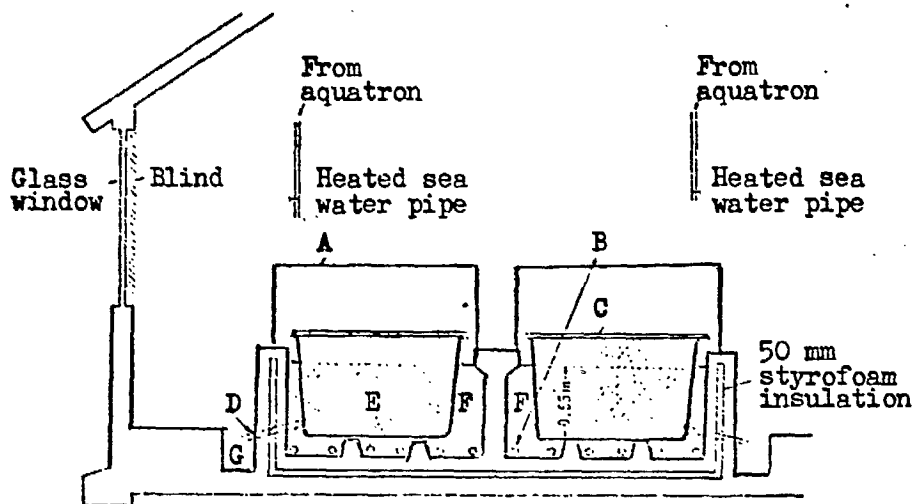
The breeding tank can be placed in an indoor temperature-controlled water tank.

The temperature-controlled water tank is made of concrete 21 cm thick and 82 cm deep lined with insulating material (styrofoam 50 mm thick), at the bottom of which is a two-ridged base (8 cm high, 7 cm wide) to support the larva breeding tank. (23)



Plan view of breeding room

Fig. IV-3.
Structure of breeding room



Cross-sectional view of breeding room

- A: Framework for vinyl cover
- B: Polycarbonated hot water pipe for temperature control
- C: Lid made of insulating material
- D: Drainage pump
- E: 1.0 ton polyethylene breeding tank
- F: Fresh water
- G: Drain

The free-swimming larva breeding tank is made of collapsible Polydia sheet (manufacturer: Nagasawa Company, Oimawari-cho, Sendai City), its dimensions being 85 cm wide, 120 cm long and 65 cm deep (1.5 ton capacity). There are holes along the upper edge to pass a rope through so that the tank can be suspended by rope from a wooden framework which is laid across the concrete walls of the temperature-controlled water tank (see Fig. IV-4).

The breeding density of the free-swimming larvae which have developed into trochophores in the breeding tank is two per cc of sea water, and the temperature

of the breeding water is maintained at 12° - 14° C with a maximum of 17° C. Direct sunlight is avoided. Aeration is not done and instead $\frac{1}{2}$ - $\frac{1}{4}$ of the total volume of breeding water is replaced daily. The water replacement operation is done by using a vinyl chloride pipe of 13 mm diameter to siphon water from the bottom of the tank, filtering it with Müller gauze before discharging it. The purpose of filtering is to prevent the outflow of larvae. (24)

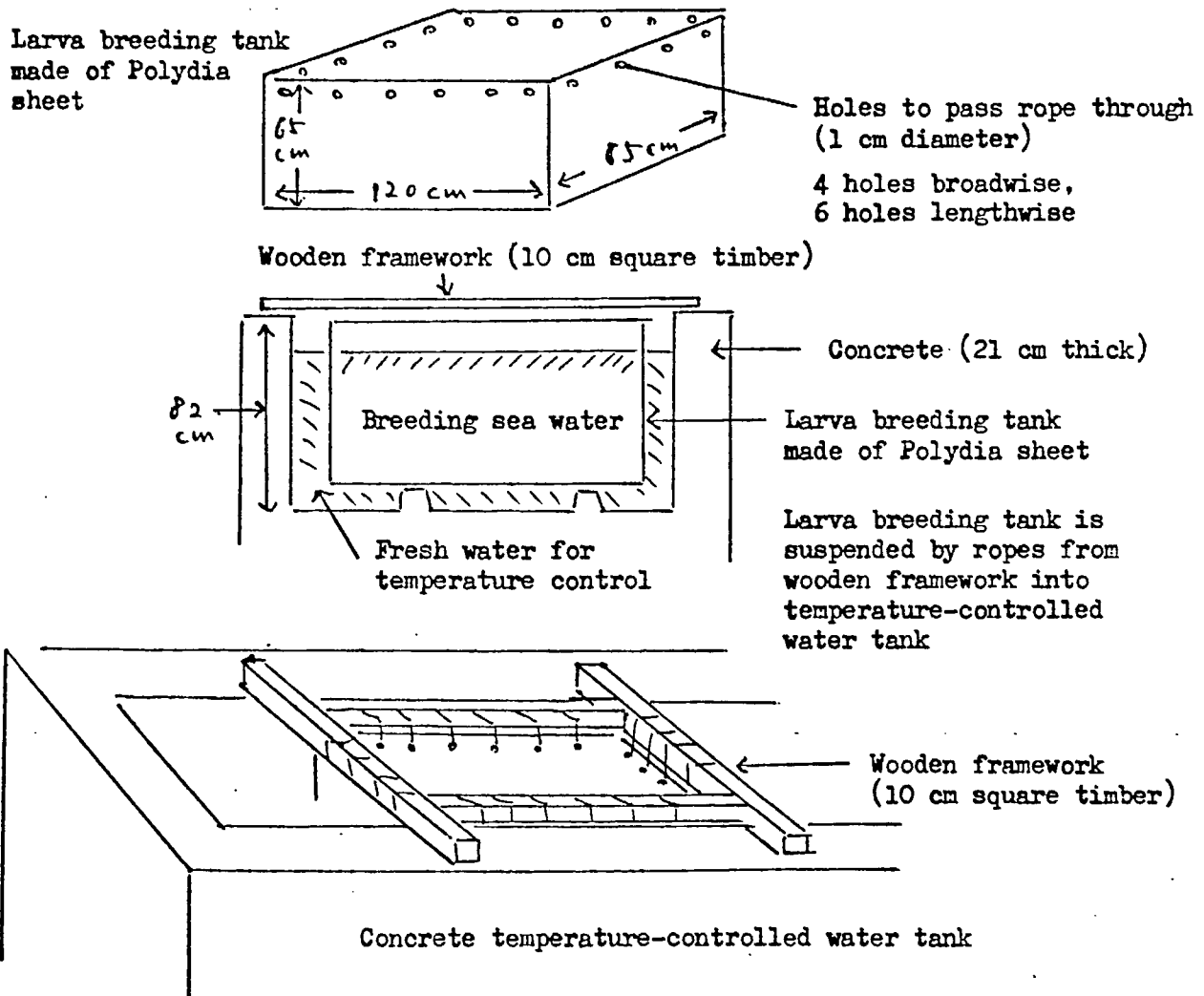


Fig. IV-4. Structure and layout of the free-swimming larva breeding tank

The breeding of larvae requires feed, and the feed organism (*Monochrysis lutheri*) cultivated in a feed cultivation tank described below is given initially at the rate of 2,500 per cc of breeding water once a day.

The feed volume is increased in accordance with the growth of the larvae, and at the final stage of larval breeding when they attain a shell length of 6 mm - 10 mm and attach themselves to the seedling collector as seedlings for intermediate breeding, the feed rate is adjusted to around 50,000 per cc of breeding water.

Twenty days after hatching or after a lapse of about 17 days since they were (25) put in the larva breeding tank, with the water temperature at 12°-14°C the larvae grow to 240-250 u and become attached to other substances. Once this stage is reached, an artificial seedling collector is suspended into the larva breeding tank. After lowering the seedling collector, aeration is carried out in the breeding tank.

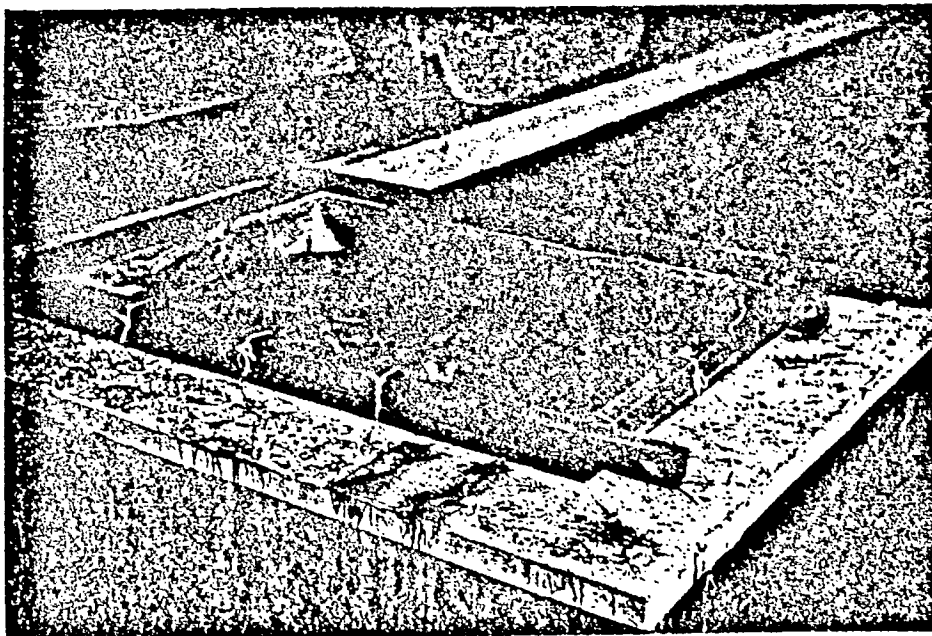


Photo IV-2.
Free-swimming larva
breeding tank

c. Seedling collector

The artificial seedling collector, as shown in Fig. IV-5 and Photo IV-3, consists of hair-like fibres made by fraying hemp-palm bark and bundled into 5 mm thicknesses 15 cm long, tying them at 5-6 cm apart with a cotton twine 2 mm in

diameter, 10 of these strung together forming a string and making 20-30 strings into a bundle.

Hemp-palm bark is available on the market at around 300 yen per bundle of 10 sheaves. Bleaching this in water to thoroughly remove the harshness, the bark is frayed into hair-like fibres.

The number of seedling collectors to be suspended in each breeding tank is 3-4 bundles.

The growth of the larvae attached to the collector is 100-150 μ per day, and at a water temperature of 15^o-20^oC they grow to a shell length of 1 cm in a period of 40-60 days, dropping from the collector and sinking to the bottom of the breeding tank.

Those which have sunk to the bottom become first stage seedlings.

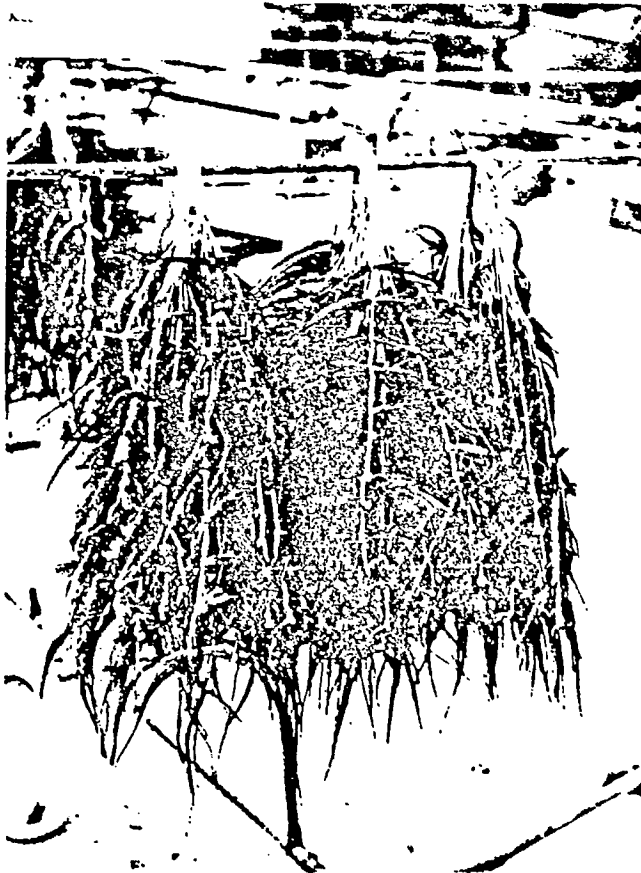
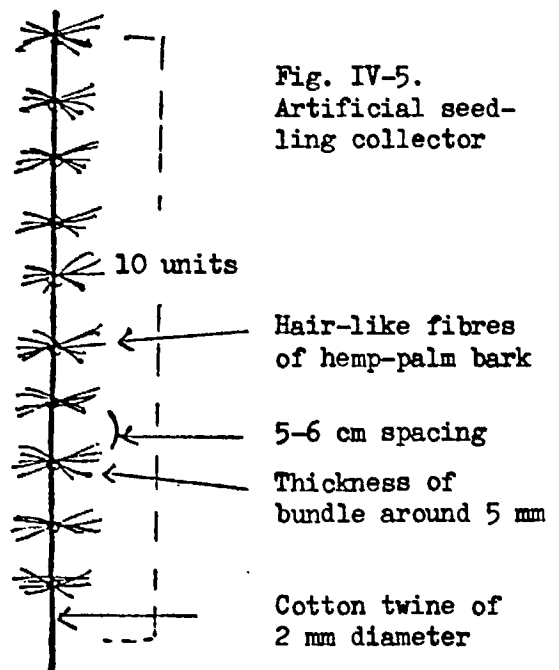


Photo IV-3.
Artificial seedling collector
(made by bundling fibres of
hemp-palm bark)

(26)



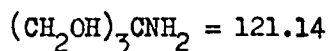
d. Cultivation of feed organism

As the feed organism for free-swimming larvae, *Monochrysis lutheri* which belongs to the Flagellata class is used.

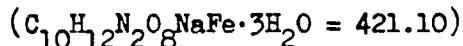
The culture fluid contains the following proportionate ingredients per L of sea water (figures in parenthesis are per 1,000 L).

1. NaHO_3 200 mg (200 g)
2. $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ 25 mg (25 g)
3. Na_2SiO_3 2 mg (2 g)
(Sodium meta sillicate)
4. Fe-EDTA 500 mg (500 g)
5. TRIS 200 mg (200 g)
6. Vitamin B_{12} 2 mg (2 g)
7. Biotin 1 mg (1 g)
($\text{C}_{10}\text{H}_{16}\text{O}_3\text{H}_2\text{S}$ --- Vitamin B compound)
8. Thiamine 100 mg (100 g)
(Vitamin B_1)

Note: TRIS = Tris (hydroxymethyl) aminomethane



Fe-EDTA = Ethylenediamine tetraacetic acid iron salt



As shown in Fig. IV-6 and Photo IV-4, the culture fluid and *Monochrysis* seeds (27) are put in a 3 L glass jar 21 cm in diameter and 46 cm high. Holding the room temperature at $10^\circ\text{--}20^\circ\text{C}$ and aerating, the *Monochrysis* will multiply to 4 million - 6 million per mL of culture fluid. The extent of propagation can be identified by the colour of the culture fluid, which initially is close to colourless transparency but gradually begins to turn yellow and ultimately becomes dark yellow. During this cultivation, there is no need to supplement the contents of the culture fluid. Aeration consists simply of passing air through water.

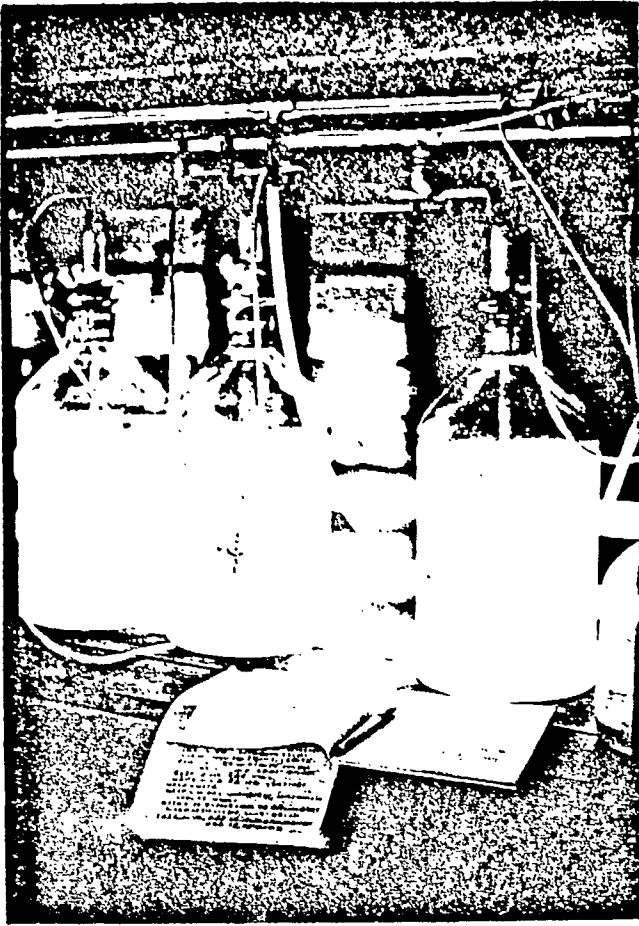


Photo IV-4. Cultivation of Monochrysis

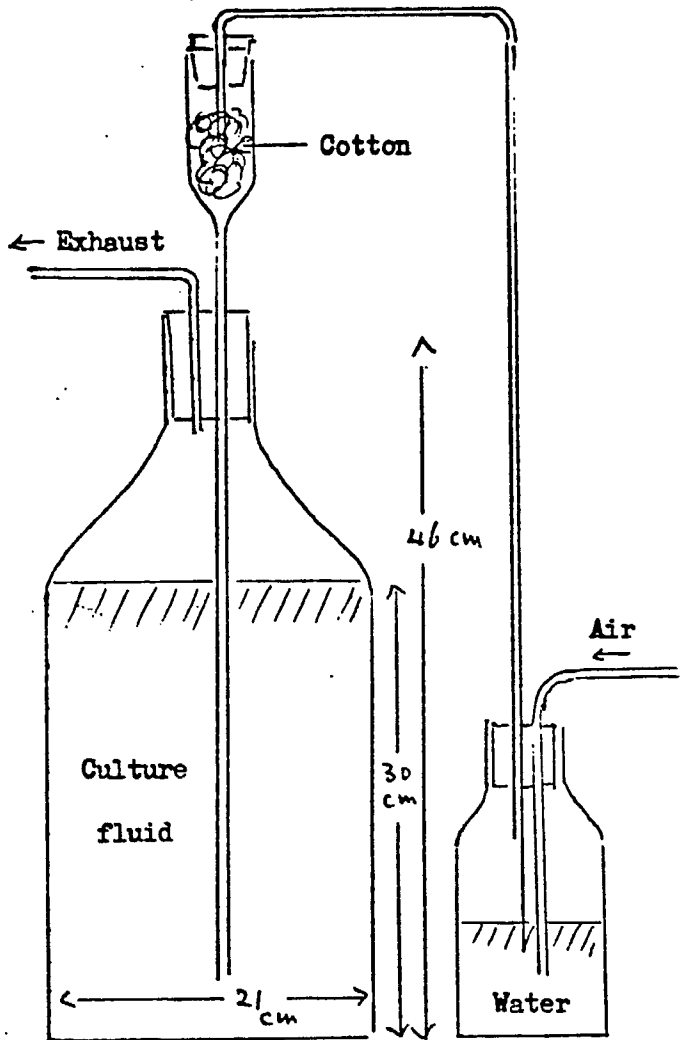


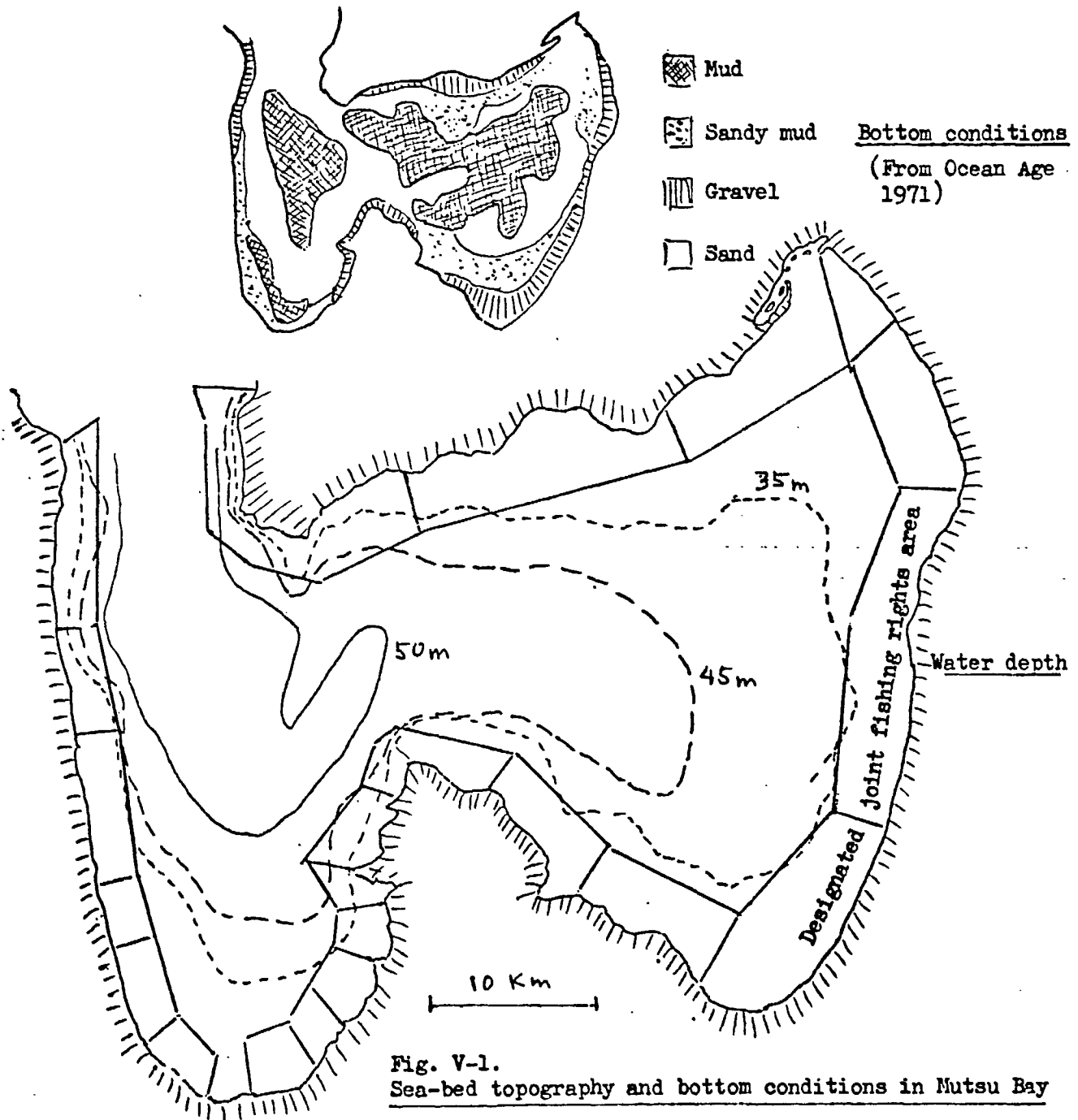
Fig. IV-6. Cultivation of feed organism

To continue the culture, when the propagation level reaches a density of 4 million - 6 million/mL, 1-2 L are transplanted into 7 L of a new culture fluid, and 10 days or so after transplantation it is ready for use.

V. CULTURE METHODOLOGY IN MUTSU BAY IN AOMORI PREFECTURE

1. Sea Environment

The unique characteristics of the sea environment of Mutsu Bay are that the mouth of the bay is narrow so the inflow of ocean water is small, the water depth in the majority of places is under 50 m and shallow, where the water depth is over 45 m



the bottom is mud, and the velocity of the tidal current along the coastal area is around 0.1 knot.

(29)

Fig. V-1 shows the sea-bed topography along with the designated joint fishing rights areas, and as is clear from looking at this the depth of the culture grounds in the majority of cases is 35 m or less. The areas where the water depth is over 45 m have mostly muddy bottoms, making them unsuitable for ground-sowing culture.

Because of such a sea environment, the suspension culture facilities do not need to cope with strong waves or tides, and the depth of the waters being utilized averages around 30 m or so. This fact largely influences the structure of the culture facilities and the various culture-related operations described below.

2. Collection of Natural Seedlings

Forty days or so after birth, when the shell length gets to around 300 μ , the scallops become attached to other substances. The collection of naturally-produced seedlings is carried out utilizing this characteristic.

At the Aomori Prefectural Fisheries Propagation Centre, the corpulence of the gonads of female parent scallops is examined at 20-30 points in Mutsu Bay around November-December. Then in March-April of the following year, 20 L of sea water are pumped up from depths of 5 m, 20 m, and 30 m at 20-30 points within the bay at weekly intervals, and filtering this with a plankton net, the number of larvae collected measuring around 200 μ is examined. In this way, a forecast of the goodness or poorness of seedling attachments is provided for the culture operators.

This is based on the results of a study on the relationship between the number of free-swimming larvae over 200 μ contained in 1 m³ of sea water and the number of attached fry per single onion bag, which relationship is depicted in Fig. V-2.

A seedling-collecting onion bag, as the name implies, is a bag used in shipping onions, a net bag measuring 80 cm in depth and 37 cm wide at the opening. The net is made of Hyzex or Netron monofilament woven into a 5 mm x 3 mm mesh with double strands vertically and a single strand horizontally.

Inside this is placed an appropriate bundle of Netron monofilament netting with a mesh of around 1 cm or old salmon and trout drift-netting of nylon monofilament as attachment material for the larvae.

The advantage of an onion bag lies in the fact that, since the mesh size is 3 x 5 mm, the larvae can attach themselves to the material inside it but when they

(30)

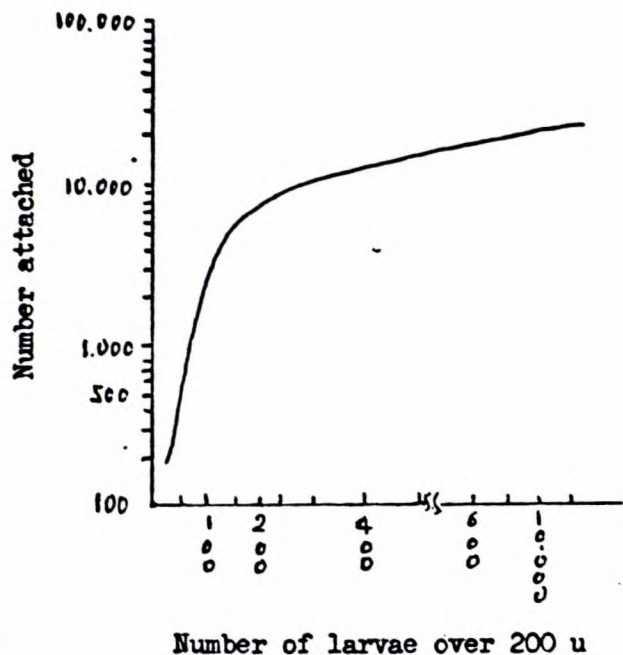


Fig. V-2. Relationship between number of larvae and number of attached seedlings

From Ito, Sugano and Takahashi, 1975. Annual Bulletin of Tohoku University Marine Life Research Institute, Vol. XV, No. 2.

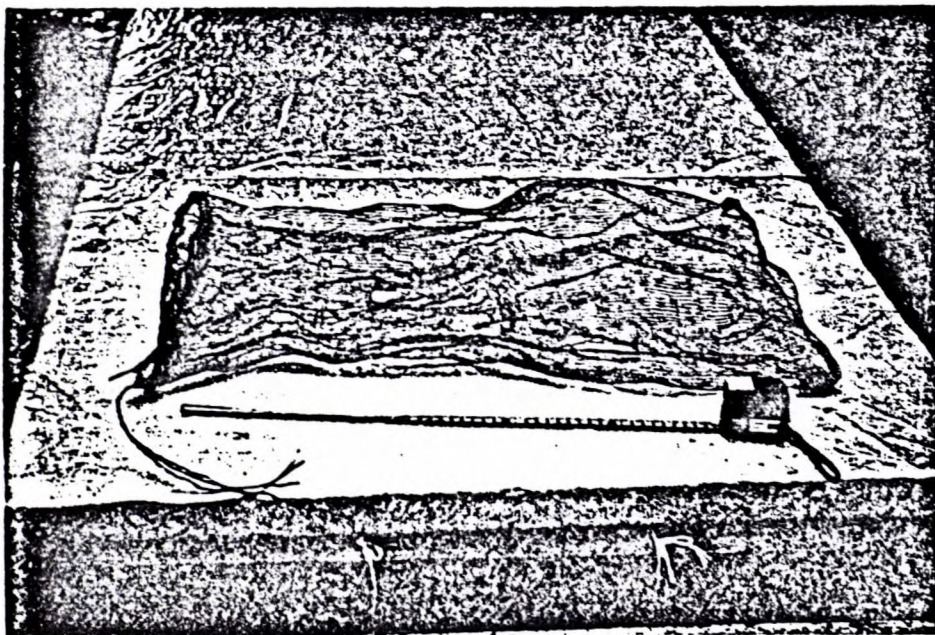


Photo V-1. Onion bag

grow to 6-10 mm and fall off, they are prevented by the onion bag mesh from sinking to the sea-bed and thus remain at the bottom of the bag.

The time of suspension of the onion bags into the sea is generally late April in Mutsu Bay, while the raising period is July-August.

The method of suspending the onion bags into the sea is by the stretched (31) rope system, and normally a 100 m length of trunk rope is called one string, from which branch ropes with bags attached are suspended at 1 m intervals (total number of 100). The length of a branch rope is 10-15 m, and the number of bags tied to each is 10-15.

Because of the shallowness of the water depth in Mutsu Bay (the depth in the large majority of culture grounds being 40 m or less), the depth limit for laying out the trunk ropes is about 35 m, and they are laid out in rows at 20-30 m intervals parallel to the tidal current.

Due to differences in the size of the designated joint fishing rights area owned by each union and in the number of union members, the length of trunk rope of the stretched rope used for seedling collection is not constant, ranging from a maximum of 300 m where the surface area per union member is large, to as little as 50 m where it is small.

The layout of the stretched rope is as depicted in Fig. V-3, while Table V-1 shows the required materials and seedling collection costs per 50 m length of stretched rope for a model seedling collection facility. The calculation of costs is based on 1975 values.

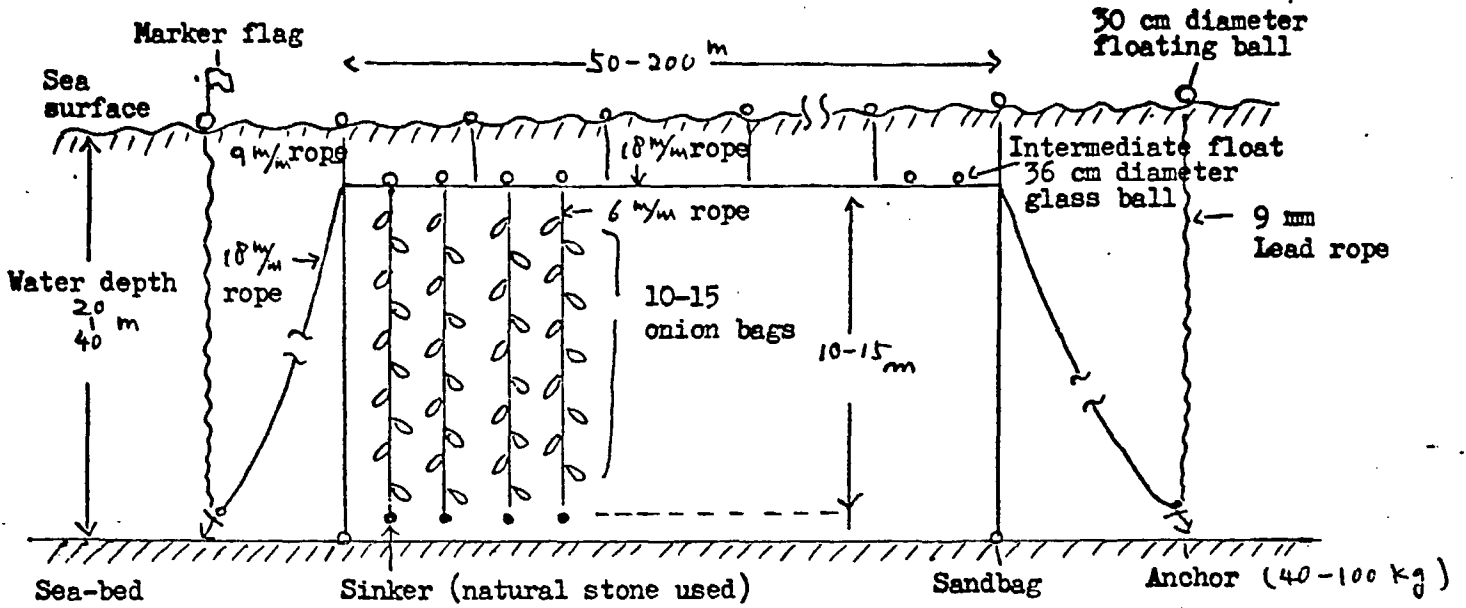


Fig. V-3. Layout of stretched rope for seedling collection

Table V-1. Required materials for seedling-collecting stretched rope and cost of seedling collection

(32)

(1) Material costs

| Item | Size | Quantity | Unit cost | Total cost | Years of life | Cost per year | Remarks |
|-----------------|-------------|----------|-----------|------------|---------------|---------------|--------------------------|
| H.Z. rope | 18 mm | 50 m | | | 5 | | Trunk rope |
| " | 18 mm | 100 m | | | 5 | | Anchor rope |
| " | 16 mm | 100 m | | | 5 | | Float rope |
| Anchor | 60 kg | 1 | | | 5 | | |
| Anchor | 40 kg | 1 | | | 5 | | |
| H.Z. rope | 9 mm | 60 m | | | 5 | | Lead rope |
| Synthetic float | Diam. 24 cm | 2 | | | 5 | | Lead float ball |
| " | Diam. 30 cm | 3 | | | 5 | | Float ball |
| Glass float | Diam. 40 cm | 2 | | | 2 | | Intermediate float |
| " | Diam. 36 cm | 40 | (yen) | | 2 | | " |
| H.Z. rope | 6 mm | 1,000 m | 6.9 | 6,900 | 5 | 1,380 | Suspension rope |
| P.P. rope | 6 mm | 1,000 m | | | 5 | | For securing glass balls |
| Onion bag | | 500 | 26.0 | 13,000 | 2 | 6,500 | For seedling collection |
| Netron net | | 500 | 8.8 | 4,400 | 5 | 880 | For seedling collection |
| Concrete sinker | 1-3 kg | 50 | | | 5 | | Sinker |
| Total | | | | 24,300 | | 8,760 | |

Note: H.Z.: Hyzex; P.P.: Polypropylene

As the stretched rope for seedling collection is utilized after seedling collection in intermediate breeding and suspension culture, those costs which have not been entered under unit cost and total cost are calculated separately as costs for intermediate breeding and suspension culture.

(2) Wages

| Item | No. of people | No. of days | Unit cost | Total cost |
|------------------------------------|---------------|-------------|--------------|--------------|
| Making branch ropes for onion bags | 1 | 1 | yen 2,000 | yen 2,000 |
| Making onion bags | 1 | 1 | 2,000 | 2,000 |
| Onion bag suspension work | 2 | 1 | 2,000 | 4,000 |
| Collection of fry | 4 | 3 | 2,000 | 24,000 |
| Total | | | | 32,000 |

Ballnet-making means the work of wrapping the glass balls with P.P. rope.

(3) Boat costs

Assuming 7 million yen for a new boat, repaid over seven years, and 200 work-days per year, the hire per day comes to 5,000 yen.

| | | |
|---|---|--------------|
| To suspend the branch ropes of the onion bags takes 1 day | } | Total 4 days |
| The work of collecting the fry takes 3 days | | |

Boat costs: 4 days x 5,000 yen = 20,000 yen

Fuel costs (300 yen a day): 300 yen x 4 = 1,200 yen

Total 21,200 yen

(4) Total cost of seedling collection

Material costs 8,760 yen

Wages 32,000 yen

Boat and fuel costs 21,200 yen

Total 61,960 yen

Assuming the number of seedlings collected per onion bag to average 1,000, 500 bags means a collection of 500,000 seedlings, making the unit cost of seedling collection:

61,960 yen ÷ 500,000 = approximately 0.12 yen.

3. Intermediate Breeding and Suspension Culture

Placing the 6-10 mm fry collected from the seedling collector around July-August into a pearl net (called a cushion basket in Hokkaido), their cultivation until they attain a shell length of 3 cm or more by December-March the following year is called intermediate breeding.

This is followed by transferring them to a lamp basket (referred to in Hokkaido as a round culture basket) and cultivating them into adult scallops, the process of which is called suspension culture. In recent years, however, the above distinction has tended to become unclear. The reason for this is that the intermediate breeding with the pearl net is being continued until the end of the attachment of sea mussels in early July of the following year, during which period an

exchange of baskets is carried out four times with the aim of reducing the population density inside the basket as well as replacing the baskets having attached organisms.

Intermediate breeding. In July-August the seedlings collected with an onion bag are raised onto the boat right in their bags. Opening the bags and removing the seedling-attached material, as shown in Photo V-3 this is shaken inside a bag net of about 1.5 m diameter hung over the side of the boat into the sea, thereby forcing the attached seedlings to drop into the bag. This bag is double layered, with the inner (34) bag being freely removable, and the seedlings remaining in this inner bag are transferred to a polyethylene tub (roughly 2 bushel size) aboard the boat (see Photo V-4).

The process of putting the seedlings into the pearl net, as shown in Photo V-5, is done by opening the mouth of the pearl nets interconnected beforehand for suspension, scooping up and inserting about 2 teacupfuls of seedlings from the tub, and then immediately sewing shut the mouth of the pearl nets. The number of seedlings put into each pearl net at this time is generally 1,000-2,000. As soon as the placement of seedlings into each string of pearl nets is completed, they are immediately suspended into the sea. As is obvious, the foregoing operation is done entirely aboard the boat.

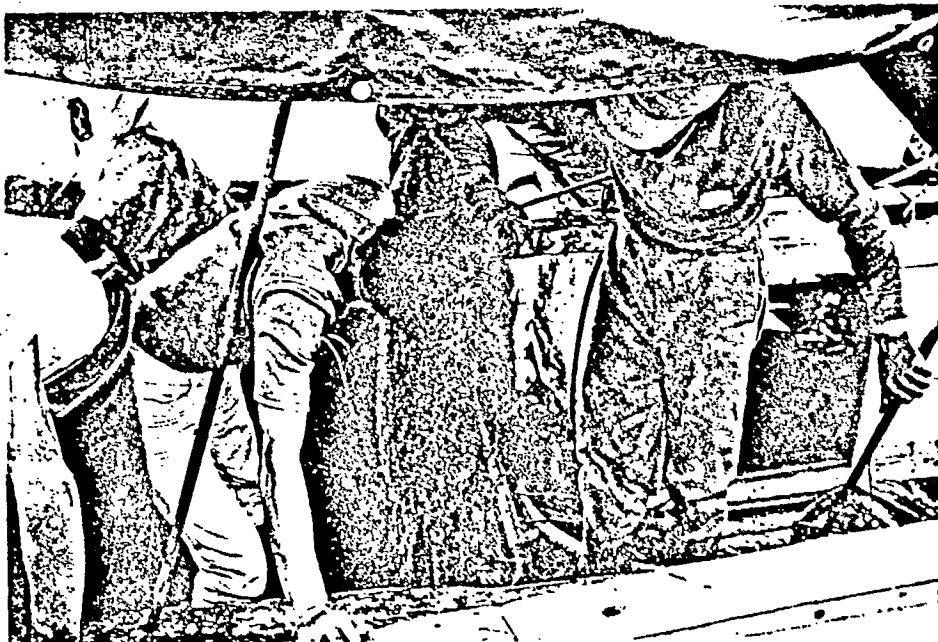


Photo V-2.
Scene depicting an
onion bag just
raised from the
sea onto the boat

In contrast to the fact that these operations in Hokkaido are carried out on land, this point may be said to be a unique operational characteristic of Mutsu Bay.

As the seedlings grow, the baskets are exchanged to reduce the population density in the baskets and increase the mesh size of the baskets.

The first exchange is in September-October, when the population density is made 200-300 per pearl net.

The second one is in November-December, when the density is reduced to 100-200.

The size of the seedlings at this stage has become approximately 2 cm, and some are used for ground-sown stocking while others are sold for transplantation.

The third exchange takes place in February-March of the following year, with (35) the density being reduced to 50-60.

The fourth one is in May-June, when the number is reduced to 35-40.

The determination of the number of seedlings constituting the appropriate population density is based on the criterion that approximately $1/3$ of the bottom area of the pearl net is covered.

Until the fourth basket exchange mentioned above, a pearl net is used, but when the attachment of sea mussels in early July is seen to be over the scallops are transferred to a lamp basket (round basket). The size of the fry at this point is around 6 cm.

The cultivation in the pearl net until the time of transfer to the round net is called intermediate breeding.

The pearl net is also sometimes called a lantern basket, the structure of which as shown in Fig. V-4 consists of a square frame made of 3 mm thick Takylon wire 35 cm to a side on which is formed a triangular net basket approximately 15 cm high. Passing a black H.Z. rope (6 mm diameter) through the centre, 7-10 of these are connected in a series spaced 20 cm apart (see Photo V-6).

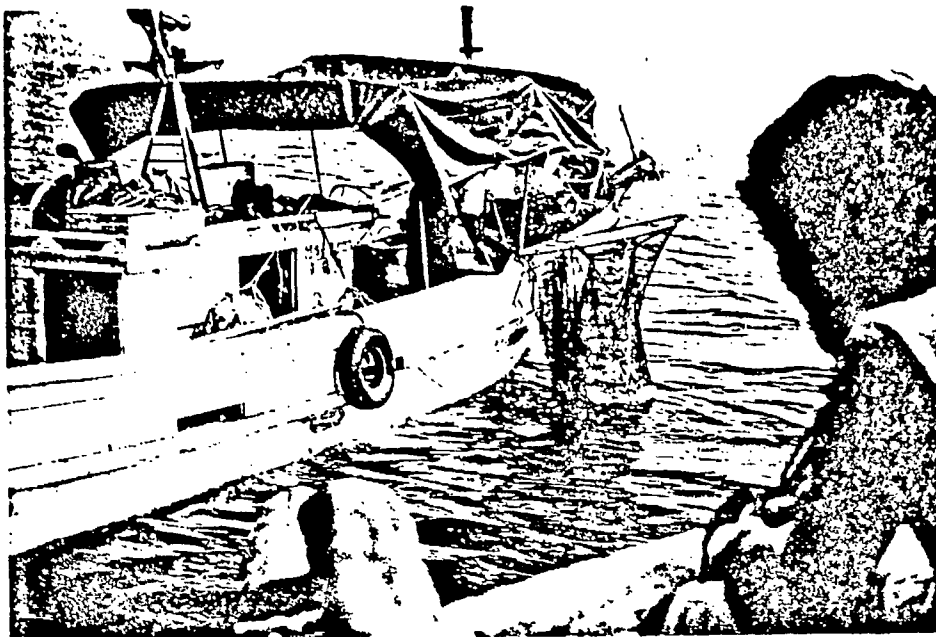


Photo V-3. Net bag into which seedlings collected in onion bags are shaken off

The bag is double layered, with the outer bag being attachable to the side of the boat.

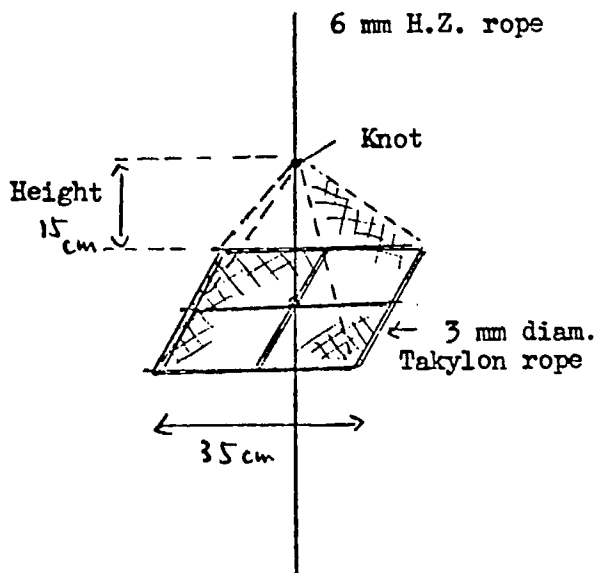


Fig. V-4. Structure of pearl net



Photo V-4.
Seedlings removed from onion bag
are put into tub aboard the boat



Photo V-5.
Process of placing seedlings
held in tub into pearl net

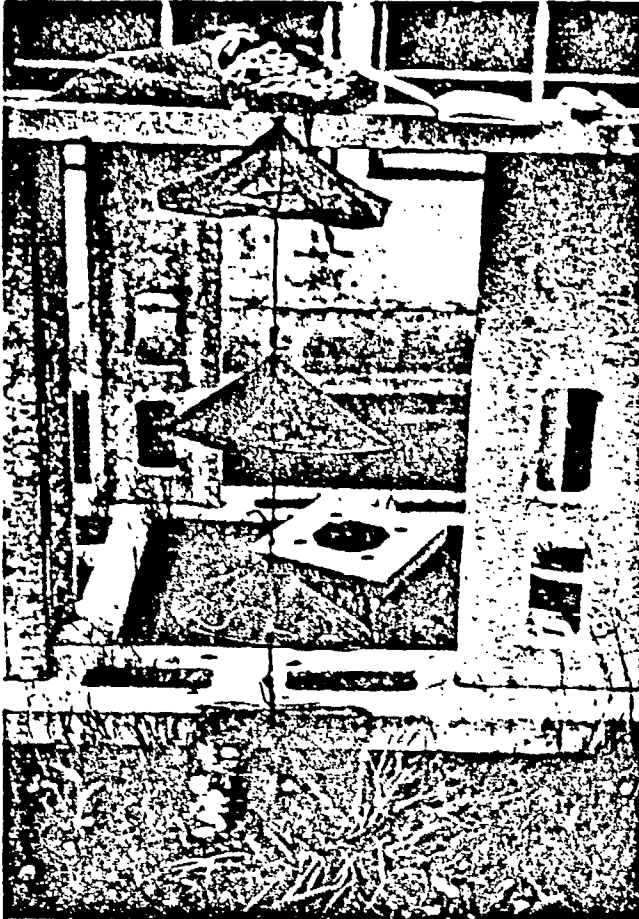


Photo V-6.
Pearl nets connected together

The suspension of the pearl nets into the sea is done with a stretched rope as shown in Fig. V-5 similar to the case of seedling collection. The layout depth of the trunk rope in this case is normally 15-20 m. The reason for this lies not only in enhancing the safety of the facility against waves but also in preventing any oscillation of the facility, improving the growth of the scallops and preventing the attachment of harmful adhesive organisms onto both the baskets and scallops.

The stretched rope used at the time of seedling collection is utilized as is for this, and after removing the branch ropes holding the onion bags, the pearl nets containing the seedlings are suspended in their place. However, because the number of pearl nets will increase as the population density of the seedlings in each pearl net is reduced, it will be necessary to add new stretched ropes. In selecting the

culture grounds for this case the following points must be taken into consideration.

1. Select as calm a place as possible (to prevent wave damage).
2. Water depth should be under 30 m from an economical standpoint.
3. The water temperature in summer should not stay above 23°C for more than two months continuously.
4. Avoid places where there are large river mouths or where river waters swell heavily during rainfalls. (38)
5. Avoid steep rocky sea-beds, and select level ground of sand or sandy mud.

In spite of the fact that the size of the designated joint fishing rights area is limited, because of an increase in the number of culture operators and the efforts of each to expand his scale of operation, there is a tendency for the spacing between the layout of stretched ropes to decrease such that, unless the stretched rope layouts are strengthened against the waves and wind, there is a danger of the stretched ropes shifting and tangling with adjacent ropes.

The layout of a stretched rope for intermediate breeding and suspension culture is as shown in Fig. V-5 for a water depth of 30 m at the layout position and a trunk rope length of 100 m, while the required materials and costs for them are as shown in Table V-2.

Suspension culture. Upon completion of the so-called intermediate breeding, the shell length grows to approximately 6 cm, and thereafter the scallops are bred into adults.

The method involves a transfer from the pearl net to a lamp basket, using the same stretched rope for suspension as was used for intermediate breeding.

The structure of the lamp basket (round basket) is as shown in Fig. V-6 and Photo V-7, and consists of 11 circular frames of 45 cm diameter made of 5 mm thick Takylon wire, which are spaced at 15 cm intervals and enveloped with a net to form a basket.

The transfer process entails first of all raising one string of pearl nets aboard the boat, emptying the scallops inside into a tub on the deck, sizing the scallops, inserting the sized scallops into a lamp basket at the rate of about 40 per layer, and suspending this lamp basket in place of the pearl nets.

Then, as the scallops grow, at the same time that the baskets are exchanged the number of scallops per basket layer is systematically reduced until ultimately it becomes approximately 8 per layer.

Using this kind of suspension method, the shell length reaches 11-12 cm by about 1 year and 7 months after birth.

The first basket exchange is generally in October, at which time the population is reduced to about 15 per layer.

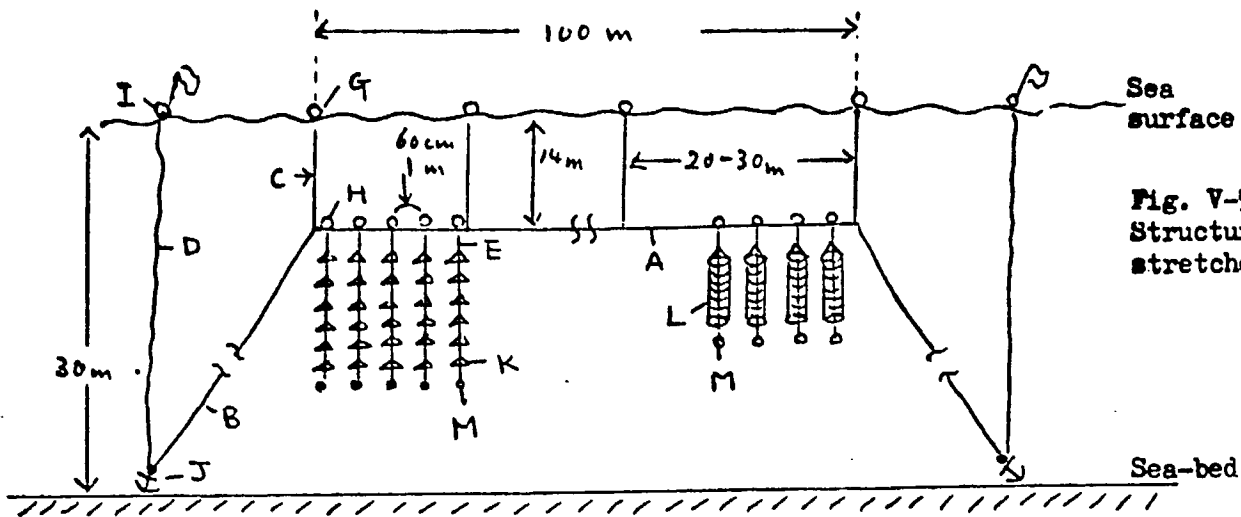


Fig. V-5.
Structure of stretched rope

Table V-2. Required materials per unit of stretched rope (100 m of trunk rope)

| Symbol | Item | Size | Quantity | Unit price (yen) | Total price (yen) | Years of life | Annualized cost |
|--------|-----------------|--------------------------------------|----------|------------------|-------------------|---------------|-----------------|
| A | Trunk rope | 18 mm Dialon rope | 100 m | 65 | 6,500 | 5 | 1,300 |
| B | Anchor rope | 18 mm " " 2 pieces | 180 m | 65 | 11,700 | 5 | 2,340 |
| C | Float rope | 12 mm " " 5 pieces | 80 m | 31 | 2,480 | 5 | 496 |
| D | Lead rope | 12 mm " " 2 pieces | 66 m | 31 | 2,046 | 5 | 409 |
| E | Suspension rope | 6 mm " " 100 pieces | 1,350 m | 6.9 | 9,315 | 3 | 3,105 |
| F | Bundling rope | 6 mm PP rope (for glass ball) | 600 m | 8.4 | 5,040 | 3 | 1,680 |
| G | Float | 33 cm diam. synthetic float | 5 | 730 | 3,650 | 5 | 730 |
| H | Intermed. float | 33-36 cm diam. glass ball | 40 | 1,350 | 54,000 | 3 | 18,000 |
| I | Lead float | 30 cm diam. synthetic float | 2 | 460 | 920 | 5 | 184 |
| J | Anchor | 60 kg single clawed or double clawed | 2 | 16,000 | 32,000 | 5 | 6,400 |
| K | Pearl net | 6 mm mesh & 3 other types | 1,000 | 60 | 60,000 | 3 | 20,000 |
| L | 10-layer basket | 21 mm mesh & 2 other types | 100 | 1,060 | 106,000 | 3 | 35,333 |
| M | Sinker | | 100 | 5 | 500 | 5 | 100 |
| | Total | | | | 294,151 | | 90,077 |

Note: Half of the pearl nets are for exchange purposes; unit prices are as of 1975. The above facility provides a capability for cultivating 150,000 scallops.

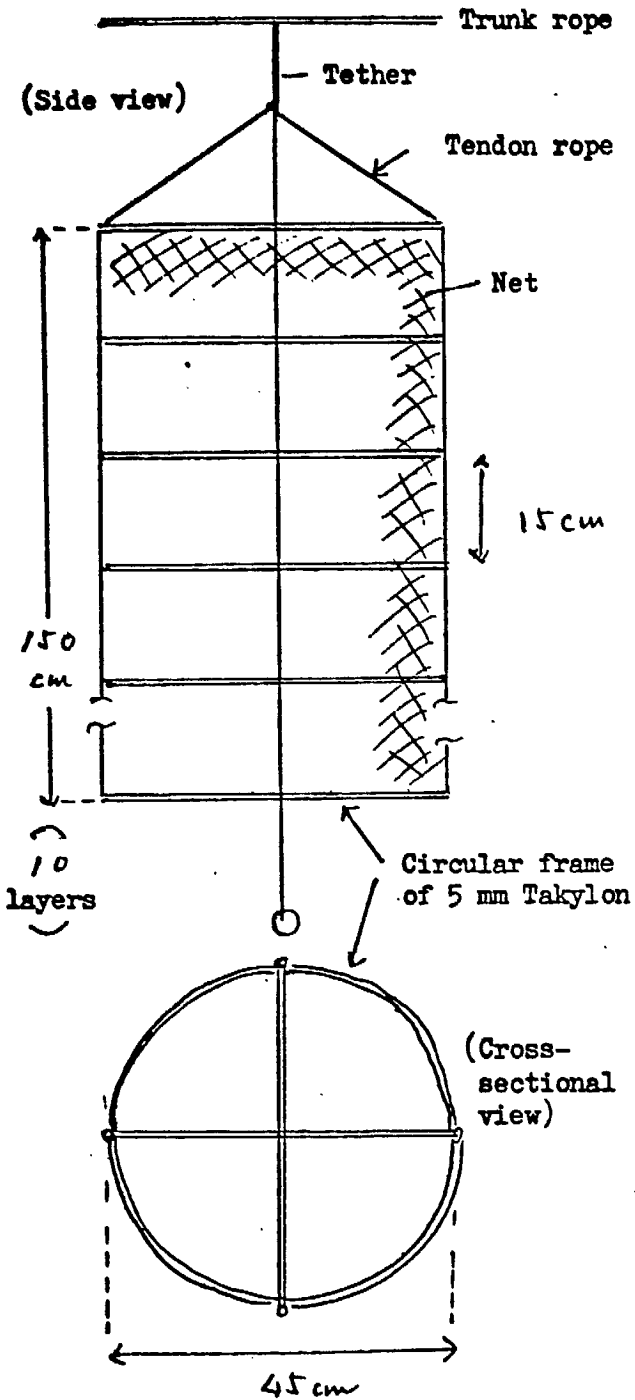


Fig. V-6. Structure of lamp basket

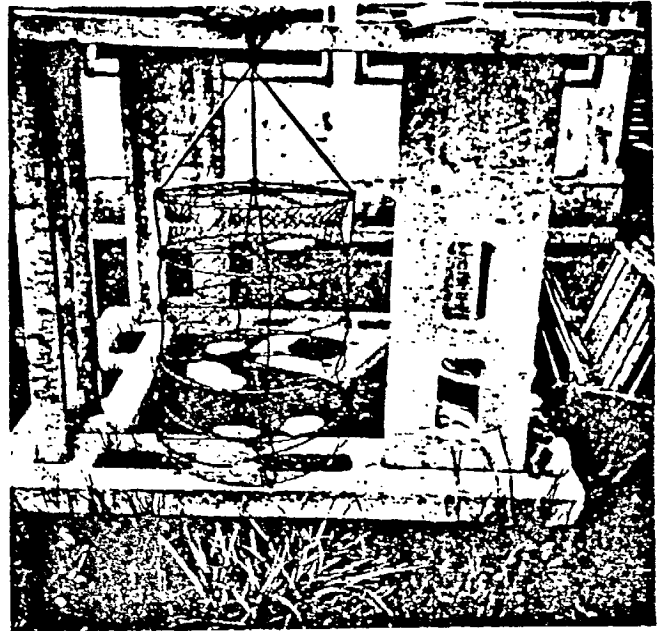


Photo V-7. Lamp basket



Photo V-8. Transfer process to lamp basket

4. Stretched Rope Layout and Basket Exchange Process

(41)

A. Trunk rope layout process

The boat used in laying out the trunk ropes and doing various other work such as exchanging baskets and harvesting is a small wooden vessel of approximately 3.5 tons with a 15-13 h.p. diesel (see Photo V-9 and Fig. V-7).

The boat is equipped with a small pulley-equipped derrick at the bow and stern, with the engine at the centre of the boat, and on the port outer side are mounted tether intake rollers at two places, one fore and one aft. On the upper forward

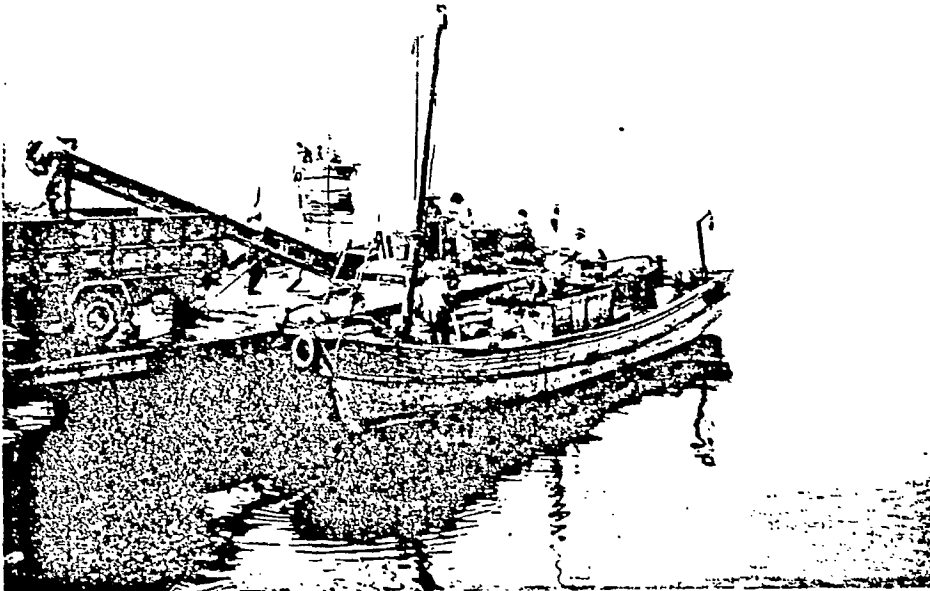


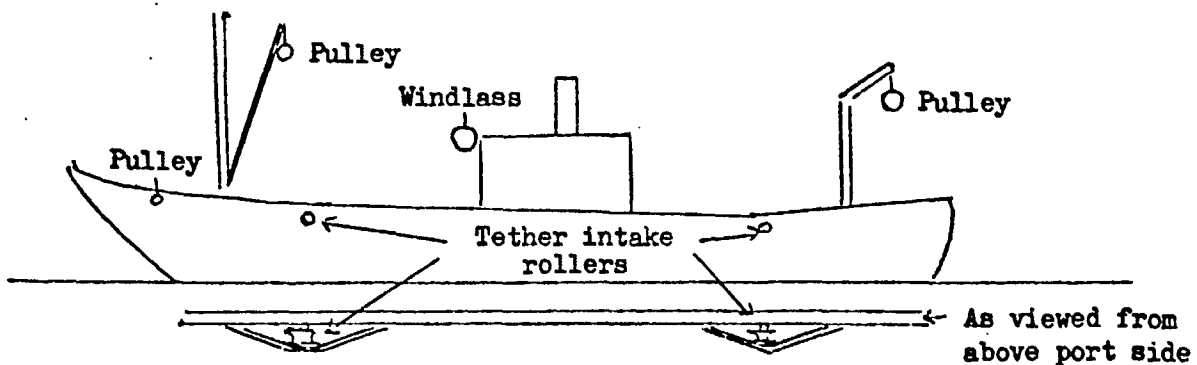
Photo V-9.
Work boat used in
scallop culture

Co-functions as a
scallop dredging
boat.

Loading operation
at the pier.

Packed in net bags
holding approximately
50 kg, these are
bulk-loaded onto a
truck after weighing.

Fig. V-7. Equipment on work boat



face of the engine room is an engine-driven windlass. There is a small roller near the port tip of the bow.

By tether is meant the rope which connects the pearl net or lamp basket with (42) the trunk rope, and the special roller which prevents the tether from becoming entangled on the roller when performing the basket exchange process while hauling in the trunk line is called a tether intake roller. The official designation is a cultivation purpose broadside roller, registered under new design patent No. 1045728 under the name of Sawatomi-type tether intake roller. Its manufacturer is Sawada Iron Works, 2-1 Aza-Hiratsuka, Okuuchi, Aomori City.

In terms of laying out the trunk rope, first of all the lead float and the anchor connected to it are dropped at the target point, and while navigating in a straight line parallel to the tidal current an anchor rope equivalent in length to three times the water depth is thrown out. Where this becomes taught the surface float and trunk rope are dropped in that order, after completion of which the surface float is observed and upon confirming that the trunk rope is in a straight line, the terminal anchor rope is thrown in followed by the anchor and lead float to fix the trunk line. At this time the pearl nets or baskets are not suspended.

B. Basket exchange process

In carrying out the suspension of onion bags, pearl nets or lamp baskets and the exchange of baskets, a 4-clawed anchor is attached to the end of a 1 cm diameter wire rope wound on the windlass (the tips of the claws are rounded into a ball-shape so as not to damage the baskets, etc.). Throwing this wire rope into the sea after passing it through the pulley at the bow, it is wound in as soon as the trunk rope is engaged, and the trunk rope thus raised is hung on the tether intake rollers at the bow and stern (see Fig. V-8).

The suspension and exchange of the pearl nets or lamp baskets are done on the trunk rope raised up by the two tether intake rollers. When the operation is finished, the trunk rope is hauled on to pull the vessel forward.

Normally, this work is performed by two people, who take four days to exchange the baskets on a 100 m unit. In the case of inclement weather when work inside the boat is impossible, the collected scallops may be left in the tub and taken ashore, and doing the exchange on shore they are re-suspended.

(43)

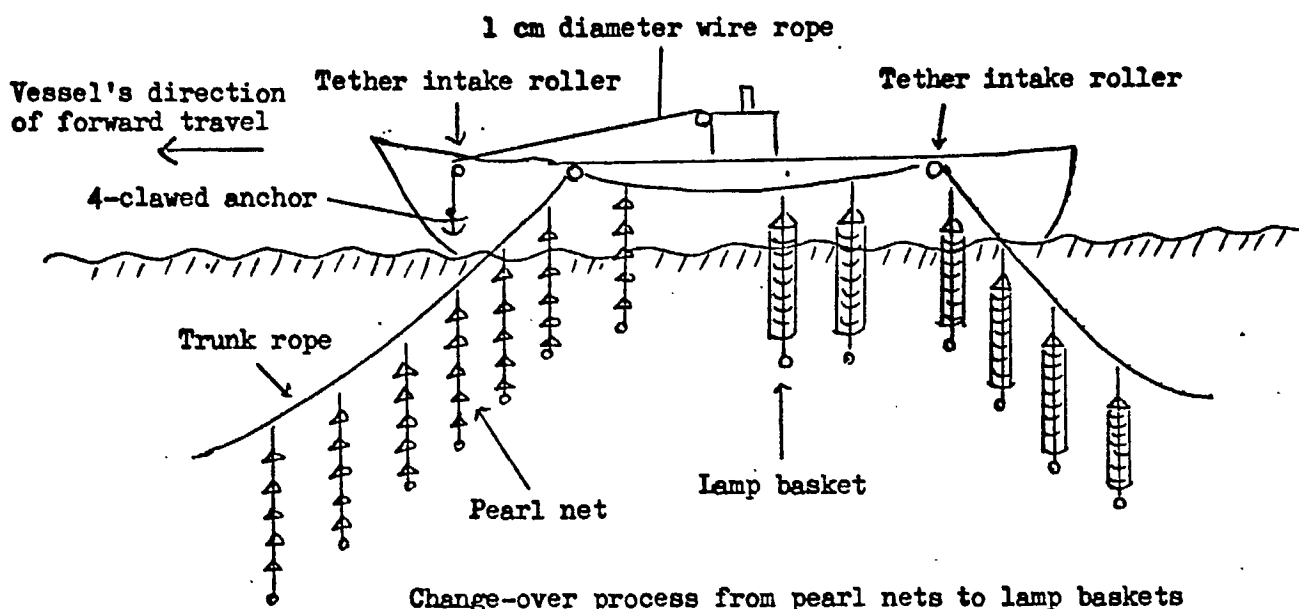


Fig. V-8. Basket exchange process

C. Maintenance of facilities

Since the culture of scallops takes approximately two years from birth, the stretched rope facilities must be strong enough to withstand use during this period. Also, while laid out at sea they are susceptible to the effect of wind and waves, so that an inspection of the facilities is necessary at least once a week. The thing to watch for in this case is the tension of the trunk rope. Upon inspecting the surface floats, if the increased weight in the baskets due to growth of the scallops is causing the floats to sink, then intermediate floats should be supplemented so that the trunk rope will maintain a fixed water depth. The stability of the anchors and any loss of the floats should also be examined to ensure that the

trunk rope always maintains a straight line at its original position.

5. Management

Recent scallop suspension cultures in Mutsu Bay are surmised to range anywhere from 20,000 to 500,000 scallops per operator, and the scale of operation is infinitely varied. Nevertheless, an operation involving two family workers and 2-3 employees is the norm, and the production by this standard operating entity seems to have a limit of 150,000 per year. In other words, the limit is approximately 10 units of a standard 100 m trunk rope facility. (44)

The revenue and expenses for this case have been approximated by Table V-3.

Table V-3. Estimate of standard production cost for scallop culture in Mutsu Bay

Production volume: Per unit of 100 m trunk rope

Assuming { Population in each lamp basket: 150 scallops
 Number of lamp baskets per unit length: 100 baskets
 Survival rate: 0.95

Then, 150 scallops x 100 baskets x 0.95 = 14,250 scallops.

1) Cost of materials

As shown in Table V-2, total cost is 294,151 yen or 90,077 yen per year.

2) Wages

| Item | No. of people | No. of days | Unit cost (yen) | Total cost (yen) |
|-------------------------------|---------------|-------------|-----------------|------------------|
| Making floating ball nets | 1 | 1.5 | 2,000 | 3,000 |
| Making concrete sinkers | 1 | 1.5 | " | 3,000 |
| Facility assembly and buildup | 2 | 1.5 | " | 6,000 |
| Suspension maintenance | 2 | 3.0 | " | 12,000 |
| Thinning and cleanup | 3 | 4.5 | " | 27,000 |
| Harvest and shipment | 2 | 3.0 | " | 12,000 |
| Others | 1 | 1.5 | " | 3,000 |
| Total | | | | 66,000 |

3) Repayment cost and cost of consumables

| Item | No. of days | Unit cost (yen) | Total cost (yen) | Remarks |
|--------------|-------------|-----------------|------------------|----------------------------------|
| Boat cost | 10 | 5,000 | 50,000 | |
| Fuel cost | 10 | 300 | 3,000 | |
| Others | | | 10,000 | Repayment cost for cleaner, etc. |
| Total | | | 63,000 | |

4) Production cost per unit scallop sold

(45)

$$\begin{array}{r} \text{Cost of} \\ \text{materials} \end{array} \times \begin{array}{r} \text{No. of} \\ \text{years} \end{array} + \begin{array}{r} \text{Wages} \\ \text{Repayment cost and} \\ \text{cost of consumables} \end{array} \div \begin{array}{r} \text{Production} \\ \text{volume} \end{array} = \begin{array}{r} \text{Per scallop} \end{array}$$

$$(90,077 \times 1.5) + 66,000 + 63,000 \div 14,250 = 18.53 \text{ yen}$$

Since the production cost of each fry has been figured as 0.12 yen by the calculations shown in Table V-1, the production cost per individual scallop becomes 18.53 yen + 0.12 yen = 18.65 yen.

There being an average of seven adult scallops per kg, the production cost per kg in shell becomes 18.65 x 7 = 130.55 yen.

The beach price in July of 1975 was approximately 190 yen per kg. Looking now at the rough profit of a standard operator who produces 150,000 scallops, since the rough profit per kg is 190 - 130.55 = 59.45 yen

we get

$$142,500 \text{ scallops} \div 7 = 20,250 \text{ kg}$$

$$59.45 \text{ yen} \times 20,250 = 1,203,862 \text{ yen.}$$

6. Utilization of Fishing Grounds

Together with the development of suspension culture, the usable sea surface for stretched rope layout has gradually narrowed, and from the aspect of effective utilization of the fishing grounds an improved culture method (multi-rope layout) in terms of the layout of stretched ropes has come to be employed.

While this system is not necessarily generalized due to differences in the allocable size of sea surface per member depending on the union, the method may be outlined as follows.

Let us say that one unit of trunk rope is 300 m long and seven units make up a set.

The required area is approximately 4.5 ha, and the suspendable number of scallops is 45,000 per unit or 315,000 for seven units.

The layout pattern of the stretched ropes is as depicted in Fig. V-9.

Area required per set:

| | | | | |
|------------|-------------|-------------|-----------|----------------------------------|
| Trunk rope | Anchor rope | Spacing | Breadth | |
| (300 m | + 240 m) | x (5 m x 6 | + 210 m) | = 129,600 m ² = 13 ha |

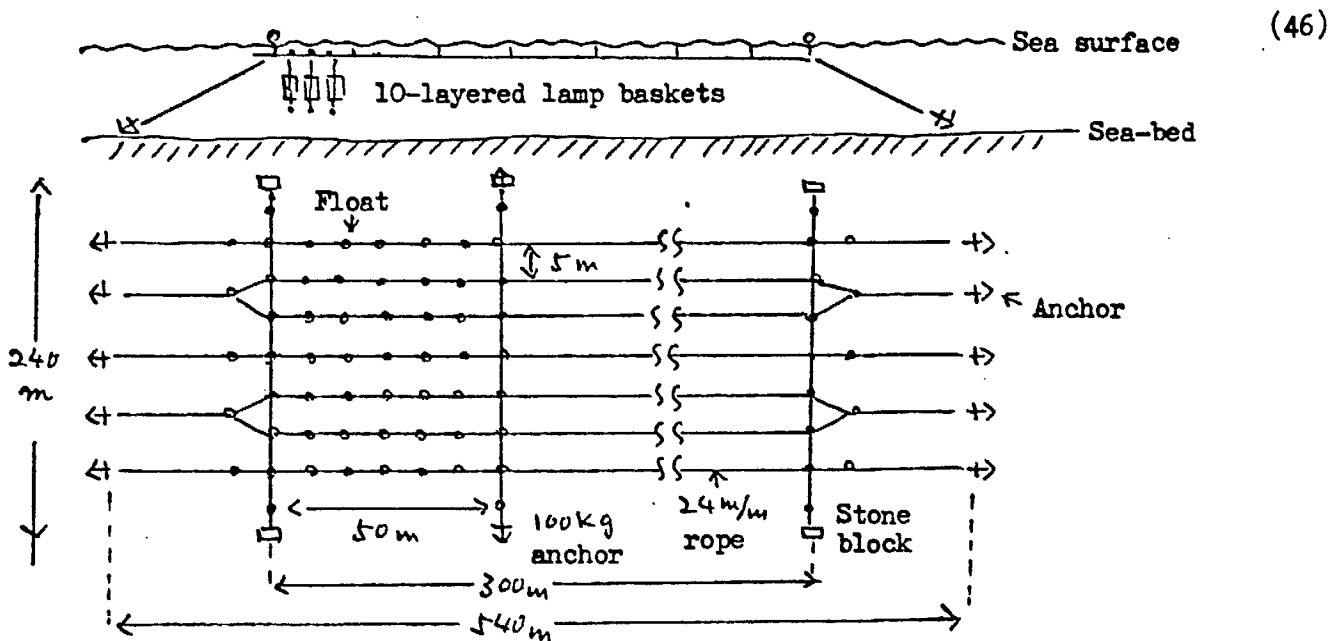


Fig. V-9. Improved culture facility layout pattern

7. Ground-sowing Culture

Ground-sowing culture is carried out away from the suspension culture grounds.

In Mutsu Bay, when the attachment of natural seedlings is good and exceeds the required number for suspension culture use, the surplus seedlings are utilized in ground-sowing culture.

The seedlings to be used in ground-sown stocking are given intermediate breeding until October-November, using those which have attained a shell length of

1.7 - 2 cm.

The stocking density is about 6 per m².

Harvesting is done with a dragnet 2 - 3 years after stocking.

Ground-sowing culture is operated by each union as a unit. The union buys the surplus seedlings from the members and does the stocking. When harvest time

(47)

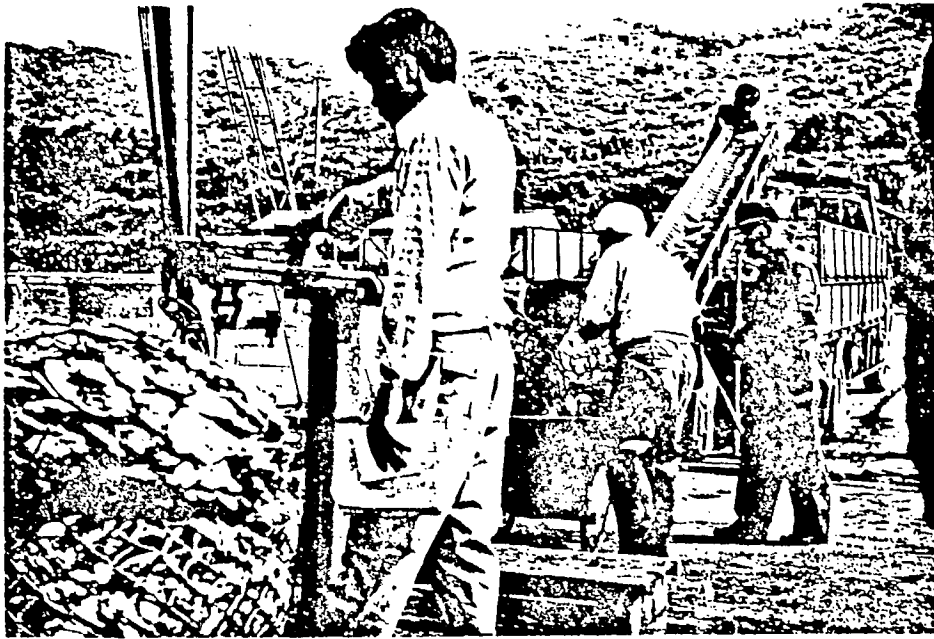


Photo V-10.
Transfer process
of harvested goods
onto truck

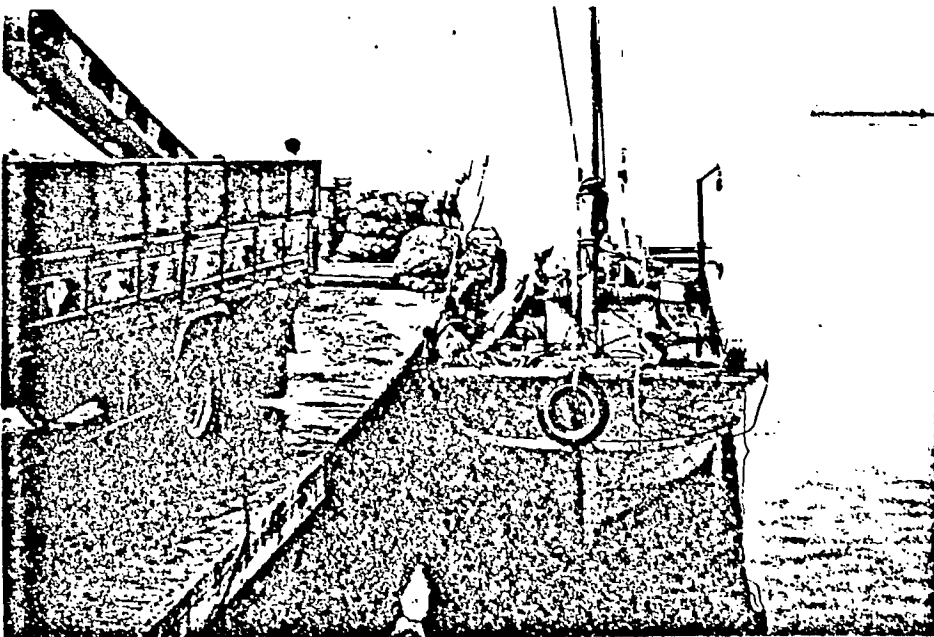


Photo V-11.
Landing point

comes, the union lets the members do the harvesting at the specified place and landing quantity for that day. At the end of the month, the union deducts the expenses from the total landing take for that month and distributes the remainder equally among all union members.

The harvest is delivered to the processor in accordance with tenders made once a month.

The harvested products are packed on board the fishing boat into 50 kg bags (47) or plastic baskets, weighed at the landing point and loaded onto the processor's truck. No sizing of the scallops is done at this time.

Whether ground-sown or suspension cultured, the harvesters leave port around 4:00 o'clock in the morning to do their harvesting and return to the landing point from around 8:30 to make their deliveries to the trucks. This is to enable the treatment and processing to be done that day. The transportation by trucks is by bulk-loading without the use of ice.

The harvesting is done by 2 - 3 persons on a 3 - 5 ton fishing boat with a (48) 13 - 15 h.p. diesel employed in suspension culture, hauling a dragnet, with the duration of a single haul at the fishing ground being 3 - 5 minutes. When a dragnet haul is completed, the wire rope is wound in by the windlass, and hanging the net up in the air by means of a boom at the stern, the scallops are lifted onto the boat. The catch in one haul is normally 200 - 250 kg. The harvest in one day comes to 1 - 2 tons, but the union establishes a harvesting schedule for the year on the basis of which it directs the daily catch for the members.

The structure of the dragnet, as shown in Fig. V-10, includes a 2.0 m long 3 cm diameter iron cross-bar at the front implanted comb-like with 17 40-cm long claws, on two of which are attached U-shaped runners called skids. Their spacing is 1 m apart. Behind the cross-bar are attached a lower net made of steel wire with chains at the leading edge and an upper net woven from twine, forming a bag net approximately 3 m long.

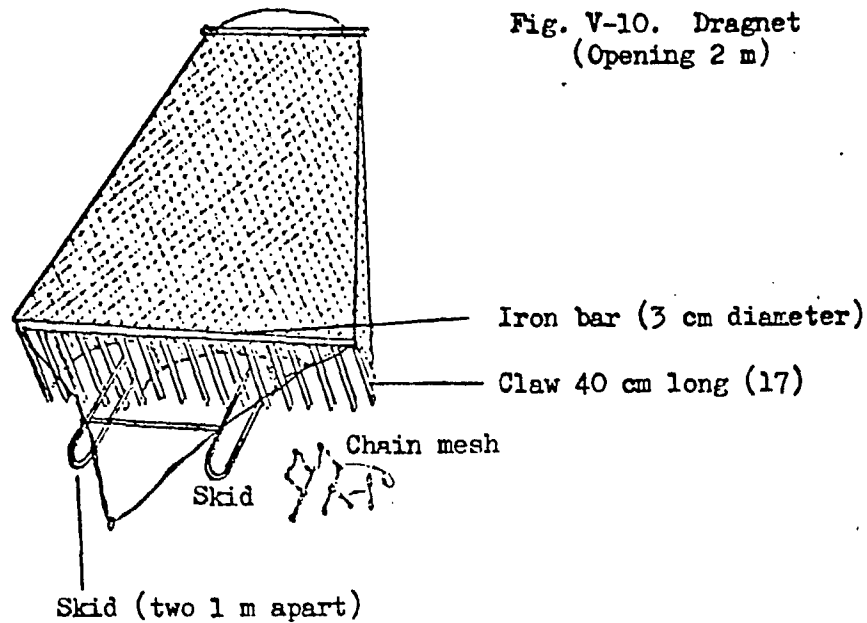


Fig. V-10. Dragnet
(Opening 2 m)

In comparison with suspension culture, ground sowing has the advantage of not requiring as much labour or capital, but its disadvantage is that growth is slow and there are disparities in size, on top of which there is sand inside the scallops, making the value 20% or so lower than the products of suspension culture.

Table V-4 shows the economical efficiency per unit ha of suspension culture and ground sowing, but in reality, because of the fact that the culture operators use the materials longer than their projected life and that the labour is predominantly family labour, in terms of unit area suspension culture is deemed to have twice the economical efficiency of ground sowing.

Table V-4. Comparison of economical efficiency per unit ha of suspension culture and ground-sowing culture

(49)

| | Suspension culture | Ground-sowing culture |
|-------------------|---|--|
| Production volume | 36,000 scallops 40,000 x 0.9 (yield rate) | 31,300 scallops 55,000 x 0.55 (yield rate) |
| Production value | 1,080,000 yen 30 yen x 36,000 scallops 1 kg - 210 yen 7 scallops per kg | 751,000 yen 24.0 yen x 31,300 scallops 80% of suspension culture |
| Production cost | 405,000 yen (300,000 yen) 11.24 yen x 36,000 scallops | 247,000 yen 7.88 yen x 31,300 scallops |
| Profit | 675,000 yen (780,000 yen) | 504,000 yen |

Note: Figures in parenthesis refer to the case where the materials are used beyond their projected life.

Source: From "Scallop Production Management Techniques in Mutsu Bay" in Nissuishi (Japan Fisheries Resources), 1972, p. 133.

8. Treatment and Processing

Scallops are treated and processed in six ways involving fresh, frozen, canned, boiled, skewered scallops and dried scallops. With the increase in production in recent years, freezing and canning have come to account for close to 40%.

The freezing process is divided into such operations as the shucking line, adductor muscle and viscera separation line, adductor muscle washing line, and taenia and kidney separation, ultimately separating the individual scallops on a freezer pan and freezing them with an air blast before packing.

Shucking is a manual operation done at the rate of 50 - 60 kg (with shell) per person per hour or 400 - 500 kg in an 8-hour day. The taenia, after washing (the mantle membrane), is sold to processors as food preserving material, while the liver is handed to fertilizer dealers free of charge.

Washing water is fresh water, which in summer is cooled by putting ice into the washing tank. Taenia is sold at 550 - 600 yen per kg, while frozen adductor

muscles bring 1,400 - 1,500 yen per kg (1975 price) (retail 2,500 yen per kg).

Drying is predominantly by sunlight, but some machine-drying is being done indoors. The required number of days is 20 - 30 days, and the price is 5,500 - 8,000 yen per kg.

The preparation of boiled scallops involves putting the scallops into a 150 kg net bag, placing them net and all with a lift into a boiling tank (mainly a herring pot) and boiling them for one minute at 100°C, after which they are raised from the pot using the lift, put into a cold water tank and after cooling emptied out of the bag onto a shucking board. Then shucking the scallops manually, washing them and weighing them into 500 g lots with the taenia and viscera attached, they are packed into plastic containers. Putting 14 each of these into a styrofoam box and packing the top with crushed ice, the 7 kg box is refrigerator-stored. The price of one box is 12,600 yen (1,800 yen per kg at 1975 prices). (50)

The cost of labour for this is an hourly rate of 200 - 220 yen per hour for females working eight hours per day.

Scallops in the shell are graded into different sizes with the price varying according to size. Table V-5 shows the prices in July 1975 as reference.

Table V-5. Scallop prices according to size

| Suspension culture product | | | Ground-sown culture product | | |
|----------------------------|---------------|--------------|-----------------------------|---------------|--------------|
| Size | No. per 10 kg | Price per kg | Size | No. per 10 kg | Price per kg |
| EL | 30 | (yen) | EL | 30 or less | (yen) |
| L | 31 - 40 | 251 | L | 31 - 50 | 237 |
| M | 41 - 50 | 234 | M | 51 - 70 | 190 |
| S | 51 - 60 | 215 | S | 71 - 90 | 170 |
| ESA | 61 - 70 | 207 | ES | 91 -110 | |
| ESB | 71 - 80 | 194 | | | |
| ESC | 81 - 90 | 183 | | | |
| ESD | 91 -100 | 175 | | | |
| Average | | 187 | | | 180 |

The ratio of the soft meat (adductor muscle and viscera) weight to the raw weight with shell does not vary much with the culture period but does vary with the season of harvest. This is because the gonad weight varies greatly with maturation and spawning.

Generally, in March-April-May prior to spawning, this ratio is 50% or so, decreasing to 25 - 30% in August-September-October.

The proportion of the adductor muscle weight to the soft meat weight is the reverse of the above, being 25 - 30% in March-May and becoming 40 - 50% in August-October.

This indicates the fact that the ratio of the adductor muscle weight to the raw weight with shell does not vary greatly seasonally. That is, it is: (51)

In March-May $0.50 \times (0.25-0.35) = 0.125-0.15\%$

In August-October $(0.25-0.30) \times (0.40-0.50) = 0.10-0.15\%$.

By averaging, the adductor muscle may be estimated to be around 14% of the raw weight with shell (total weight).

While the foregoing refers to the ratio in terms of raw weight, if we consider the preparation of boiled scallops and look at the ratio of the soft meat weight after boiling in terms of the total weight, we find that it varies from 20% to 30% in relation to the spawning period as mentioned earlier but averages out to 25%.

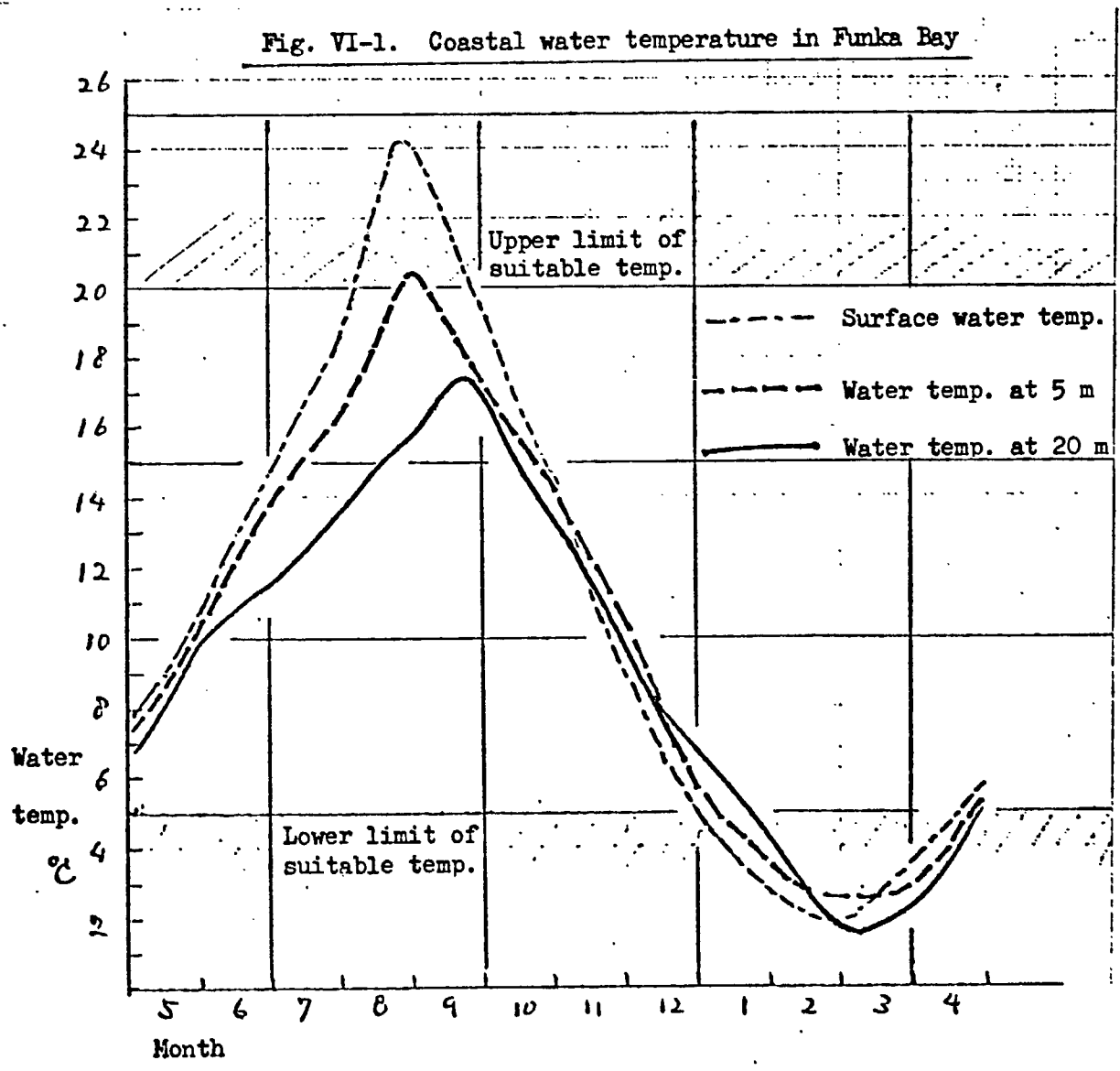
VI. CULTURE METHODOLOGY IN UCHIURA BAY IN HOKKAIDO

(52)

1. Sea Environment

The tidal current in Uchiura Bay flows in a counterclockwise direction at up to two knots, and compared to conditions in Mutsu Bay the briskness of the current is the big characteristic difference.

The variation in water temperature throughout the year is shown in Fig. VI-1 and Table VI-1. At depths of 5 m or less, for a short period in August-September it exceeds the critical temperature of 20°C for scallops, but at 20 m or deeper the maximum is 18°C. However, in winter it drops to around 1.5°C, and the period



during which it is below the 5°C minimum suitable temperature for scallops lasts up to four months from January to April. For this reason, the obstruction rings on the shell of the scallops get formed at this period in Uchiura Bay.

Table VI-1. Average monthly water temperature along Funka Bay coast
(End-month temperature shown) °C

(53)

| Month | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. |
|------------|------|------|------|------|-------|------|------|------|------|------|------|------|
| Surface | 10.7 | 14.7 | 18.5 | 24.2 | 19.2 | 14.5 | 8.9 | 5.1 | 2.7 | 1.8 | 3.7 | 6.2 |
| 5 m depth | 9.9 | 13.9 | 16.4 | 20.5 | 17.2 | 14.3 | 10.7 | 5.7 | 3.7 | 2.5 | 2.8 | 6.0 |
| 20 m depth | 9.3 | 11.4 | 13.7 | 15.7 | 17.0 | 13.5 | 9.8 | 6.9 | 4.5 | 1.8 | 2.3 | 5.5 |

The sea-bed topography of Uchiura Bay (Funka Bay) is as shown in Fig. VI-2, with the areas shallower than 50 m being narrow, the large majority being 70 m or deeper. Comparing this with Mutsu Bay where it is mostly 50 m or shallower, the deepness of the water constitutes the second major point of difference.

2. Socioeconomic Environment

In terms of the socioeconomic environment for scallop culture along the Uchiura Bay coast, let us look at the conditions in the Mori district which embraces a typical fishing ground in Uchiura Bay.

A. Utilized sea surface

While the length of the coastline is 17.3 km and the extent of the area 50 m or shallower is 4,340 ha, the Type 1 designated joint fishing rights area includes all of the 60 m depth zone and part of the 70 m zone, the total area of which is being utilized.

B. Jurisdiction of fishing ground

The Type 1 designated joint fishing rights area owned by the Mori Fisheries Cooperative Union is, as shown in Fig. VI-3, the area contained by a line drawn out to sea on a bearing of 346°15' (perpendicular to the coastline) from the boundary with Sunahara Town, another line drawn out to sea on a bearing of 27°30' from the boundary with Yakumo Town, and a line drawn parallel to the coast 4,000 m offshore.

Fig. VI-2. Sea-bed topography of Uchiura Bay and its comparison with Mutsu Bay

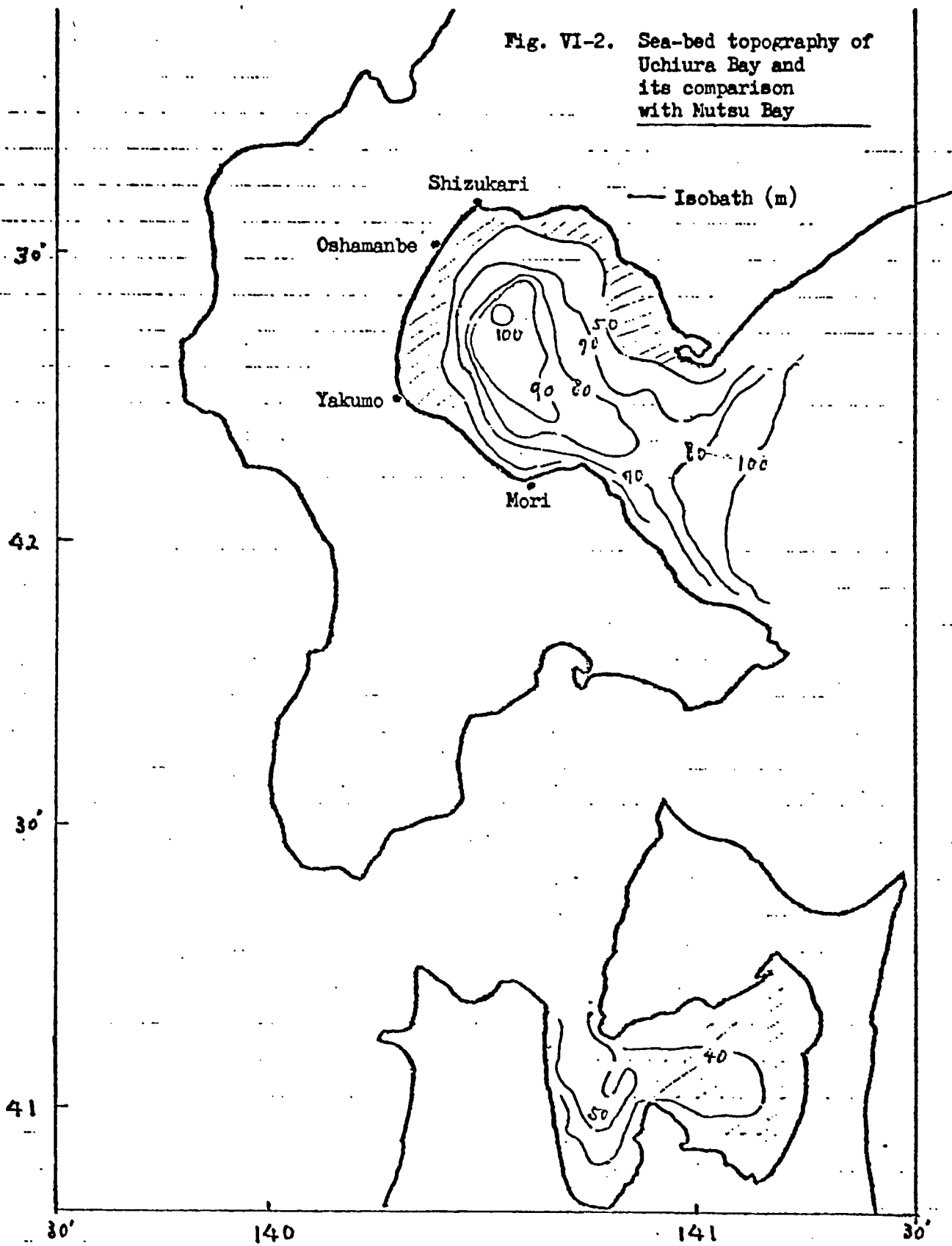
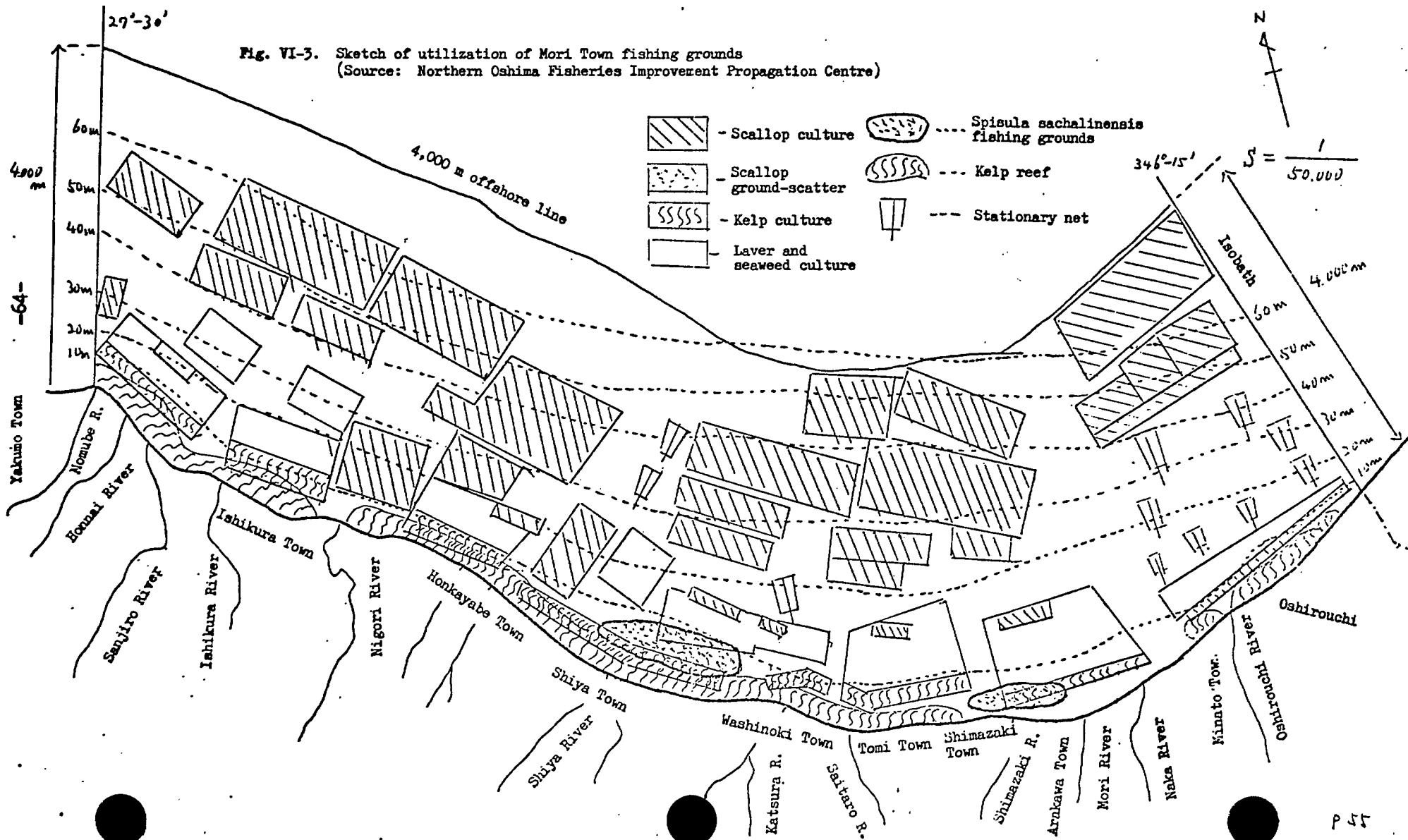


Fig. VI-3. Sketch of utilization of Mori Town fishing grounds
(Source: Northern Oshima Fisheries Improvement Propagation Centre)



Within this area, various fishing operations involving stationary nets, kelp gathering and cultivation are undertaken exclusive of boat fishing.

C. Mori Fisheries Cooperative Union rules with respect to scallop culture

In utilizing the designated joint fishing rights area owned by the Union, the Mori Fisheries Cooperative Union has voluntarily established what are called Regulations for the Exercise of Type 1 Zone Fishing Rights, within which have been established regulations governing scallop culture as well as the culture of kelp, sea urchins, *Undaria pinnatifida* seaweed and laver, etc., aimed at the orderly maintenance of fishing ground utilization. Their main points are outlined below. (56)

Qualifications of persons who have the right to operate a culture business

1. Must be a member of the union and must have operated or engaged in fisheries within the district of this union for 250 days or more.
2. Must have cooperated and engaged in the shallow water propagation program being undertaken by this union for three years or more, or must have paid allotment dues in lieu of this for three years or more.
3. Must not have violated this regulation or any agreement based on this regulation two times or more.
4. Must not engage in fisheries using a motor boat of 20 gross tons or more.
5. Must not operate a primary business other than fisheries.

In the event of death of a person possessing these qualifications, his heir, if he is already a union member or when he subsequently becomes a member, shall be deemed to possess said qualifications.

Application for approval

Any person who wishes to operate a scallop culture business must submit an application form to the director during the period specified by him and obtain his approval.

Effective period of approval

The period of approval for scallop culture shall be no more than three years.

Prohibition of loan

Any person who has received approval must not, except in the case of succession, loan, assign, transfer or delegate to another person the right to operate the fisheries business.

Quota of approvals

The director may, when he deems it necessary to safeguard the propagation of marine organisms and plants or to regulate fishing, limit the number (quota) of approvals for this fisheries business. When establishing this quota, the director shall consult the views of the board of directors beforehand.

Restricting the method of fisheries

Scallop culture is deemed to be by means of the suspension process, and the amount of trunk rope to be used by one household shall be no more than 15 units of a unit length of 150 m or less. The trunk rope layout area may be anywhere within the zoned fishing rights area, while the period of operation (57) may be throughout the year.

Fishing restrictions

In addition to the previous provision, the director may, when he deems it necessary to safeguard propagation or otherwise regulate fishing, impose restrictions on the method of fishing, operating area, period and other fishery-related aspects. In such cases, the views of the board of directors shall be consulted beforehand.

Liability for fishing rights management fees, etc.

Approved members must pay a fishing fee to the union to defray costs incurred in the maintenance and control of the fishing rights concerned as well as the protection and propagation of resources.

The amount of the fishing fee, the time of collection and the method of collection must be decided at a general meeting or delegates' meeting.

(In respect of scallop culture, the present fee per trunk rope of 150 m length is 2,000 yen annually.)

D. Determination of fishing rights boundaries with adjacent fisheries cooperative unions

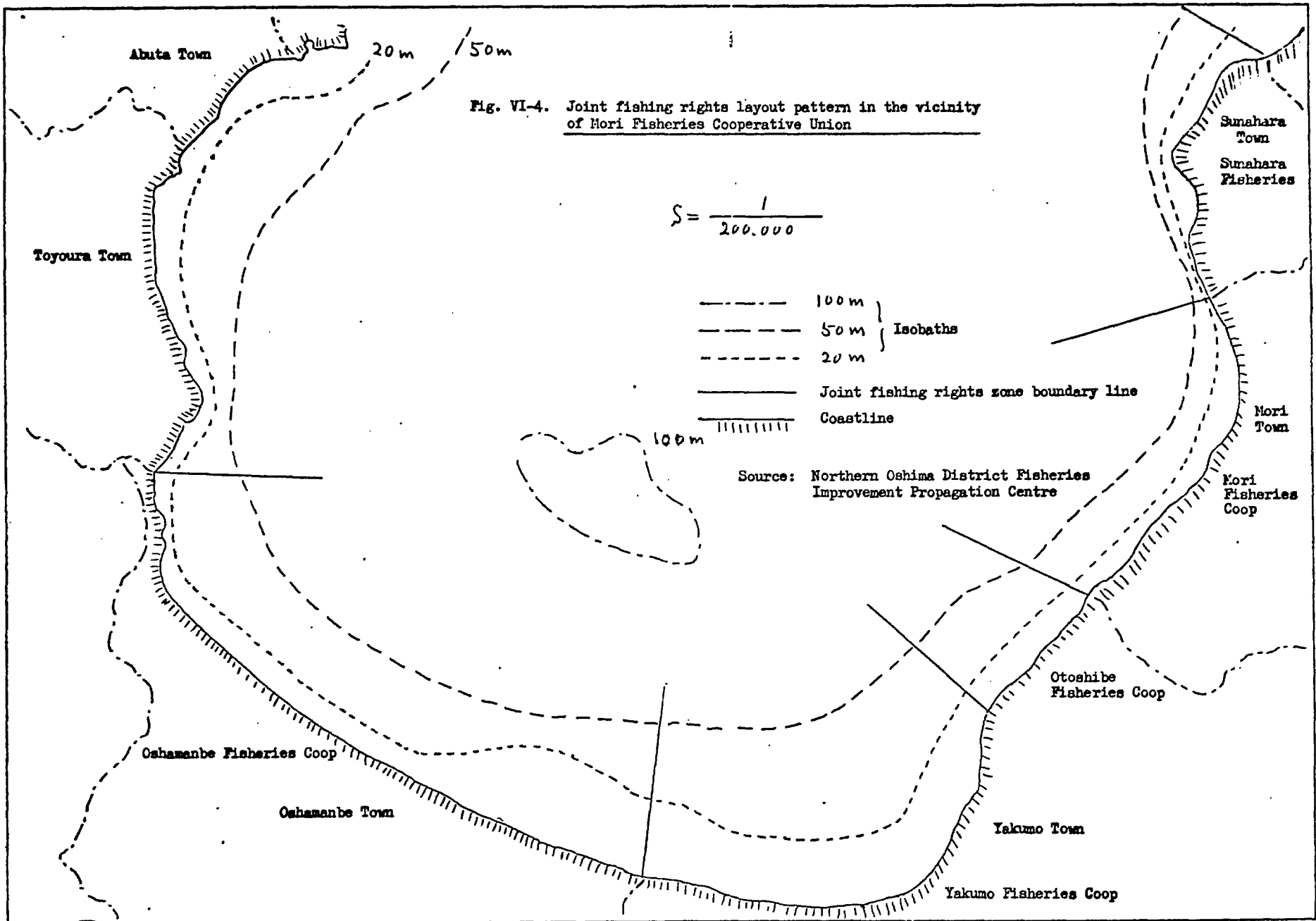
The determination of fishing rights boundaries with adjacent unions is done by the Minister of Agriculture and Forestry through the deliberation of the Regional Fisheries Coordinating Council. The general rule in this case is that a straight line be drawn out to sea perpendicular to the coastline (see Fig. VI-4).

The offshore boundary for the Mori district is at present 4,000 m offshore. It was extended out to 4,000 m for the two reasons that the trunk rope layout limit is at the 65 m depth and that the fishermen who had been engaged in fisheries using bottom-standing nets and coarse gillnets offshore had converted to scallop culture, thereby releasing the offshore fishing grounds. Incidentally, expansion of the zone out to 5,000 m is being desired, but because of problems in coordination with the coarse gillnetters and fishermen who go after free-swimming fish in other districts, it is not possible at the moment.

E. Distribution of rights to communities and individuals

In the Mori Fisheries Cooperative Union, the zone vested with joint fishing rights is apportioned first of all to each community within the union. As a general rule, the waters fronting on each community are allocated to that community.

Within each community, the apportioned section is further subdivided among each union member. Because the environment for the growth of scallops is better offshore, in order to eliminate any unfairness whereby one member may be allocated only good fishing grounds or only poor grounds, the allocation to each individual is done by distributing good and poor grounds randomly. To this end, the distribution is done by drawing lots and changed every year. Therefore, an individual's allocated area is not located together in one spot.



In order to prevent the confusion of fishing grounds between communities (59) as well as prevent poaching, the fishing boats are coloured differently for each community as a means of facilitating the identification of fishing boats by community.

The distribution of sections to each individual is done on the basis of the number of suspension trunk ropes (each 120 m or 150 m long) to be laid out within the section.

F. Comparison of culture conditions among adjacent unions

Including Mori Town, there are five fisheries unions for the towns of Sunahara, Mori, Otoshibe, Yakumo and Oshamanbe situated on the southern and western stretches of Uchiura Bay (Fig. VI-4).

The scallop production by these unions altogether has increased 10.6 times over the past five years (Table VI-2). Looking at the statistics of each individual union (Table VI-3), there is a significant difference in the number of culture facilities per operator between a union with a designated joint fishing rights area that is wide and one that is narrow, with a big difference also being seen in the harvest per culture facility (150 m of suspended trunk rope). For example, the number of facilities per operator in Oshamanbe is 22.7 whereas it is 9.65 in Mori. In contrast to this, the harvest per facility is 0.91 ton in Oshamanbe compared with 2.68 tons in Mori which is approximately threefold. Since there cannot be considered to be any big difference in sea conditions between these two, it is surmised that a difference in the management of facilities has given rise to this difference in harvest.

Table VI-2. Shift in scallop production by the five unions of Sunahara, Mori, Otoshibe, Yakumo and Oshamanbe combined (unit: ton)

| Year | 1971 | 1972 | 1973 | 1974 | 1975 |
|------------------|-------|-------|-------|-------|--------|
| Production level | 1,604 | 1,800 | 3,900 | 9,100 | 17,129 |
| Growth rate | 1.0 | 1.12 | 2.43 | 5.67 | 10.67 |

Source: Northern Oshima District Fisheries Improvement Propagation Centre

Table VI-3. Present state of scallop culture by union (1975)

| Union name | No. of operators | No. of culture facilities | Catch (ton) | No. of facilities per operator | Catch per facility (ton) |
|------------|------------------|---------------------------|-------------|--------------------------------|--------------------------|
| Sunahara | 85 | 1,020 | 2,320 | 12.0 | 2.27 |
| Mori | 290 | 2,800 | 7,500 | 9.65 | 2.68 |
| Otoshibe | 178 | 2,300 | 2,010 | 12.9 | 0.87 |
| Yakumo | 148 | 2,330 | 2,139 | 15.7 | 0.92 |
| Oshamanbe | 152 | 3,460 | 3,160 | 22.7 | 0.91 |
| Total | 853 | 11,910 | 17,129 | Average 14.0 | Avg 1.44 |

3. Schedule of Culture Operations

(60)

Scallop culture in Uchiura Bay in Hokkaido, from seedling collection to the sale of harvested products, is carried out according to the following schedule with due consideration for the state of scallop growth, attached organisms and predators.

Spawning season: Mid-April - mid-May; water temperature 6° - 8°C

1. Placement in seedling collector: Early June - mid-June; water temperature 6° - 14°C
2. Recognition of attached fry: Early to mid-July
3. Commencement of seedling collection: Late July; placement in cushion baskets at the same time
4. Completion of seedling collection: Mid-August

The 2,500 - 3,000 seedlings collected per onion bag (containing catgut netting) are sized on shore, and those with a shell length of 6 mm or more are placed 1,500 - 2,000 each into a 3 - 4.5 mm mesh cushion basket (alternatively called a pearl net).

5. First stage intermediate breeding

Following seedling collection until the end of August, after putting 1,500 - 2,000 each into a 3.0 - 4.5 mm mesh pearl net, breeding is carried out by suspension from a trunk rope.

6. Second stage intermediate breeding

At the beginning of September, the first thinning of the population in each pearl net is carried out, changing the pearl net mesh to 6 mm and reducing the number of scallops per basket to approximately 500. Twenty days of breeding in this condition is undertaken until mid-September.

7. Third stage intermediate breeding

In late September the second thinning is carried out. A 9 mm mesh round basket is used, and the population in each layer of the round basket is made approximately 250. This is restricted to those showing good growth. Approximately 40 days of breeding in this condition is carried out until the end of October. When this is finished, the shipment of seedlings at the end of October becomes possible.

8. Third thinning

Between late October and early November, the population per layer in the 9 mm mesh round basket is reduced to 100 or less.

9. Mid-growth scallop culture

This is from the end of the third thinning in early November until mid-February the following year.

10. Fourth thinning

From mid-February to the end of March, the population per layer in the (61)
9 mm mesh round basket is thinned to 20 - 30.

11. Second stage mid-growth scallop culture

This refers to the period after completion of the fourth thinning until the end of August the following year (approximately six months).

12. Fifth thinning

Those which have completed the second stage mid-growth scallop culture are transferred to a 21 mm mesh round basket with 15 - 20 being accommodated per layer. This thinning is carried out during the period from early

September until the end of November.

13. Second-year scallop (fully one-year-old scallop) culture

This refers to the approximately seven-month cultivation period from after completion of the fifth thinning until mid-April the following year.

14. Shell cleaning

During the second-year scallop culture period, twice in November and March of the following year the scallops are taken ashore for shell cleaning, exchanging the baskets at the same time. For the March basket exchange, a 30 mm mesh basket is introduced, but the population per layer is kept at 15 - 20 without thinning.

15. Shipment

At the terminal stage of second-year scallop culture in mid-April, those with a shell length of 9 - 10 mm emerge, which are large enough to be shipped out for sale.

16. Third-year scallop culture (fully two years old)

Those which have completed cultivation as second-year scallops in mid-April subsequently enter third-year scallop culture. The period until early April the following year is the third-year scallop culture period; thereafter they become fourth-year scallops. During this cultivation period, because August-October and January-February are the attachment seasons for barnacles, in October-November the first basket exchange and shell cleaning in third-year scallop culture are carried out, together with thinning the population per layer in the round basket to 13 - 14. In February-March of the following year, the second basket exchange and shell cleaning are done, thinning the population per layer in the round basket to 12 - 13.

17. Shipment of third-year scallops

The shipment of third-year scallops starts from October.

18. Commencement of ear-hanging culture

At the time of the second basket exchange and shell cleaning during the second-year scallop culture period, those with a shell length of 8 - 9 mm are sometimes given to breeding into third-year scallops by the ear-hanging method.

The ear-hanging process is carried out during February-March, with shipment from mid-October the following year (see Table VI-4).

Table VI-4. Scallop culture management schedule

| Month | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | |
|--|---------------------------------|---|--|---------------------------------------|------------------------------------|--|-------------------------|--|--|---|--|---|---|---------------------------------------|
| Seedling collection - Fry | Seedling collection preparation | Seedling collection Placement of seedling collectors | Seedling collection Recognition of attached fry Fry collection from kelp | Fry collection (Thinning) 1,500-2,000 | Thinning 500 | Thinning Rd. basket 250 | Thinning 100 or less | Seedling management Seedling selection and shipment | Mid-growth scallop culture | Basket exchange (20-30) Shell cleaning | Thinning 9 mm round basket (25-30) | | | |
| Second-year scallop (fully 1 year old) | | | Mid-growth scallop culture | | Basket exch. 21 mm mesh 15-20 each | | Shell clean. | | Basket exchange; shell cleaning (15-20) | Ear-hanging of 8-9 mm scallops | Mid-growth scallop shipment 9-10 mm scallops | | 3rd yr scallop culture | |
| Third-year scallop (fully 2 years old) | | | 3rd-year scallop culture | | | Basket exchange & cleaning Round basket (13-14) | | | Basket exchange & shell cleaning Round basket (12-13) | | | | 3rd-year scallop shipment Ear-hanging shipment | To 4th yr To 4th yr scallops scallops |

4. Prediction of Spawning Season

(63)

Normally, the spawning season is between mid-April and mid-May, with spawning occurring when there is a rapid rise in water temperature during this period. Because this sudden rise in water temperature usually occurs about twice a year in Uchiura Bay, spawning also takes place at roughly two different times.

In order to carry out effective seedling collection, it is necessary to accurately know the spawning season, calculating from this the attachment period of scallop larvae and setting out the seedling collectors in the sea to coincide with this period. For this reason, in the Uchiura Bay district, the Fisheries Improvement Propagation Centre carries out observations of coastal water temperatures (to check for the time of rapid rise in water temperature), observations on the degree of maturity of the scallops and measurements of the developmental density and size of free-swimming larvae, and advises on when to set the seedling collectors on the basis of their observations and measurements.

The surface water temperature at spawning time during the last three years on the Mori Town waterfront is as shown in Fig. VI-5, which indicates that in both 1975 and 1976 the initial spawning took place in late April and the second spawning occurred around May 10.

The observations on the degree of maturity consist of examining the periodic change in the ratio of gonad weight to the soft meat weight of adult scallops, and they indicate that spawning takes place when the ratio of the ovary weight has abruptly dropped. Fig. VI-6 shows the observed findings on maturity for the last three years at the Mori Town waterfront, and indicates that values of 20% or less start appearing from late April.

A scallop egg under natural conditions at a water temperature of $8^{\circ} - 9^{\circ}\text{C}$ becomes a blastula in 40 hours after fertilization, a gastrula in two days, a trochophore in four days, a veliger in 5 - 6 days, attains a shell length of $120\ \mu$ ($1/1,000\ \text{mm}$) in the umbo stage in 15 - 16 days and a shell length of $300\ \mu$ in 40

days (growth per day is 6 - 7 μ), attaching itself to another substance. The larva at this stage is called a mature larva.

To measure the developmental density and size of the free-swimming larvae, a plankton net for quantitative analysis is used. Taking a 15 m vertical drag from the 15 m depth to the surface, the number and size distribution of the collected larvae are examined, from which may be estimated the number of larvae in one ton of sea water. Normally, this number is approximately 1,000. The distribution by size (64) is broken down into four classes consisting of under 150 μ , 150 - 200 μ , 201 - 260 μ and 261 μ or over. From the date and time of observation and the growth of larvae at 6 - 7 μ per day, a forecast of the time of emergence of the mature larvae is worked out.

The results of observations made off Mori Town in May 1976 are shown in Table VI-5. Based on this, the advice was given to set out the seedling collectors at two different times, the first around June 1 - 3 and the second around June 6 - 9.

Table VI-5. Scallop larvae measurement results on Mori Town waterfront

| Collection date | Collection site | Method of examination | Count | Distribution of larvae by size (μ) | | | |
|---------------------|-----------------------------------|-----------------------|-------|--|---------------|-------------|---------------|
| | | | | 150-200 | 201-260 | 261 or more | Under 150 |
| May 17 6:30 a.m. | Oshirouchi, Mori Town; 40 m depth | Vertical drag 15 m | 78 | 23 (29.5%) | 18 (23.0%) | 3 (3.8%) | 34 (43.6%) |
| May 21 4:30 a.m. | Off Mori fishing port; 20 m depth | As above | 111 | 54 (48.7%) | 3 (2.7%) | 2 (1.8%) | 52 (46.8%) |
| May 23 1:40 p.m. | As above | As above | 134 | 63 (47.0%) | 19 (14.2%) | 7 (5.2%) | 45 (33.6%) |

Source: Northern Oshima District Fisheries Improvement Propagation Centre, 1976

5. Natural Seedling Collection and Intermediate Breeding

A. Method of seedling collection and structure of seedling collection facility

The method of seedling collection consists of utilizing the characteristic that mature larvae attach themselves to other substances. A substance which is suitable for attachment, convenient for collecting the attached fry and other handling,

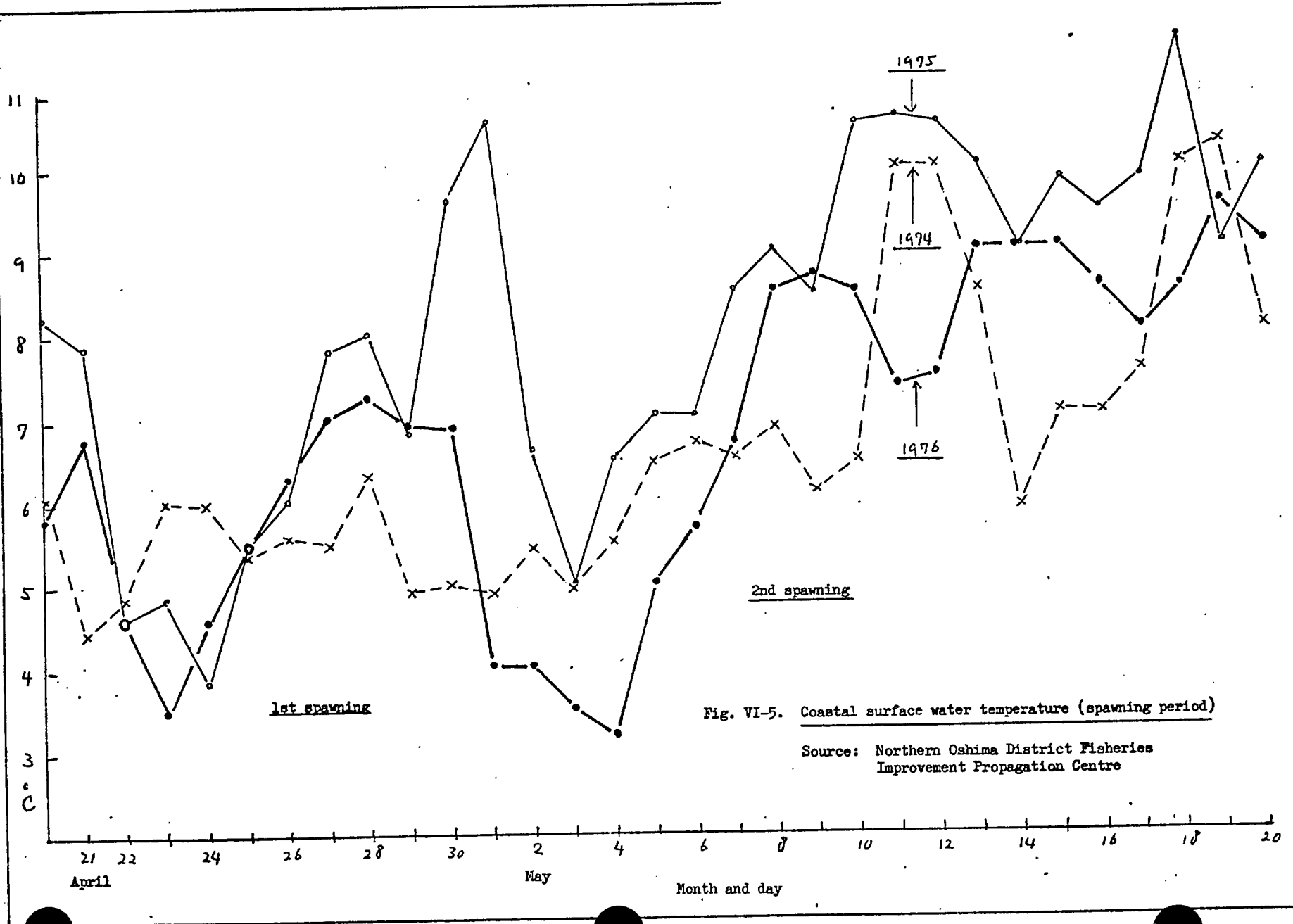
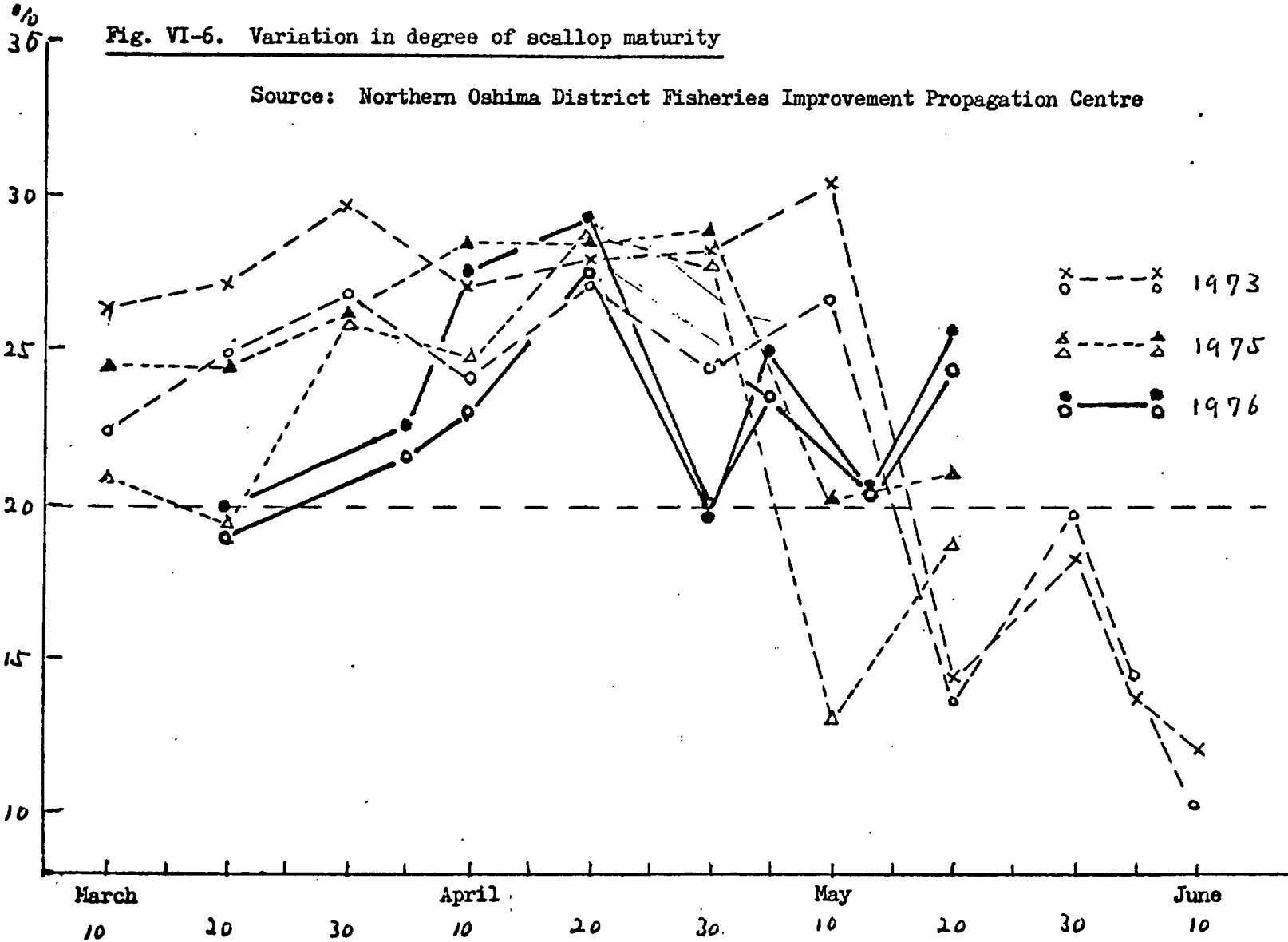


Fig. VI-5. Coastal surface water temperature (spawning period)

Source: Northern Oshima District Fisheries Improvement Propagation Centre



cheap in price and does not require much expense is placed into the sea where mature larvae are distributed, and after awaiting their attachment they are collected.

To serve as this seedling collection material the following varieties of substances are available, and due to differences in the material used there is a certain amount of variation in the structure of the seedling collection facility. In the general case where onion bags are used, however, the method is identical to that in Mutsu Bay, involving a stretched rope system fixed as shown in Fig. VI-7.

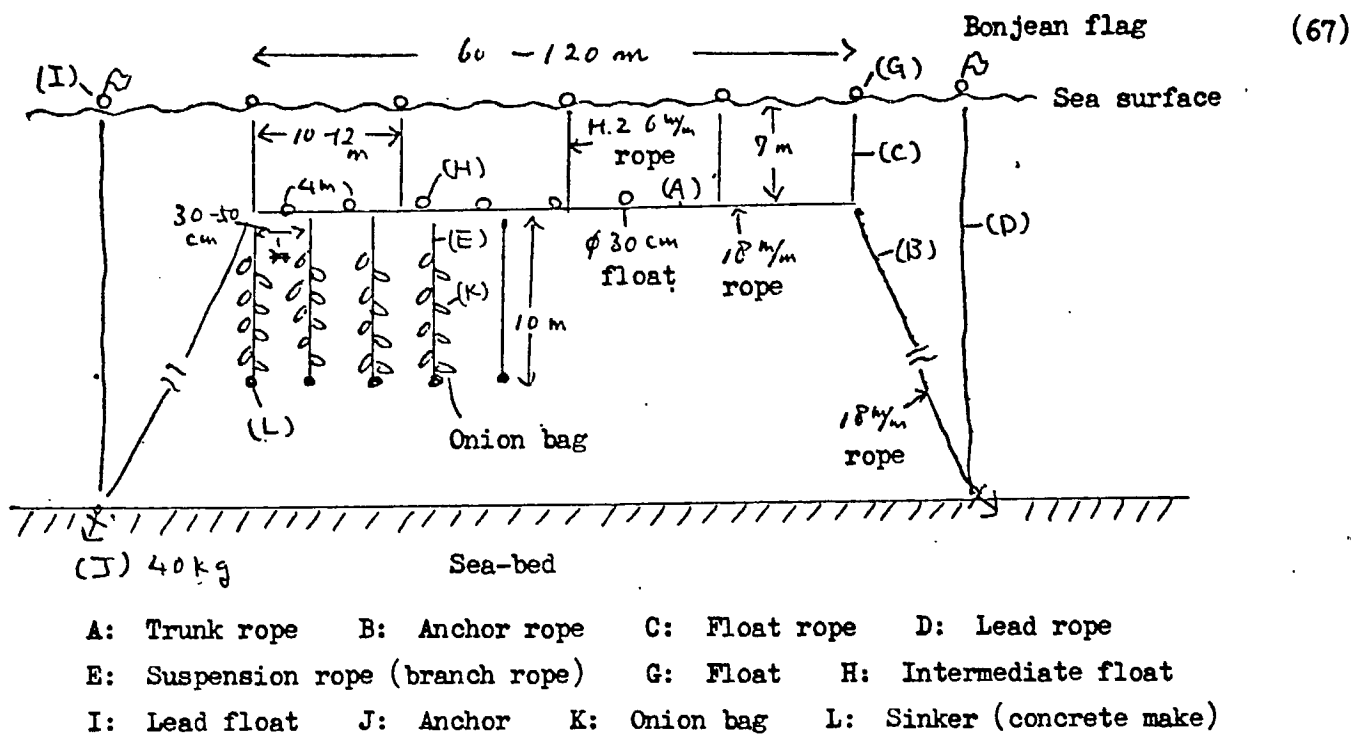


Fig. VI-7. Structure of a single seedling collection facility

The length of the trunk rope is 60 m - 120 m, with 120 m being the standard and referred to as one unit.

The length of each branch rope suspended from the trunk rope consists of 7 - 8 m attached to a 2.5 m tether, with 15 - 16 seedling collection onion bags attached to it.

The interval at which the branch ropes are tied to the trunk rope is 30 - 50 cm, with the total number of branch ropes tied to a single trunk rope being 100.

The water depth for laying out the trunk rope is limited to 35 m and the direction of layout should be parallel to the tidal current, the spacing between trunk ropes being 20 - 30 m.

The dimensions of the ropes, floats and anchor, etc., in use are as shown in the figure.

B. Selection method and necessary conditions for the seedling collection facility layout site

Because the size of the designated joint fishing rights zone is limited and the layout area of the girder ropes for suspension culture therein is fixed, the waters for possible layout of the stretched ropes for seedling collection are the remaining areas outside the above. As a result, generally an area of 15 - 20 m (68) along the waterfront where the operator resides is used, meaning that it is not selected specifically with any biological or environmental conditions in mind. However, those areas with an inflow of river water are avoided as much as possible.

C. Method of layout of stretched ropes for seedling collection

The layout of the girder ropes for suspension culture is, apart from the expense, undertaken as a responsibility of the union, but the layout of the stretched ropes for seedling collection is carried out as a joint operation of the fishermen using the same waterfront section.

The stretched ropes for seedling collection are used strictly for seedling collection and not also utilized from intermediate breeding to suspension culture as in the case of Mutsu Bay. Consequently, once seedling collection is over they are removed.

The water depth at which the stretched ropes are strung is 7 m, and to maintain this depth a 30 cm diameter plastic float is tied to each pair of branch ropes.

Normally, dividing the depth down to the sea-bed into four equal parts, the top and bottom quarters are avoided and only the middle second and third quarters

are utilized as the seedling attachment layers. The reason for maintaining a depth of 7 m is to avoid any drop in salinity due to rain as well as variations in water temperature due to the air temperature and because the attachment of sea mussels is prevalent in the upper layer.

D. Materials for seedling collection

The materials used for seedling collection are not limited to onion bags but include a variety of items as shown in Fig. VI-8. While the onion bag has its strong point in collecting the seedlings after they drop off, some of the other items have their strong points in collecting the attached seedlings prior to drop-off.

The method of use of the seedling collection materials shown in Fig. VI-8 is described below.

① Onion bag

The onion bag is identical to that in Mutsu Bay, measuring 80 cm deep and 37 cm wide at the mouth. The bag is made of Hyzex or Netron monofilament woven into a 5 mm x 3 mm mesh with double strands vertically and a single strand horizontally. Inside this is placed an appropriate bundle of Netron monofilament netting (69) with a mesh of 1 cm or so before drawing tight the mouth. In place of Netron netting, old netting from northern salmon or trout drift-nets is sometimes used.

The number of onion bags tied to a single suspension rope is 15 - 16.

The special feature of the onion bag is that, because of its small 3 x 5 mm mesh size, even if the scallop fry attached to the Netron netting inside grow to a shell length of 6 mm - 10 mm and drop off, they will collect at the bottom of the onion bag. There is, however, the weak point that the fry being collected at the bottom of the bag will pile up on top of each other so that growth will be inhibited.

② Hyzex film

(70)

Hyzex film is tied in a bundle as shown in the figure, and before the attached seedlings start dropping off, they are put into the onion bag depicted by ③ or into a 3.3 mm mesh cushion basket (pearl net).

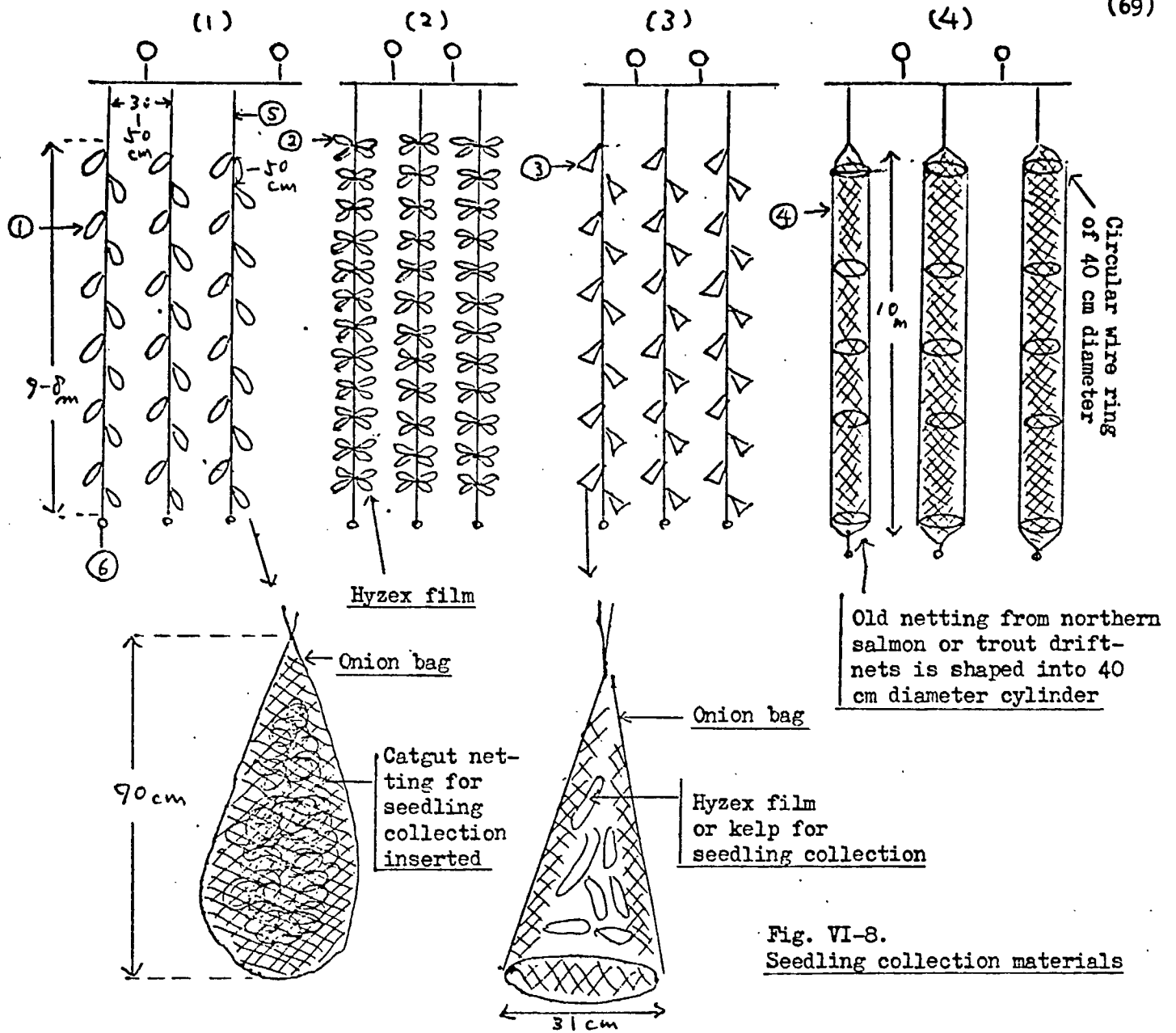


Fig. VI-8. Seedling collection materials

(3) Basket made from onion bag

This is an onion bag with a vinyl-coated wire ring (31 cm diameter) inserted into the bottom. The seedling-collected film at (2) and the fry collected at (4) or attached to the surface of kelp during culture are all collected before drop-off begins and put into this basket.

④ Seedling collector using old netting from sole gillnets and coarse gillnets

The aforementioned used netting is tied together into a cylindrical shape 10 m long and 40 cm in diameter. As framework, 4 - 5 vinyl-coated wire rings of 40 cm diameter are inserted as shown in the figure. The fry which become attached to this are put into the onion bag basket of ③ or a 3 mm mesh cushion basket prior to drop-off.

The reason that seedling collection is undertaken by the methods of ②, ③ and ④ is to obtain seedlings of good growth, and the fry which become attached to cultivated kelp in particular are said to be the finest of seedlings.

For the suspension rope shown by ⑤ a 6 mm diameter Hyzex rope is used, while the sinker shown by ⑥ is made of sand or concrete weighing 0.8 - 1.0 kg.

Apart from the seedling collection methods shown by ① to ④, a wide variety of items capable of the attachment of fry as shown in Fig. VI-9 from (5) to (9) is being used.

(5) Use of cushion basket (pearl net)

Collecting the fry attached to the cushion basket (4.5 - 6 mm mesh) prior to drop-off, they are put into a cushion basket or onion bag shown at ③.

(6) Vinyl bag (empty fertilizer bag)

Cutting an empty vinyl fertilizer bag into bands 1 m long and 20 cm wide, one end is tied and attached to the suspension rope. The fry which become attached (71) are put into an onion bag prior to drop-off the same as in the case of (5).

(7) Use of round culture basket

The fry which have become attached to the round basket for suspension culture exchanged in the spring are collected by wrapping the entire basket in a 4.5 mm mesh net bag.

(8) Use of gillnets

Various types of gillnets are floated 1.0 - 1.5 m off the sea-bed and fixed, and the fry which become attached to them are collected prior to drop-off, after

which the same procedure as in (5) is followed.

(9) Use of vinyl sheets

Vinyl sheets 93 cm long by 25 cm wide are attached in a string of 15 sheets at 20 cm intervals and treated the same as in (6).

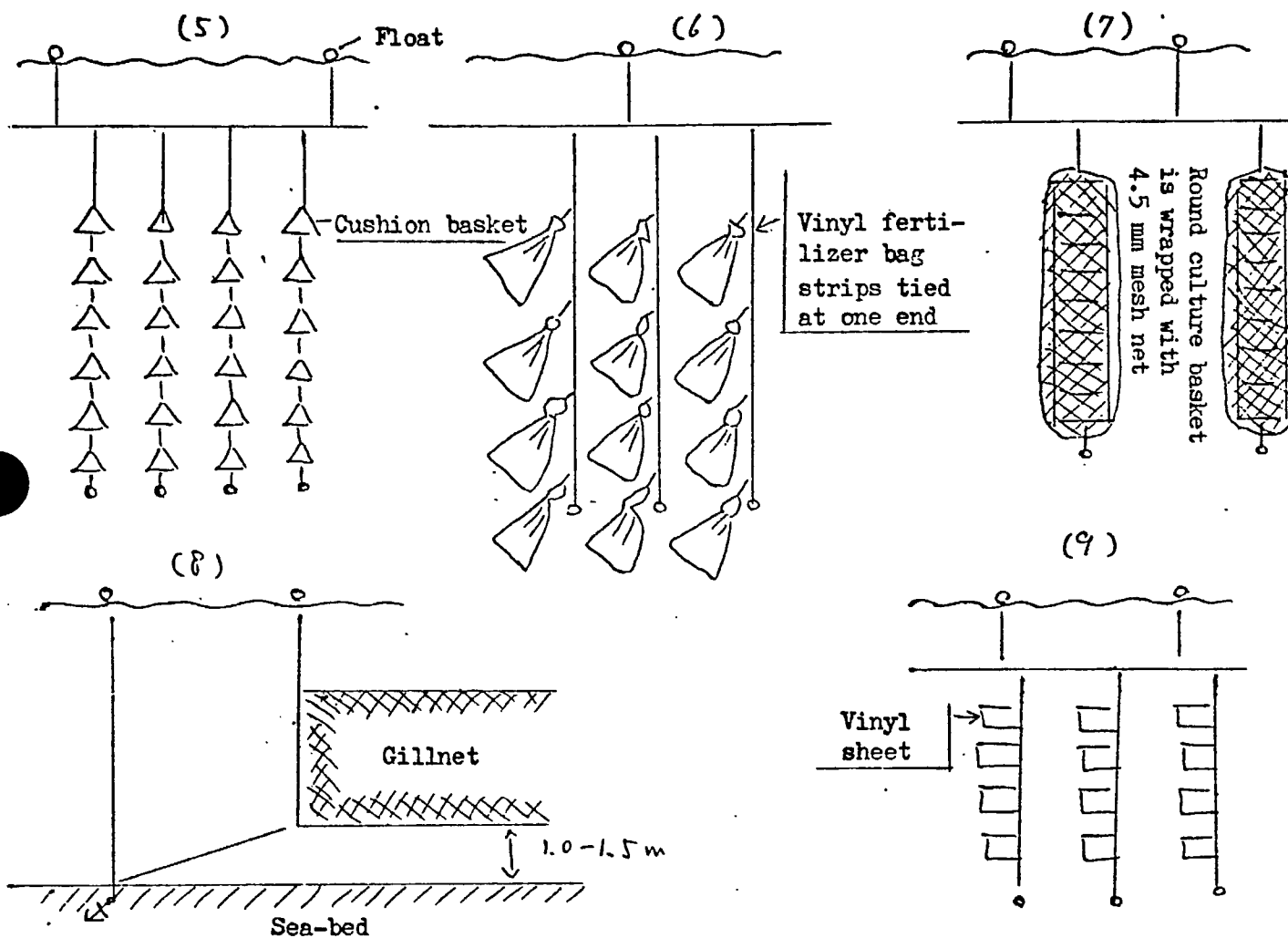


Fig. VI-9. Seedling collection materials

E. Average number of seedlings collectable from one seedling collection facility (72)

When carrying out seedling collection with onion bags, the number of seedlings collectable per bag averages 2,000 - 3,500. Of this, however, those of good growth (around 6 mm) which can be used as healthy seedlings are normally about one-third of the total number.

Normally, the number of bags suspended per unit of stretched rope for seedling collection is 500, and assuming the number of seedlings collected per bag to be 2,000, the number of seedlings collected per unit of stretched rope is estimated at 1,000,000.

F. Number of seedling collection facilities laid out by medium-scale fishermen specializing in scallop culture

The annual production target of medium-scale fishermen specializing in scallop culture is sales of 1,200,000 scallops. Normally, the yield rate up to mature scallops is one-third, and the seedling collection target is a maximum of 5,000,000 or so. Assuming the number of seedlings collected per unit seedling collection facility to be 1,000,000, the stretched ropes (120 m unit) for seedling collection required by one fisherman are five units. This, however, is for the case where onion bags only are used for seedling collection. Because a variety of materials can be used for seedling collection as mentioned in D, it may be that onion bags are used for three units or so and other methods of seedling collection are used to make up the rest. For example, in waters with a depth of 10 m, kelp cultivation by the stretched rope system is being undertaken, and the seedlings which become attached to the surface of this kelp may be collected.

G. Harvest of seedlings and intermediate breeding

Healthy seedlings for use in intermediate breeding are 6 mm or over in size. Because the fry naturally drop off from their attached substance as they attain a shell length of 6 mm - 10 mm, where such fry which have dropped off are being collected, they can be immediately utilized as seedlings for intermediate breeding. However, when collecting fry which are attached to a vinyl film, vinyl sheet, gill-net or kelp, etc., the shell length of the fry is still around 3 mm, so that they are put into a basket made from an onion bag or a 3 mm mesh cushion basket for breeding until they grow to a size of 6 mm or so. The number put into one cushion basket at this time is 1,500 - 2,000. This process, as shown in Table VI-4, is performed during the period from mid-July to mid-August.

The attached fry collection process involves raising the branch rope complete (73) with the baskets or vinyl sheets onto the boat, transporting them to the workshop on shore and collecting the attached seedlings inside a tank. Sizing the collected seedlings with a 3 mm mesh sieve, those 3 mm or larger are placed in a 3 mm mesh cushion basket. During this process, starfish, crab and other miscellaneous substances are removed.

In early or mid-September, when these seedlings have grown to 6 mm or more, they are raised once more to become seedlings for the 2nd stage intermediate breeding. In the case where the fry which drop off from their attached substances are being collected in the onion bag of Fig. VI-8 or round culture basket of Fig. VI-9, there is no need for the previously mentioned 1st stage intermediate breeding, and thus they are collected at the beginning of September as seedlings for the 2nd stage intermediate breeding.

The fry collected as seedlings for the 2nd stage intermediate breeding are sized with a 6 mm mesh sieve, and those 6 mm or larger are utilized as seedlings. Normally, the yield rate at this time is 70 - 80%, with 1,000,000 seedlings becoming 700,000 - 800,000.

Photo VI-1 shows various shore operations (sizing of fry, exchange of baskets, etc.) set up on the wharf, the tank in the centre being used to hold the seedlings. During seedling accommodation, aeration is carried out with compressed air.

Photo VI-2 shows where the sizing of seedlings is being done with a sieve.

While these photographs depict the shore workshop of a medium-scale fisherman, the large-scale fishermen do not operate in temporary tent huts as shown in Photos VI-1 and 2 but have permanent workshops equipped with tanks.

Photos VI-3 and 4 show a tank-equipped workshop of a large-scale fisherman. This tank is 2.72 m square by 0.85 m deep, and is equipped with a sea-water intake pipe and a compressor-fed air supply pipe. The capacity of this tank is such that one can accommodate the seedlings from 200 onion bags. In actual practice, a tank to

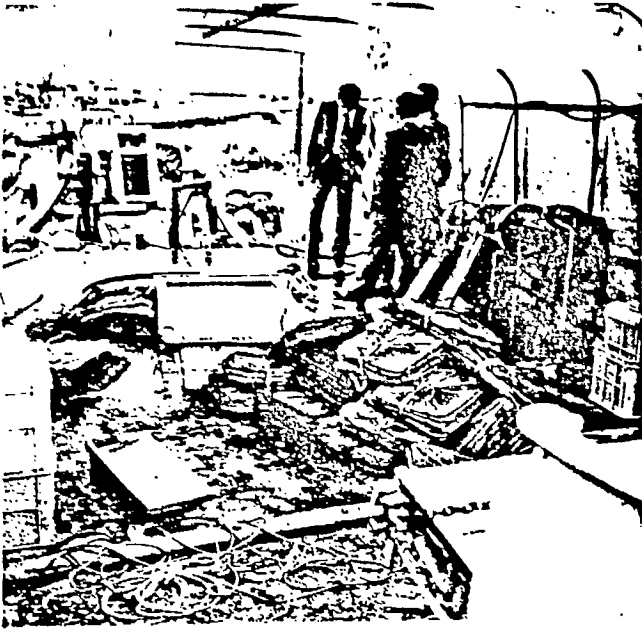


Photo VI-1. Temporary shore workshop



Photo VI-2. Fry sizing process

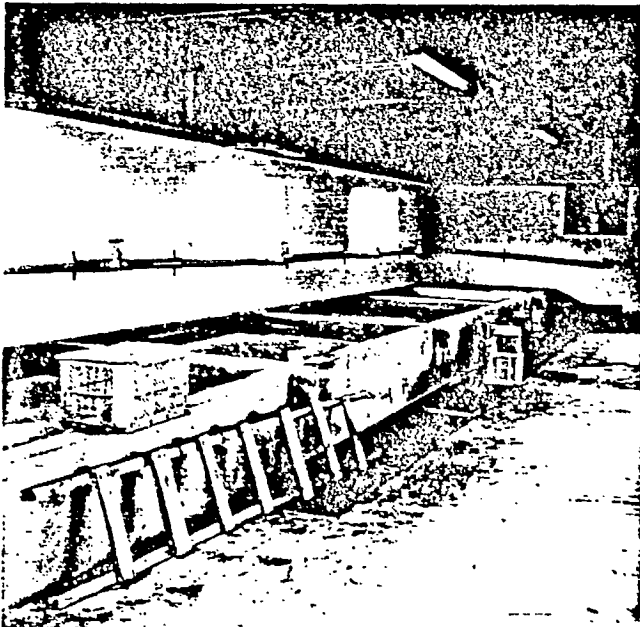


Photo VI-3. Tank-equipped workshop

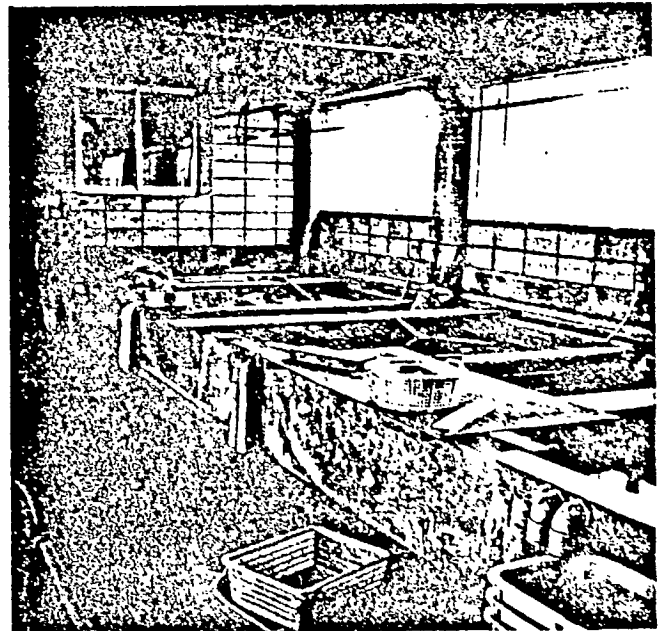


Photo VI-4. Sea-water and air supply system to tank

accommodate the bags and all, and another tank to hold the fry after sizing and cleaning are needed, so that a pair of tanks is required as a set.

There are other fishermen who are unable to afford a workshop ashore. While they are few in number, such individuals buy a fishing boat which has been scrapped, moor it in the harbour and use the boat as a workshop.

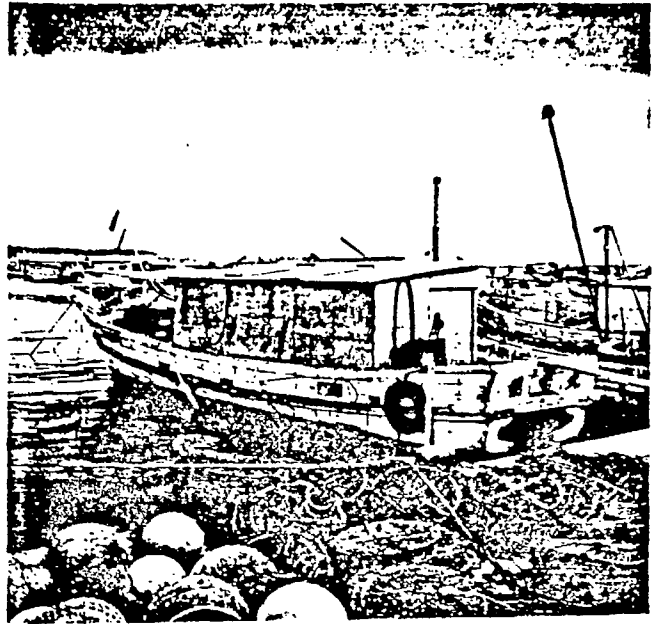


Photo VI-5. Work boat

Photo VI-5 depicts such a work boat.

Finishing the 1st stage intermediate breeding by around the end of August, those which have attained a shell length of 6 mm or more are placed 500 each in a 6.6 mm mesh cushion basket from early or mid-September, and the 2nd stage intermediate breeding is carried out from late September until the end of October.

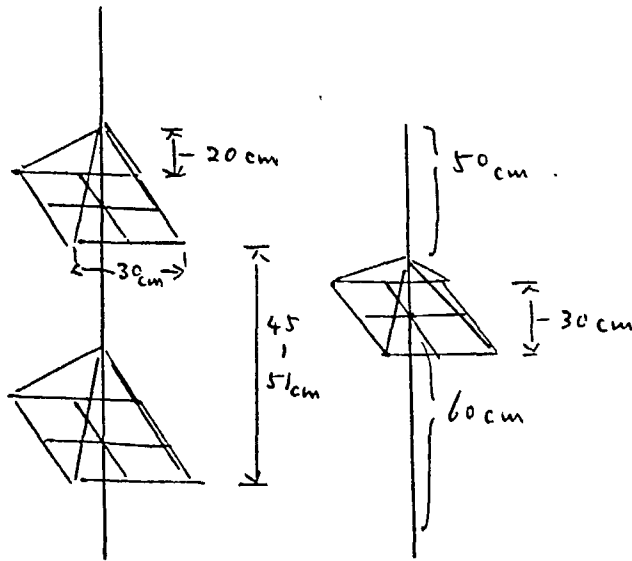


Fig. VI-10.
Structure of cushion basket

The bottom is made of a Takylon frame.



Photo VI-7. Round basket

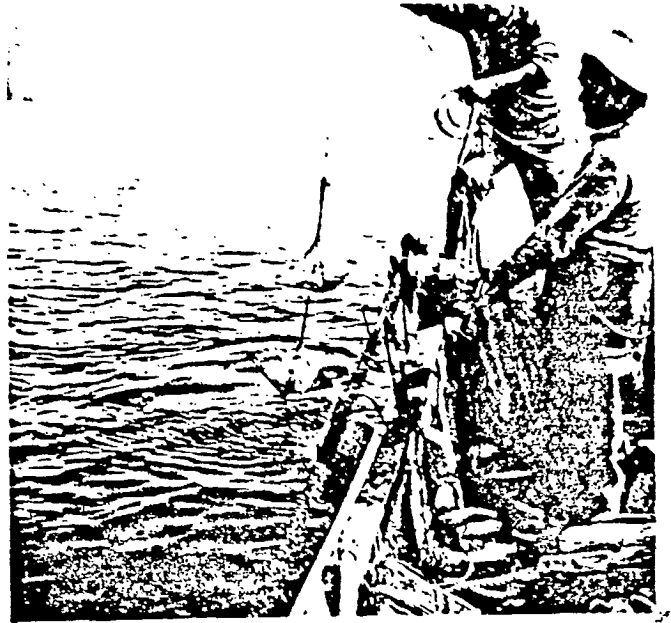


Photo VI-6. Cushion basket

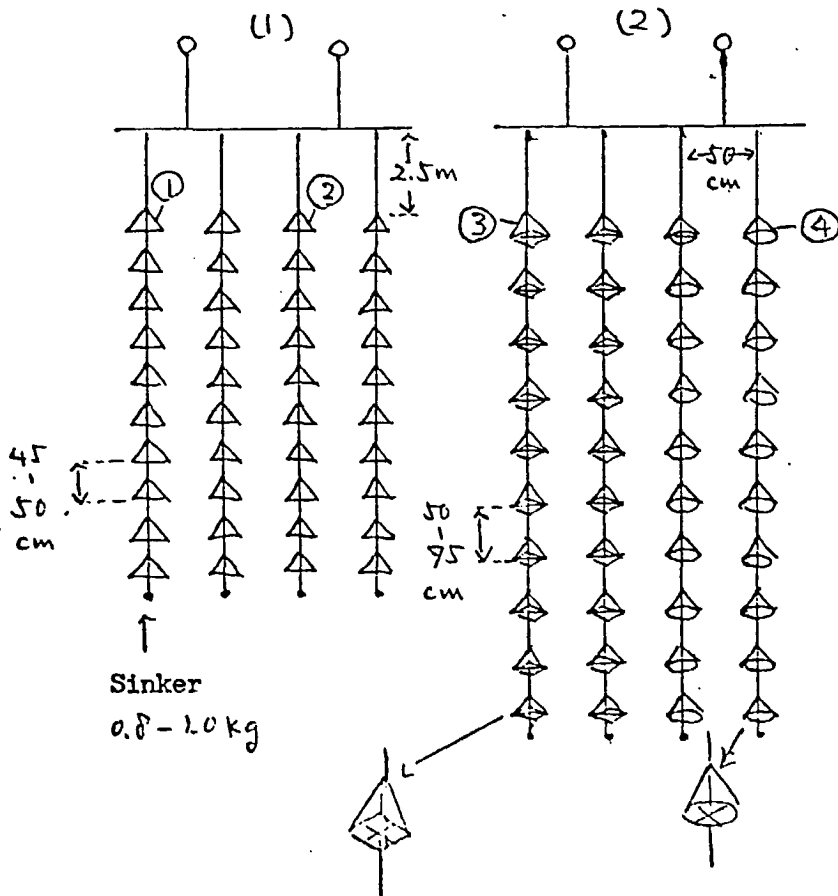


Fig. VI-11. Intermediate breeding facility

- ① 3 mm mesh basket
1,000-2,000 accommodated
Late July - late August
- ② 4.5 mm mesh basket
700-800 accommodated
Early - late September
- ③ 6 mm mesh basket
500-600 accommodated
Early October
200-300 accommodated
- ④ 9 mm mesh basket (substitute for round basket)
20-50 accommodated
Exchanged in late October - early November, cultivated until spring

The duration of the 2nd stage intermediate breeding is approximately one month, and those which have completed this period are placed in a 9.9 mm mesh round basket at the rate of 250 per layer to undergo the 3rd stage intermediate breeding until the beginning of November.

Intermediate breeding thus extends from the 1st stage to the 3rd stage, with which the breeding as seedlings is completed, and thereafter it becomes mid-growth scallop culture.

The structure of the cushion basket used during this period is as shown in Figs. VI-10 and 11, 10 - 15 of which are strung at 45 - 50 cm intervals on a single branch rope. The round basket (lamp basket) is 45 cm in diameter and has 7 - 10 layers.

Photo VI-6 shows a cushion basket being thrown in, while Photo VI-7 depicts the structure and size of a round basket. Both are identical to those used in Mutsu Bay.

H. Onshore work for seedling collection

(77)

The main onshore work for seedling collection is the preparation of seedling collection materials.

Typical of such work are the making of onion bags for use in seedling collection and stringing 10 - 15 of them onto the suspension ropes. The work involved in preparing 1,000 onion bags and stringing them onto 100 suspension ropes takes a person two days working 10 hours a day.

Other work is similar in nature to the work after intermediate breeding, and includes the collection of attached seedlings, sizing of the collected seedlings, preparation of cushion baskets and stringing them together, basket exchange process, basket cleaning and such.

After seedling collection, the process of washing the scallops in the tank, removing sea mussels and other miscellaneous substances, and putting the seedlings into the cushion baskets can be done by two people with an efficiency of around

70,000 seedlings per day. Consequently, to do the basket exchange work involving 1,000,000 seedlings will take two people 10 - 15 days.

The cushion basket stringing process can be done at an efficiency of 150 - 200 baskets per person per day, and assuming that 1,000 seedlings are put into one basket, then 1,000 baskets would be needed to accommodate 1,000,000 seedlings, which means it will take one person five days or so to do this.

In performing the work of collecting the fry, the following points are important:

1. Only the necessary number of large-size fry should be collected.
2. Direct sunlight should be avoided during work, and the handling should be done expeditiously so as to finish by noon.
3. The length of time the seedlings are kept in a tub or bucket should be made as short as possible.
4. Starfish and sea mussels must always be removed.

6. Mid-growth Scallop Culture

A. Shipment of first fry

The size of the fry in early November, when the 3rd stage intermediate breeding has been completed, is around 2.5 cm, and these are called the first fry. (78)

When they become first fry, their shipment and sale for transplantation purposes become possible. In the Mori district, some are sold for transplantation purposes to the Japan Sea side or Okhotsk Sea side within Hokkaido.

For shipment, the fry are put in a plastic container, dampening hemp cloth to provide moisture, and cooled in a refrigerated truck with blocks of ice and shipped by truck as is. Dry ice was at times used for cooling, but because of partial over-cooling and problems with carbon dioxide generation, it is no longer used at present. The shipment capacity of a single truck is around 500,000 seedlings, and the transportable time by this means is around three days, with the survival rate deemed to be about 80%.

In the case of such sales, the containers are on loan and the shipment fee (truck charge, ice fee, etc.) are borne by the buyer. The price of the seedlings is determined by tender, so that it is not figured out from the production cost. The bid price in 1975 for one seedling 2.5 cm in size was 1.80 yen (delivered at the point of production). Those which have wintered and have been grown to around 3.0 cm are called second fry, for which the bid price was 2.20 yen apiece.

B. Mid-growth scallop culture method

The fry which became first fry in November grow to a shell length of 3.0 cm or more by February - March the following year and become second fry. By March of the year after that, they will have grown to a shell length of 9 - 10 cm, when they are shipped out as mid-growth scallops. During this period, the baskets are exchanged at the rate of twice a year, on each occasion the mesh size of the baskets being enlarged and the population being thinned.

The first exchange is done in early November when the first fry emerge. At this time the mesh size of the round basket is made 9.9 mm and the population per basket layer is reduced to 100 or less.

The second one is done when they become second fry in February - March the following year, and while the mesh size of the round basket remains unchanged at 9.9 mm, the population per basket layer is thinned to 20 - 30 with shell cleaning being undertaken at the same time as the exchange.

The third time is between September and November, when the mesh size of the round basket is made 23.1 mm while the population per layer is made 15 - 20. Shell cleaning is done at the same time. (79)

The fourth time is between January and mid-April of the year after, when the mesh size of the round basket is made 33 mm and the population per layer 15 - 20.

After completion of the fourth basket exchange, some are shipped out as second-year scallops (one full year of culture) while some are steered towards third-year scallop culture. In the course of this third-year culture, instead of

using round baskets some of the scallops may be cultivated by the ear-hanging method.

The yield rate during the foregoing mid-growth scallop culture period is generally 80%.

Third-year scallop (two full years) culture and fourth-year scallop culture follow the same procedure as mid-growth scallop culture. In the case of third-year scallop culture, the basket exchange and shell cleaning are done in October - November when the population per layer is made 13 - 14. Then in February - March the following year, another basket exchange and shell cleaning are carried out, when the population per layer in the round basket is made 12 - 13.

The reason that the basket exchange and shell cleaning are carried out twice a year in October - November and February - March is because the attachment season for barnacles occurs twice a year in August - October and January - February, making the time when this attachment is finished the most appropriate for shell cleaning.

Other attached organisms are starfish and sea mussels, the attachment season for both of which being May - July, but because these attachments are restricted to the upper layer of the sea, the scallops which have been suspended in the middle layer are not greatly afflicted by them.

As a point of caution during the breeding period, the growth of the scallops is rapid during their growth period in early autumn and if they are left for a week or more, there is a risk that their increased weight will exceed the buoyancy of the floats and cause the suspension rope to sink. For this reason, the condition of the floats should be inspected at least once a week, and where the floats are submerged when they should be above the water, additional floats should be attached to the girder rope so that the girder rope will not sag.

Also, in the course of basket exchange and shell cleaning when the scallops are being held in a tank, it is important to avoid any lack of oxygen, high water temperature (20°C or above), low water temperature (5°C or less), exposure to rain or fresh water, and any mechanical process involving strong shocks.

C. Structure of suspension culture facility

(80)

Upon entering the mid-growth scallop culture stage (the stage using 9.9 mm mesh round baskets in November with the population per layer being 100 or less), the round baskets are suspended from a suspension culture facility (called a girder rope) laid out separately from the stretched rope used for seedling collection.

The layout pattern of the girder ropes differs not only with the size of the designated joint fishing rights zone owned by each union and the number of members belonging to that union, but also varies with the water depth in the layout area, the velocity of the tidal current, and the size of the fishing boats in use, etc. The basic structure, however, is as shown in Fig. VI-12.

The direction of layout of the girder ropes is set parallel to the sea and tidal currents to minimize their resistance, and in the Mori district it is parallel to the coast line.

In order to fix the girder rope layout positions, 5-ton, 8-ton and 10-ton concrete blocks are used in the longitudinal direction, to which the girder ropes are attached by anchor ropes.

The weight of the concrete blocks is determined as a result of dynamic calculations such that, taking into consideration the length of the girder ropes and the velocity of the tidal current, there would be no movement even in the face of rapid tidal currents arising out of storms.

Concrete blocks are likewise used for lateral stability as well, the weight of these concrete blocks being 3 tons or 5 tons and lighter than those for the longitudinal direction. These are positioned at both ends and at 120 m intervals. This lateral stabilization rope is called an inner tension rope.

For the anchor rope, a 30 mm diameter Dunline rope is normally used. Because the girder rope would move if there is slack in the anchor rope, Lytak floats (30 cm - 36 cm diameter) are attached at two points along the rope to minimize any slack. The same applies to the inner tension rope.

Mooring cable set-up

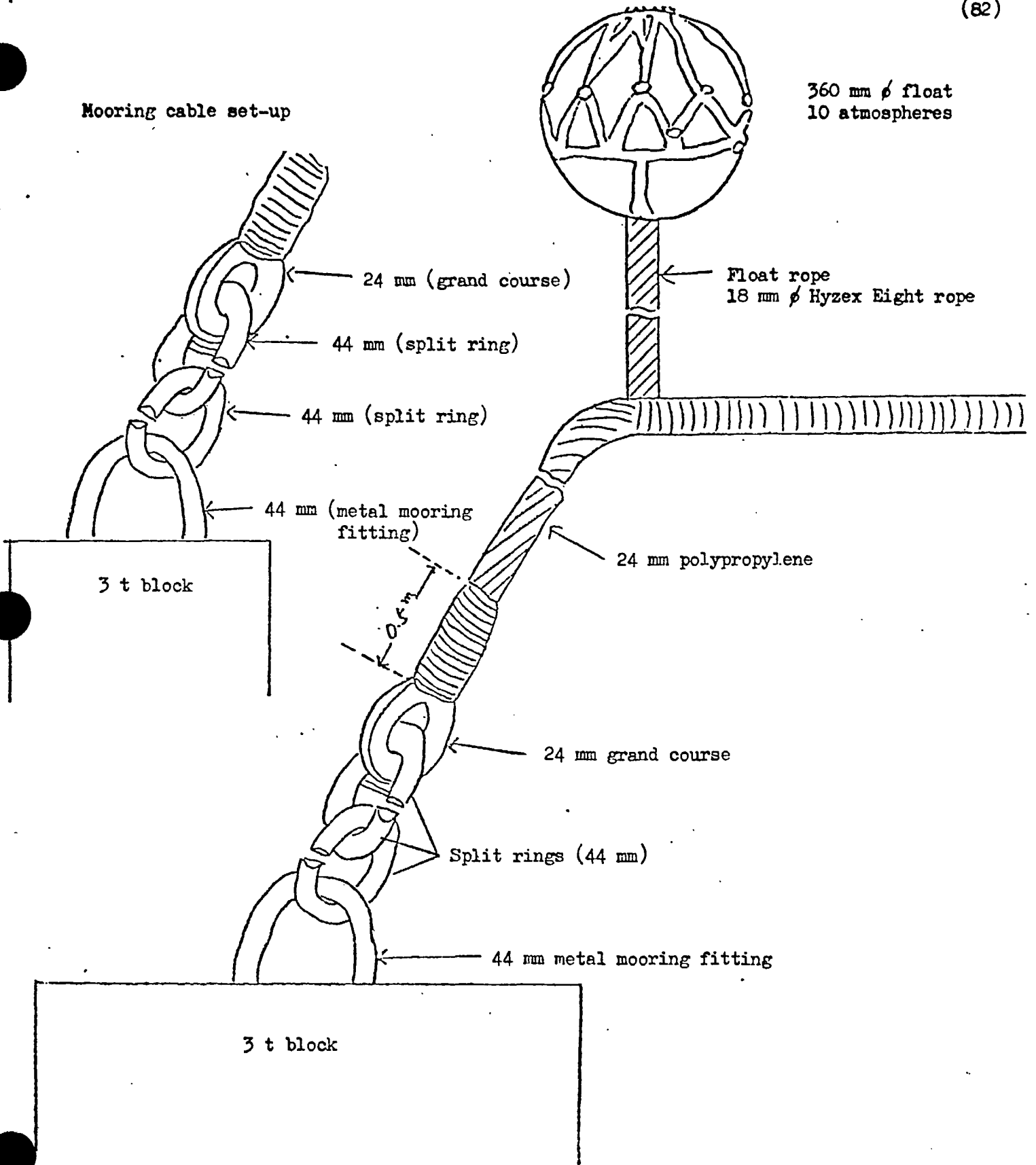


Fig: VI-13 (1). Attachment of anchor rope to concrete block

The attachment of the anchor rope to the concrete block is done by connecting two iron split rings to the grand course at the end of the anchor rope as shown in Fig. VI-13.

For the girder rope, a 26 mm diameter Dunline rope is used. To fix this so as to maintain a specified depth of 2 - 5 m below the water surface, 30 - 36 cm diameter floats (Lytak) and 2 - 5 m lengths of 12 mm diameter Hyzex rope to reach the specified depth are used. The girder rope is suspended at a specified depth from the float by this Hyzex rope. (84)

This float effectively serves to reveal whether the girder rope is stretched straight in the horizontal direction or is sunk in the vertical direction, and is attached at the rate of one per every 10 - 12 m interval.

To prevent the girder rope from sinking when the baskets are suspended, floats are attached directly to the girder rope. The number of floats in this case is suitably adjusted in conjunction with the weight of the baskets so that the girder rope will neither sink nor float up.

D. Method of layout of girder rope

To lay out the girder ropes of many union members within the designated joint fishing rights zone of limited size, there is a need for the union to exercise control over this layout. Also, the process of laying concrete blocks weighing 5 tons and 10 tons at specified positions is hardly something which individual fishermen can do. For these reasons, the laying of the concrete blocks is contracted out to specialists (mainly salvage companies). The cost for this is about 10,000 yen per single 10-ton block (1975). Other work is carried out jointly by the union members.

The costs incurred in this girder rope layout are later charged to the union members who pay the union based on the number of girder ropes allotted to each member.

Once the concrete blocks have been sunk into position and the outer frame ropes are laid out, the girder ropes can be strung within that framework. This process is carried out jointly by 30 people at the rate of around 30 ropes per day.

E. Layout pattern of girder ropes

With due consideration for effective utilization of the designated joint fishing rights zone which is limited in size as well as the convenience of various operations involved in culture, each union adopts a layout in its own unique form and there is no particular standard to follow. In the Mori Fisheries Cooperative Union, given that the girder ropes used by a single family are limited to 15 units with each length of 150 m or less being counted as a unit, the length of the girder ropes is either 150 m or a multiple thereof. The spacing between the girder ropes should correspond to the minimum width in which the fishing boats working among them can turn around, so that while there is some variation depending on the size of the fishing boats involved, the present minimum is 20 m (the length of a fishing boat being approximately 10 m). To avoid over-crowding, it is said that a spacing of 40 m is necessary, but because many people want increased facilities it is at present set at 20 m. While in Fig. VI-12 the length of one unit of girder rope is shown as 120 m, this is because there are some unions where the unit length is 120 m. This length is determined for convenience at the time each union distributes the rights to its members and there is no special reason for it. (85)

The girder rope layout pattern at Oshirouchi Village in the Mori Fisheries Cooperative Union shown in Fig. VI-14 is a good example showing the layout of many girder ropes within a narrow allocated water area. This figure depicts the case where the layout is at a water depth of 75 m and 4,000 m offshore, and consists of a total of 45 girder ropes (90 units) spaced at 20 m intervals.

F. Types of suspension culture baskets

As the basket for use in suspension culture, normally a 10-layered round basket (otherwise called a lantern basket or lamp basket) is used. Others referred to as a pocket basket, accordion basket and mansion basket are available. There is also the method which does not use a basket but involves opening a hole in the ear of the shell and passing a wire through this to attach it to the suspension rope.

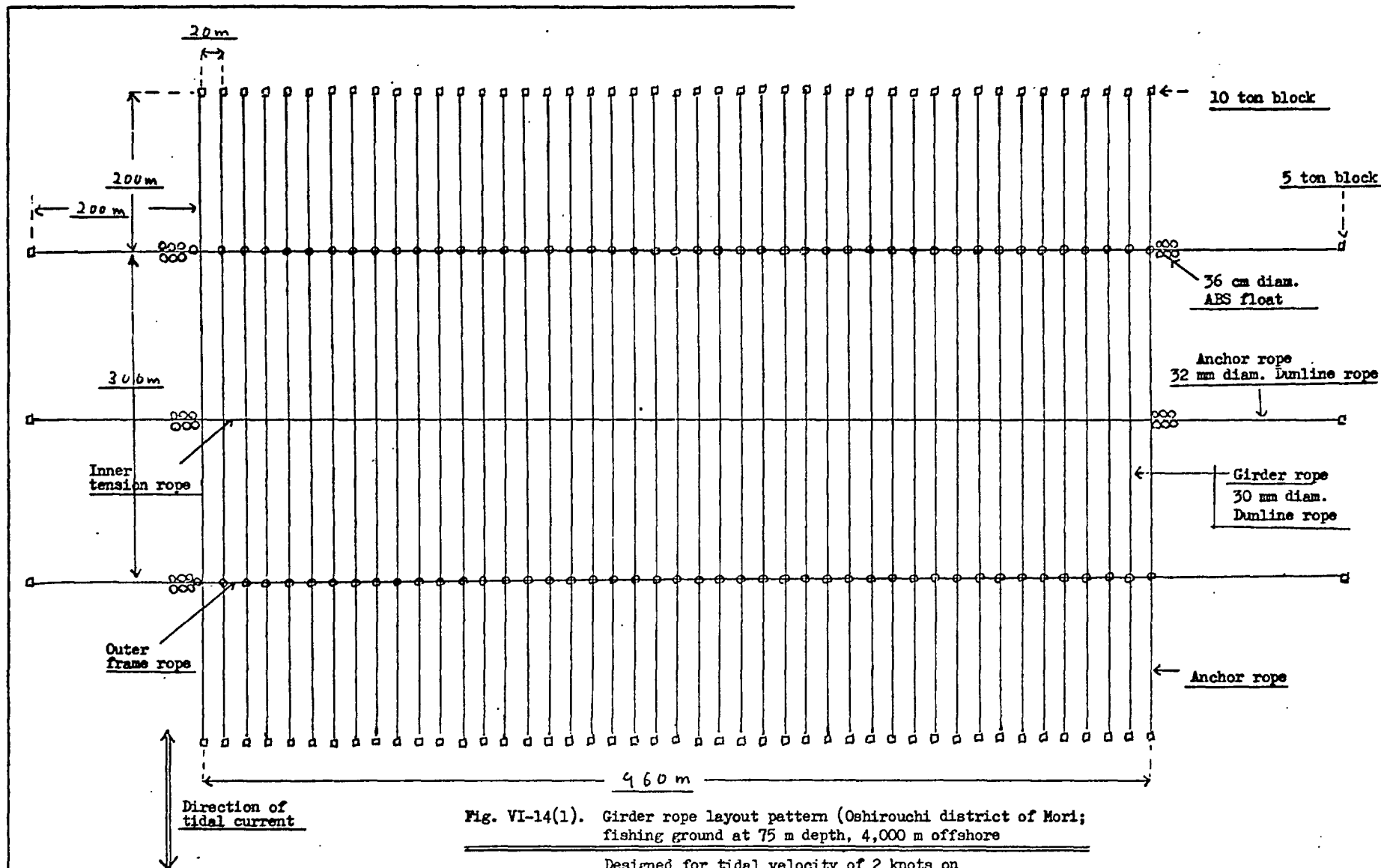


Fig. VI-14(1). Girder rope layout pattern (Oshirouchi district of Mori; fishing ground at 75 m depth, 4,000 m offshore)

Designed for tidal velocity of 2 knots on average and 4 knots at rapid tide time

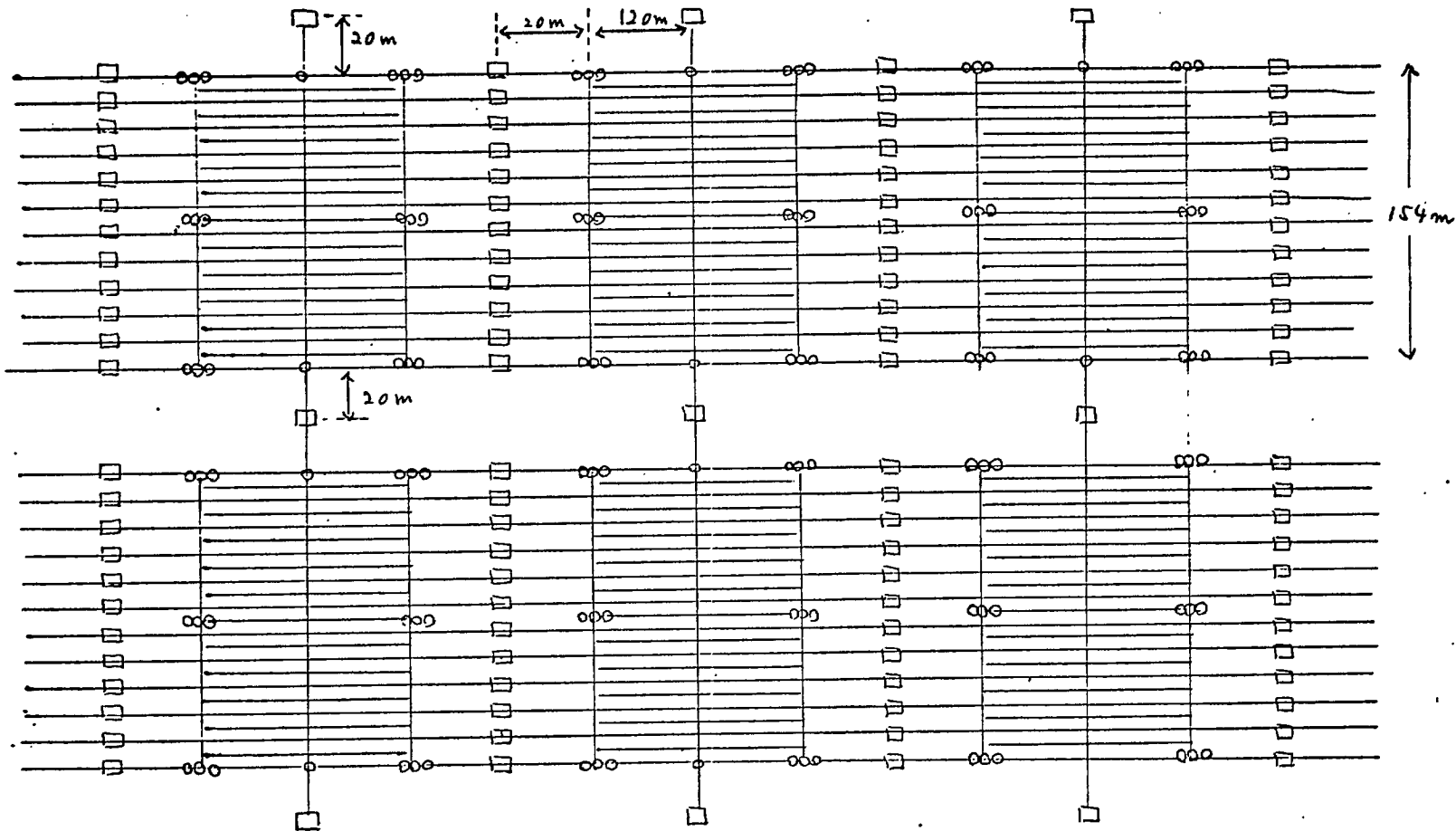


Fig. VI-14(2). Girder rope layout pattern (Sunahara Town)

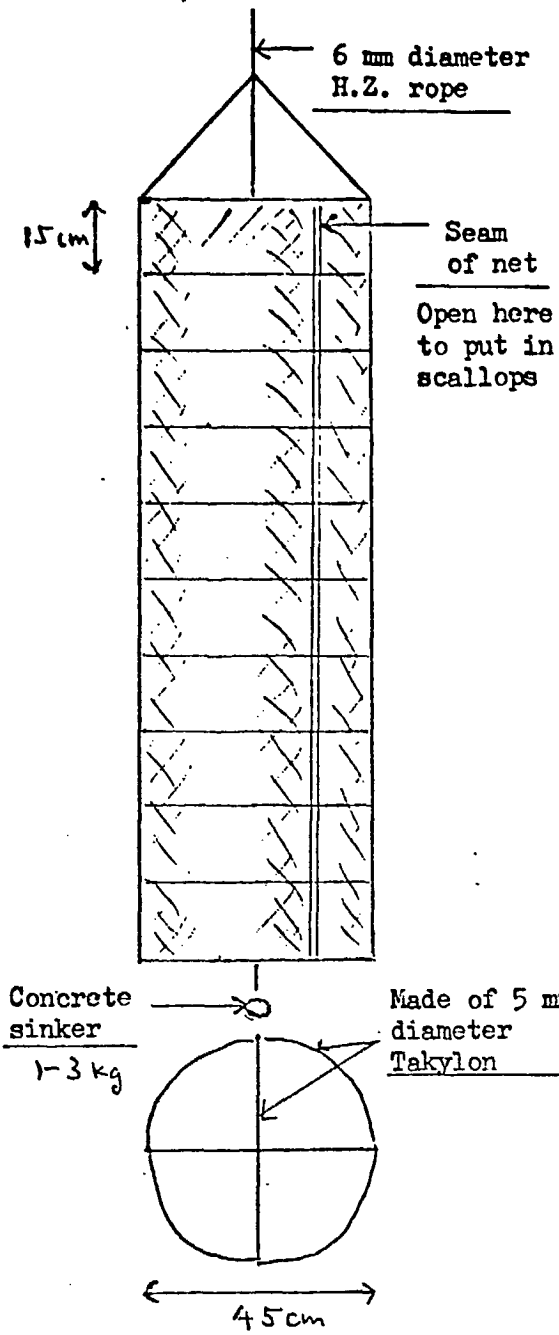


Fig. VI-15. Structure of round basket (10-layered)

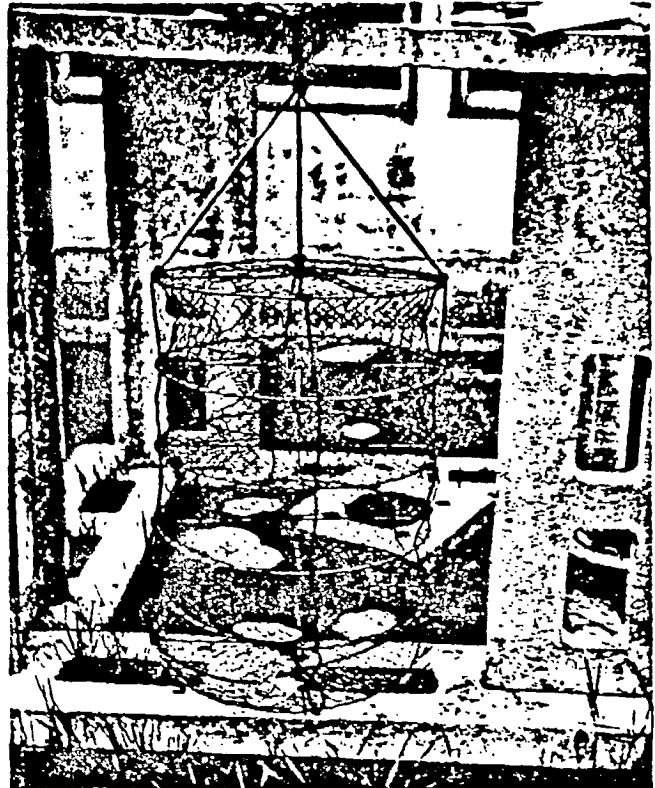


Photo VI-8. Round basket (above)

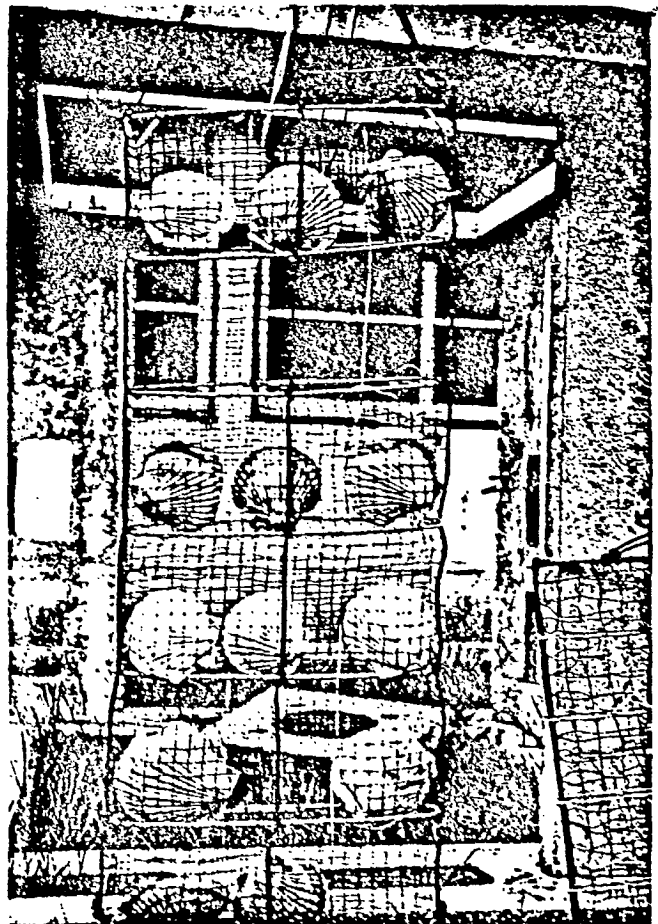


Photo VI-9. Pocket basket (right)

The round basket is as shown in Fig. VI-15 and Photo VI-8, with 15-layered ones also coming into use recently. Its advantage is that they are cheap in price and easily stored or handled because of its collapsibility. Its weakness, on the other hand, is that it is troublesome for putting in or taking out the scallops.

The pocket basket is as shown in Photo VI-9, with two rows of pockets in 25 layers, each layer being 15 cm deep by 30 cm wide. Putting the scallops in and out and storing the baskets are easy, but from the aspect of efficient utilization of limited culture space, it is not efficient and not widely used. (89)

The accordion basket and mansion basket, as shown in Fig. VI-15, are made of a totally plastic framework. Putting the scallops in and out is extremely easy,

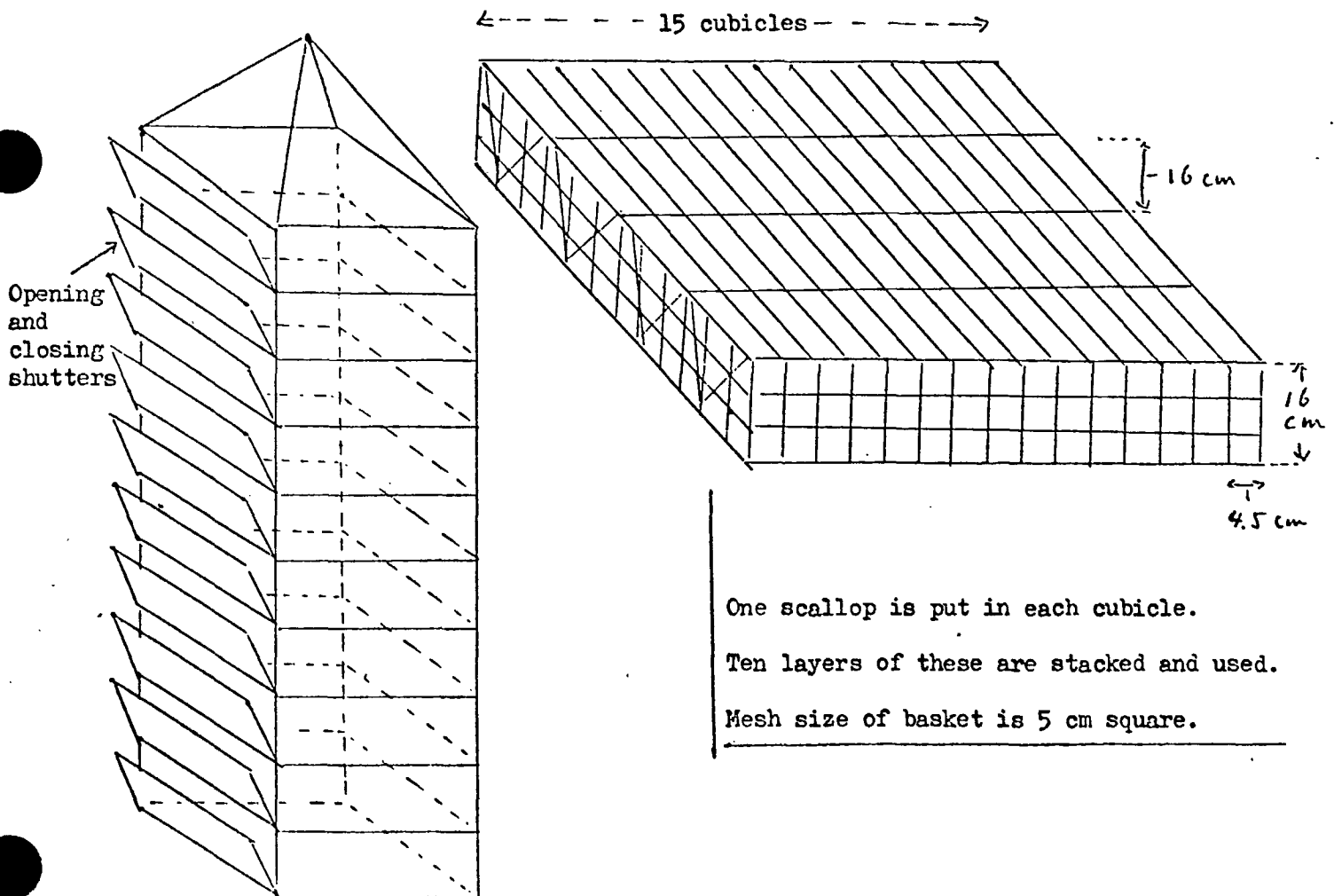


Fig. VI-15. Accordion basket (left) and mansion basket (upper right)

but because of the space taken up in storage and their high price, they have not as yet enjoyed general use. Nevertheless, in that there is a saving in personnel costs, some use is being made of them in the Saroma Lake region of Hokkaido.

Ear-hanging culture

(90)

After one full year of culture as mid-growth scallops, the shell length grows to 7 cm or more and they can be shipped out for sale, but of those which are cultivated as third-year scallops, some are cultured by the ear-hanging method. This is because when the shell length becomes 7 cm or more it becomes possible to pierce a hole in the ear of the scallop shell.

The culture period by the ear-hanging method is one year, during which time, unlike the case of basket culture, no shell cleaning is carried out. Consequently, that much labour can be saved.

The ear-hanging method has been improved upon a number of times since 1970 until the present method was evolved, called the hook-type ear-hanging method.

Under this method, as shown in Fig. VI-16, hooks are tied at 15 cm intervals to a 6 mm diameter Hyzex suspension rope suspended from the girder rope, and on these hooks are hung the ear of the scallops for suspension.

The hooks are made by cutting vinyl chloride-coated wire #12 (3.2 mm diameter) or stainless wire #16-18 (type 2 soft) into 15 cm lengths and bending them as shown in the diagram into an inner W shape, outer W shape or S shape. Making both the height and width around 4 cm, the hooks are fastened to the suspension rope with an aluminum wire fastener about 1 cm down so that the fixture will not shift downwards under the weight of the scallop.

The number of hooks per single suspension rope is around 60 - 70, from which 120 - 140 scallops are suspended.

Normally, this method is applied to those which have attained a shell length of 8 - 9 cm, during the period from January to March. In that the breeding period by this method is limited to one year, the harvest and shipment take place between

December and March the following year. The reason for this lies in the fact that since no shell cleaning or other mid-period maintenance work is carried out during the cultivation period the attached substances increase, making cultivation beyond that difficult.

While the primary advantage of the ear-hanging method is reduction in cost, there are other advantages such as the fact that the fleshiness of the scallops is good, both sides of the scallop swell out and grow, the adductor muscle enlarges, the spacing between suspension ropes can be narrowed and the cultivation volume per unit area rises. In terms of fleshiness, it is said to be about 10% better than compared to round basket cultivation.

(91)

When stainless wire is used, however, the wire tends to break due to friction with the shell and there is a risk of drop-off, and even in the case of coated wire there is the risk of the coating wearing out.

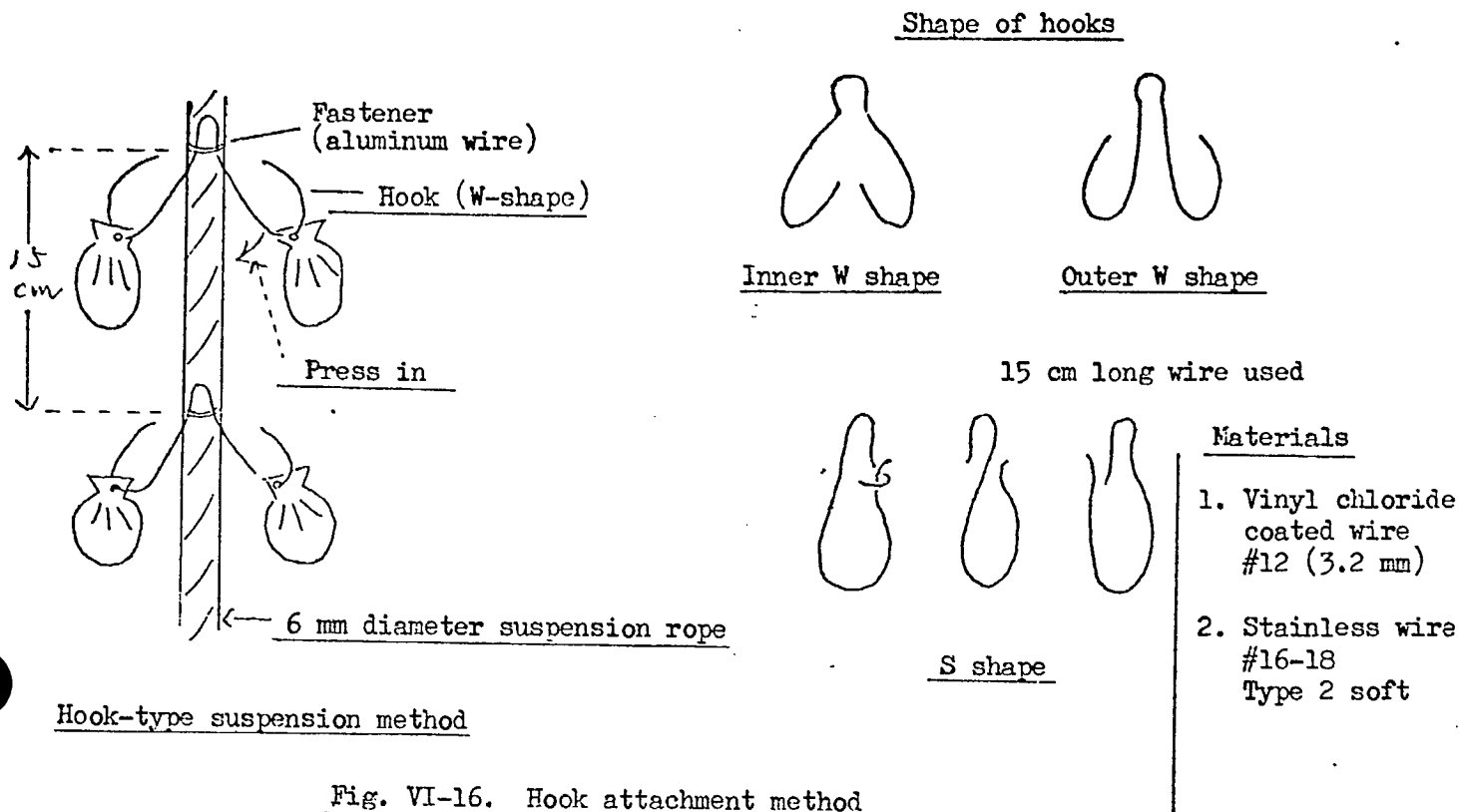
To give some concrete figures in terms of cost savings, in the case of cultivation using round baskets, a 10-layered basket 50 cm in diameter costs 1,600 yen (1976), and assuming that each basket can hold about 120 mature scallops with 200,000 being shipped annually, then the number of baskets needed is 1,666, for a total cost of $1,600 \text{ yen} \times 1,666 = 2,665,600 \text{ yen}$.

By contrast, in the case of ear-hanging, no more than 1,450 suspension ropes with 70 hooks attached and 15,000 m of wire for making the hooks are needed, making the cost of materials less than half that when round baskets are used.

Also, since the spacing between suspension ropes is 40 cm for ear-hanging and 75 cm or so for round baskets, more efficient utilization of the girder ropes becomes possible.

For ear-hanging work, however, two persons doing 5,000 per day is about the limit, while the job of fastening the hooks to the rope progresses at approximately 50 a day per person, making the work efficiency extremely low in comparison with the use of round baskets.

For this reason, it is unsuitable for large-scale culture, and in reality only a small number are being cultivated by this method.



G. Suspension methods

(92)

a) Methods of suspension of round baskets

Normally, girder ropes are laid out at a depth of 2 - 5 m below the water surface, and as shown in Fig. VI-17 there are three methods of tying the tether of the round baskets to the girder rope and suspending them.

In the interest of efficient utilization of the fishing grounds, there is a tendency towards increasing the number of baskets suspended on a fixed length of girder rope. While this in turn has led to larger sized concrete blocks (use of 10-ton blocks) to anchor the girder ropes as well as stronger girder ropes (30 mm), what effect this might have on the growth of scallops at this point is not clear. The length of the tether also varies from 1 m to 5 m depending on the region, while

the spacing between suspended baskets likewise varies from 50 cm to 70 cm or 100 cm according to the area.

Fig. VI-17 (1) shows an example where 10-layered round baskets with 3 m long tethers are suspended from a girder rope at 1 m intervals. Used to support this are ABS floats (hollow ones) 30 - 36 cm in diameter, while 9 mm diameter HZ (Hyzex) rope is used for the girder rope.

The number of floats to be attached in relation to the baskets is initially one per eight suspended baskets when the round baskets are holding a scallop population of about 250 per layer, but as the weight of the baskets increases along with the growth of the scallops the number of floats must be increased accordingly. At the ultimate stage there will be one float per basket. This augmentation of the floats is done as deemed necessary according to how much the flotation-regulating ball (float) floating atop the sea surface has sunk below the water line.

Fig. VI-17 (2) shows 10-layered round baskets suspended in two tiers, while (3) illustrates the case where two 10-layered round baskets are coupled in series and suspended. Both are designed for efficient utilization of the sea surface, but which is better in terms of the relative ease or difficulty of raising them or suspending them is not clear.

b) Method of suspension of ear-hanging ropes

One of the advantages of the method of culture by the ear-hanging system is that, unlike the case where baskets are suspended, the weight of the suspension ropes suspended from the girder rope is light. Consequently, in contrast to the girder rope for suspending baskets normally being 30 mm diameter Dunline rope, the girder rope in the case of ear-hanging is 8 - 9 mm Dunline rope and much thinner.

Also, unlike the case involving baskets, the volume taken up in the water is small, so that the spacing between the suspension ropes suspended from the girder rope is narrowed to 40 cm. The other characteristics are as mentioned earlier.

(See Fig. VI-18.)

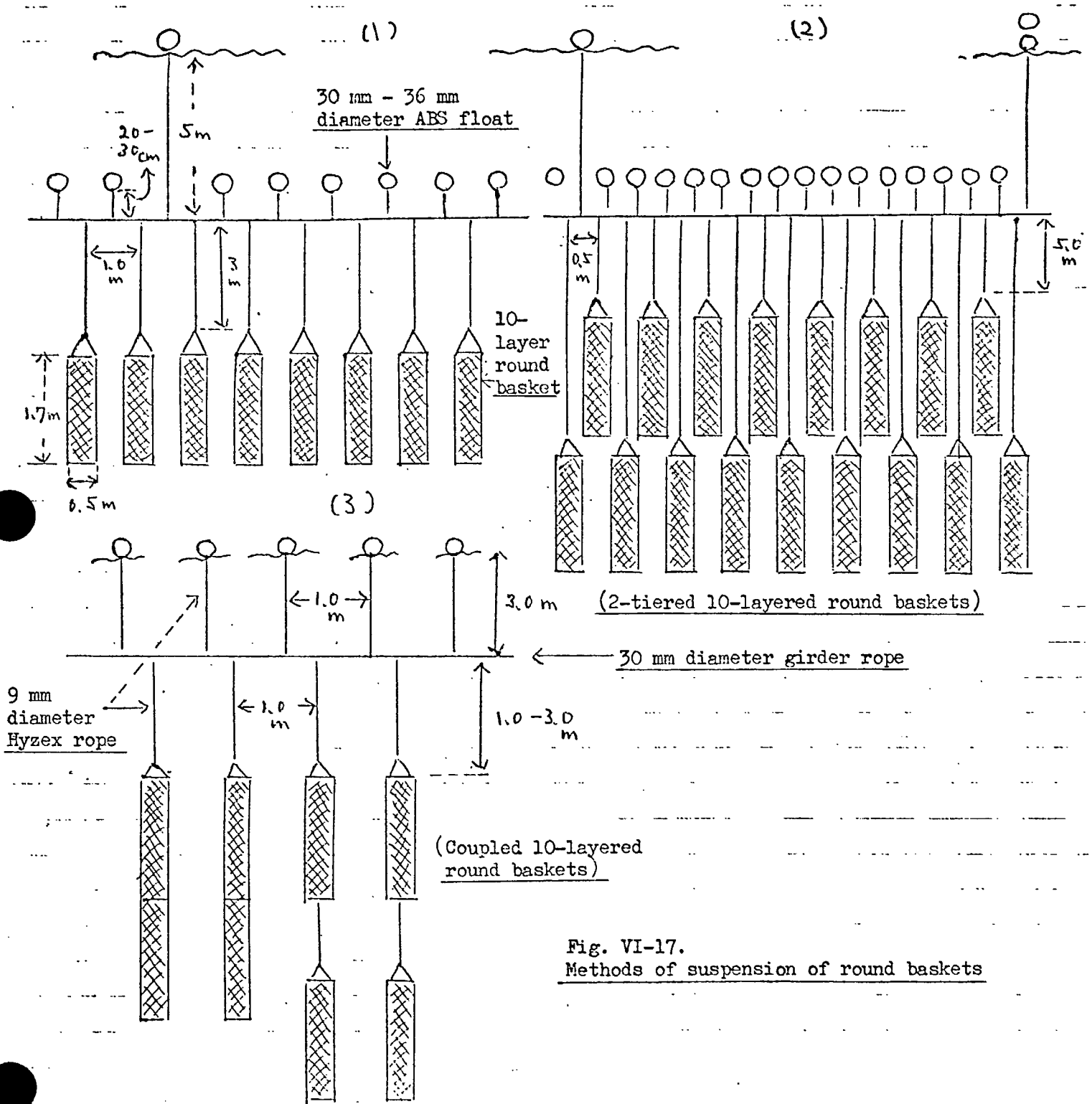
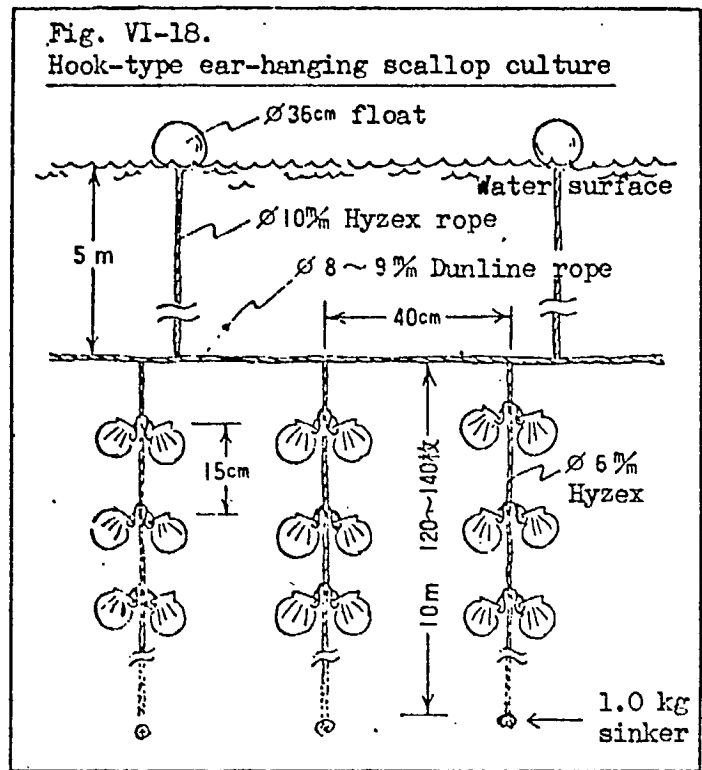


Fig. VI-17.
Methods of suspension of round baskets



c) Prevention of movement due to waves

With either the basket method or ear-hanging method, if the scallops under cultivation are subjected to oscillation, the growth of the scallops becomes suppressed. Also, in the case of baskets, the basket may sometimes tilt with the scallops all bunching up at one side, and this likewise suppresses the growth of the scallops.

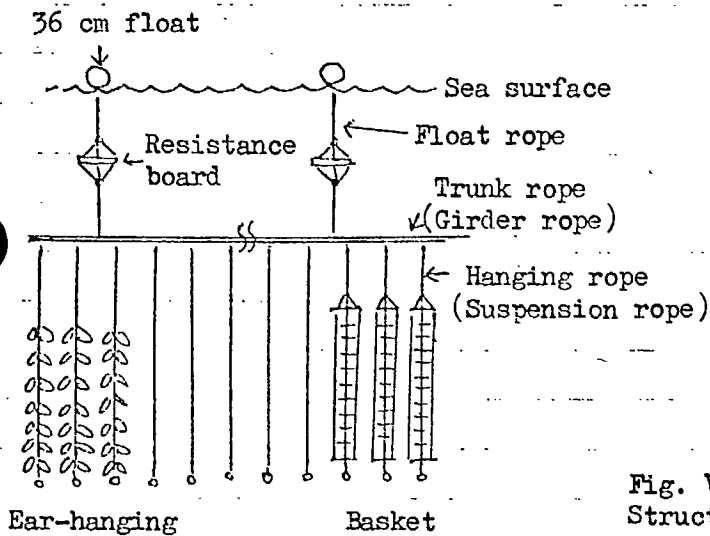
During observations in Iwate Prefecture involving fry, the scallops have been reported to have closed their shells because of oscillation due to waves and stopped feeding, with more than half of them dying.

Various methods or implements have been devised to keep the vertical motion (95) induced by the waves on the floats at the surface from being transmitted to the girder rope. However, for reasons of being impractical or costing too much, hardly any of them have been put into practical use, and the only one which can be considered readily usable both economically and technically is the resistance board.

While this is still in the trial stage and not generally widespread, its method of use and structure are as described below.

The resistance board, as shown in Fig. VI-19(A), is meant to be attached at the mid-point of the float rope and is designed to prevent the float from moving up and down even as the waves move up and down. At the outset of the experiment a wooden board was used, but with some indication of its effectiveness in suppressing the oscillation, a strongly insect-resistant and rot-resistant plastic board has come to be used. Its structure is as shown in Fig. VI-19(B).

(A) Manner of attachment



(B) Structure

{ Material: Hypanel (foam H.Z. board)
{ Dimension: 33 cm x 33 cm x 12 mm thick

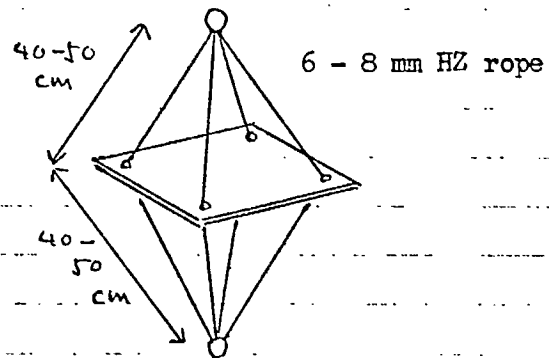


Fig. VI-19.
Structure and attachment of resistance board

The movement of sea water due to waves is generally a circular motion in the vertical direction of water droplets, with the height of the wave being the diameter of the circular motion, and it is known that the wave length is about three times the diameter of the circle.

Aside from such unique situations as in the case of storms, in the general case the movement of sea water due to waves decreases logarithmically as the depth increases, and at a depth equal to the wave length it has been computed to be around 1/530 of that at the surface (see Table VI-6).

Table VI-6. Relationship between wave height at the surface and wave height at a given depth (in the case of trochoid waves)

$$H_z = H e^{-2\pi \frac{z}{\lambda}}$$

where Z: a given depth (m)
 λ: wave length (m)
 H: wave height at the surface (m)
 H_z: wave height at a given depth (m)

| Wave length λ (m) | Period r (sec) | H _z /H | | | | |
|----------------------|-------------------|-------------------|-------|-------|-------|-------|
| | | 2 m | 10 m | 20 m | 50 m | 100 m |
| 6.2 | 2 | 0.134 | 0 | 0 | 0 | 0 |
| 25 | 4 | 0.605 | 0.080 | 0.007 | 0 | 0 |
| 56 | 6 | 0.800 | 0.327 | 0.107 | 0.004 | 0 |

In the case of a wave length of 25 m and a period of around 4 seconds as seen on the coast, at a depth of 2 m the diameter of the circular motion only decreases to about 0.6 of that at the surface, but at 5 m it decreases to 0.2 or 1/5 of that at the surface and at 10 m it decreases to 0.08 or less than 1/10.

From this relationship, in order to raise the effectiveness of the resistance board, the point at which it is attached to the float rope must be made as deep as possible. However, since the length of the float rope is normally around 5 m, it would seem best if it were attached as close to the girder rope as possible.

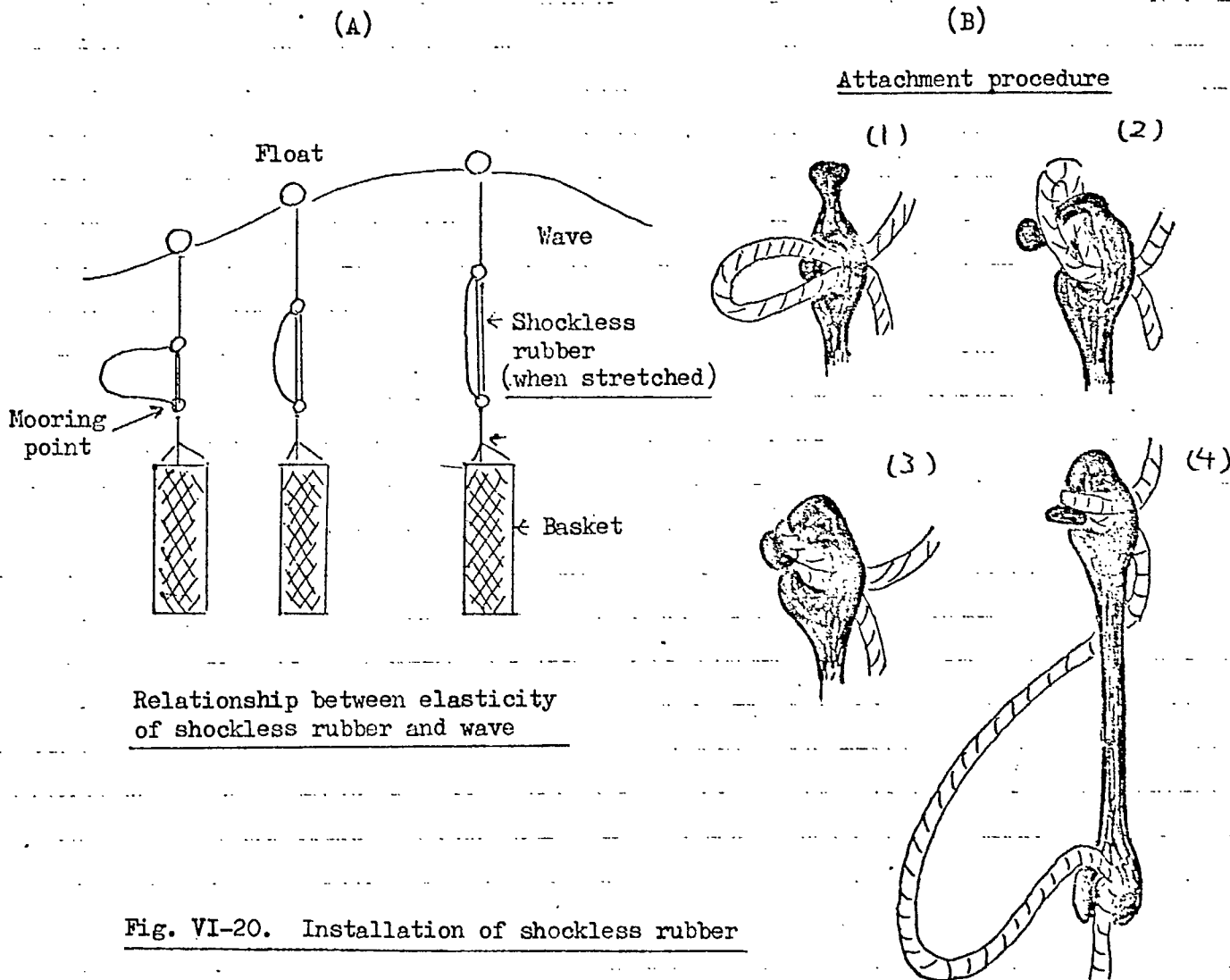
The method generally used to prevent the vertical movement of the waves from being transmitted to the baskets is one that has been devised experimentally and involves making the float that bobs on the surface (called a regulatory ball) extremely small so as not to give it too much buoyancy.

With this method, the basket itself suspended 5 m or more below the surface has the same effect as a resistance board, so that when the wave moves upward the float will not rise with the wave because of the resistance of the basket but instead will easily remain in its current position and be able to submerge into the water.

Consequently, the regulatory ball bobbing on the surface is not meant to be attached so that it floats completely atop the water, but is attached with its

buoyancy adjusted so that even in periods of calm, half of the float is submerged in the water.

Apart from this, something called shockless rubber has been conceived which (97) utilizes the elasticity of rubber. This is designed to give elasticity to the float rope so that the shocks due to waves will not be directly felt by the baskets. Its form and method of use are as shown in Fig. VI-20(A) and (B).



The structure consists of a cylindrical piece of special rubber 30 cm in length and approximately 2.5 cm thick with loops at both ends, which can be attached so that the float rope can expand or contract as the rubber expands or contracts.

Even though this may be able to dampen the shock of a sudden wave, it may be risky to depend upon this alone. As things now stand, it has some effectiveness, but because of cost increases it has not yet reached the point of general usage.

As far as the effectiveness of shockless rubber is concerned, experimental (98) results as shown in Table VI-7 have been obtained at the Iwate Prefectural Fisheries Experimental Station.

Table VI-7. Effect of using rubber in ear-hanging type culture

1. Method of culture: Ear-hanging type
2. Fishing ground: 1,000 m off Tomari Harbour in Hirota Bay
3. Water depth: 23 m
4. Suspension depth: 3 m
5. Cultivation period: January 19, 1972 - July 14, 1972
6. Rubber used: Processed product of old tubes

| | | With rubber | Without rubber |
|----------------------|----------------------|-------------|----------------|
| Commencement time | Population | 40 | 40 |
| | Average shell length | 6.42 cm | 6.41 cm |
| | Average weight | 27.5 g | 26.5 g |
| Survey time | Yield rate | 73% | 85% |
| | Average shell length | 7.92 cm | 7.05 cm |
| | Average weight | 67.1 g | 54.6 g |
| | Growth (weight) | 2.44 times | 2.06 times |

Data source: Shockless rubber advertising pamphlet of Kitafuji Rubber Co. (1-1 Sanjo, Higashi Sapporo, Shiraishi-ku, Sapporo City)

H. Basket exchange process

During the mid-growth scallop culture period, the process of exchanging baskets is carried out twice a year. On both occasions a thinning of the scallop population and shell cleaning are undertaken together, the first time during February-March and the second time during September-November.

In performing this operation, first the required number of replacement baskets is made ready. Using baskets which have been completely rid of attached

substances by means of a high pressure washing pump, the partition netting which forms the layers is checked and adjusted so as to keep level when suspended as well as maintain a uniform spacing of 15 cm.

The number of baskets raised offshore is around 30 at one time, and taking this number ashore by boat they are put into a water tank at the workshop.

Removing the starfish, crabs and other miscellaneous substances inside the (99) tank, a shell cleaning device is used to remove the barnacles attached to the shells.

At the time of the first basket exchange (February-March) the shell length of the scallops has grown to 3 cm or more, so that a fry sizing device is used to select those 3 cm or more, which are thinned and put into the baskets readied beforehand and then transported to the fishing ground to be suspended on the girder rope. The sizing process is shown in Photo VI-10.

When transporting the landed baskets from the beach to the workshop or when transporting the baskets from the workshop to the fishing boat after completion of the exchange, a hand-cart or special truck operable in sandy terrain is used. The high pressure pump for basket-washing, the shell-cleaning device and the truck will be shown separately in the section on work equipment.

The basket exchange process, as described above, is primarily a shore operation, and its efficiency is normally such that three people can handle 70 - 80 baskets per day. This means that when 120 baskets are suspended on one girder rope (120 m unit), it will take three persons a day and a half.

The basket exchange operation is carried out twice a year throughout the mid-growth scallop culture (2nd-year scallop culture) and mature scallop culture (3rd-year scallop culture). Because the population in each basket layer gets reduced on successive exchanges from around 100 at the outset to 20 - 30, then 15 - 20 and down to 13 - 14, the work efficiency gradually picks up to the point where at the final stage three persons can exchange about 300 per day.



Photo VI-10.
Mid-growth scallop sizing process
Cylinder in centre shows rotating sizer.

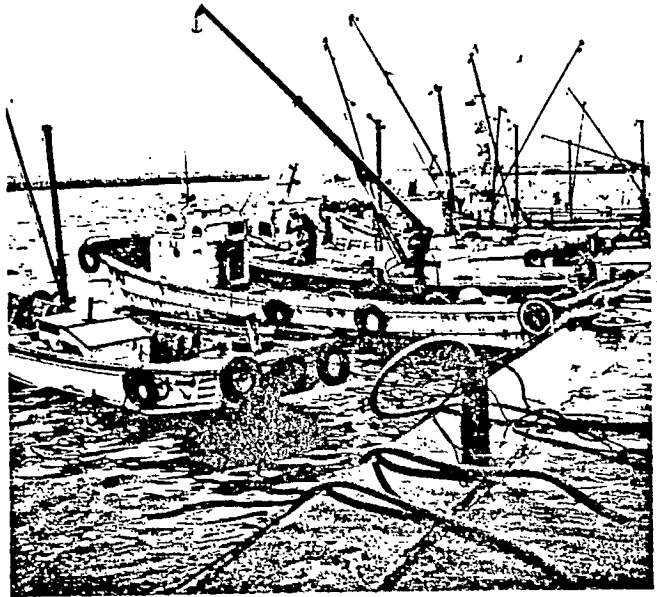


Photo VI-11.
Fishing boats with derrick booms mounted

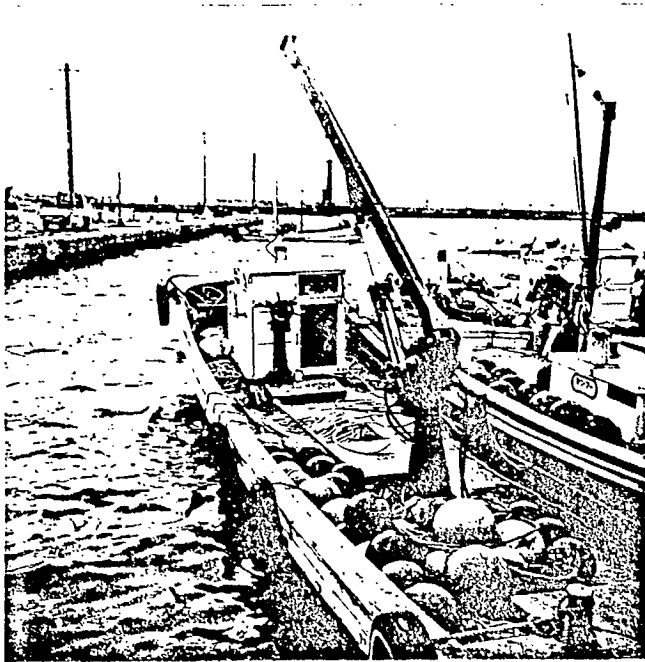


Photo VI-12. Derrick boom

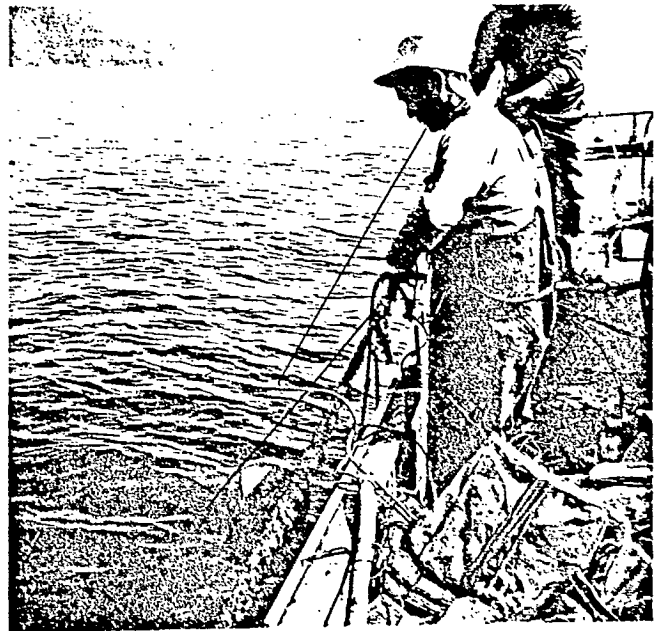


Photo VI-13. Casting in cushion baskets
Rope at side of ship is girder rope, and
scene depicts tether being fastened to
girder rope.

In terms of work aboard the boat, a derrick boom - hydraulically driven - located amidships on vessels with a stern engine or slightly aft of amidships on vessels with a bow engine, is used to first raise the girder rope (see Photos VI-11 and 12). Then, this is hung on a tether-intake roller mounted on the ship's side as shown in Photo VI-6, and successively raising the baskets while winding the tether-intake roller (hydraulically wound), they are removed and collected inside the boat.

A similar procedure is followed when suspending the baskets, fastening the suspension ropes to the raised girder rope and casting them in. Photo VI-13 shows the casting operation.

I. Precautions during the mid-growth scallop culture period

(101)

a) Maintenance and inspection of facilities

In order to see that the girder ropes are laid out properly and whether or not they are sagging or sinking, it is necessary to inspect the condition of the floats floating on the sea surface at least once a week. Especially during the growth season in early autumn, if the inspection is left for longer than a week, there is a danger that the girder rope will sink because of a weight increase in the baskets due to the growth of the scallops. In such cases, intermediate floats (attached directly to the girder rope) must be added to the sunken sections. Also, albeit rare, it may happen that a concrete block anchoring the girder rope will shift as a result of a storm or tidal wave. Particularly when the spacing between the baskets is reduced or when the number of suspended baskets is increased by such means as the coupling method, the resistance to tidal currents increases and this may cause a block to shift.

To discover these things early and devise appropriate countermeasures is an important function of the inspection.

b) Precautions at basket exchange time

The process of removing starfish, crabs, etc., at basket exchange time to

prevent loss as well as eliminating the other attached substances by cleaning the shells is indispensable to improving the yield and promoting growth. It is also necessary to size the scallops and group them according to size. Because these operations are conducted ashore, however, the weather, temperature, and the water temperature, salinity and oxygen level within the shore tank have a great impact on the physiology of the scallops. To minimize this effect, in addition to avoiding direct sunlight, dehydration of scallops, high and low temperatures exceeding the optimal temperature, it is necessary to pay thorough attention to the aeration of the sea water in the tank. Additionally, some types of cleaning devices used for shell cleaning may injure the scallops, so that the usage of such types of machines must be stopped. The primary object of shell cleaning is to prevent the attachment of barnacles and sea mussels, but the attachment season for barnacles is January-February and August-October while the attachment season for sea mussels is May-July. For this reason, the cleaning is done twice a year during February-March and October-November, but since barnacles get attached most numerously near the 5 - 12 m layer below the surface and do not become attached at 30 m below the surface, the suspension of baskets in deep waters would be effective in preventing the attachment of barnacles. (102)

7. Mature Scallop Culture

The fry which become first fry in November grow to a shell length of 3 cm or more to become second fry by February-March the following year, and after a further lapse of one year, by March of the year after that, they grow to a shell length of 9 - 10 cm and are shipped out as mature scallops. Their cultivation as mid-growth scallops is up to this stage, and subsequent cultivation becomes mature scallop culture which progresses to 3rd year scallop or 4th year scallop culture.

For the cultivation of mature scallops, there are two methods consisting of the basket suspension method and the ear-hanging method.

The ear-hanging method is as already described, and consists of taking those which have reached a shell length of 8 - 9 cm at the time of basket exchange in February-March and subjecting them to suspension culture by this method. Harvesting and shipment are carried out from around November that year, but even if the shipment takes place after November and well into the following year, no shell cleaning or other care is undertaken whatsoever and they are left alone for the duration.

In contrast to this, with the basket suspension method the population per basket layer is made 15 - 20 between February-April. The next basket exchange and shell cleaning are done in October-November, at which time the population per basket layer is thinned to 13 - 14. The shipment of 3rd-year scallops is begun from this period, but those which continue to be cultivated are given another basket exchange and shell cleaning in February-March the following year, at which time the population per layer is thinned to 12 - 13. The procedures involved in this basket exchange, shell cleaning and population thinning process are the same as those for mid-growth scallop culture. That is, they are done twice a year, in October-November and in February-March. The only difference is in the mesh size of the basket netting, which is 21 mm to start with but becomes 30 mm at the time of the second basket exchange.

The mortality rate of the scallops during this 3rd-year scallop culture is virtually nil, with the yield rate being estimated as 99%. Compared with the 80% yield rate during the mid-growth scallop culture period, it may be surmised that once they grow to 8 cm or more the scallops do not perish.

8. Required Equipment and Machinery not Directly Related to Cultivation

(103)

A. Surface-related (fishing boat)

The size, capability and equipment of a standard-type fishing boat being used for scallop culture in the Uchiura Bay district are generally as given below.

Structure: Wood or FPR (plastic)
Size: Length 8.0 m, width 2.2 m
Tonnage: 2.9 tons (there are some as large as 5.0 tons)
Horsepower: 50 - 65 h.p. gasoline diesel engine
(corresponds to 20 h.p. under the Fishing Boat Act)
Equipment: One rope-winding drum at the stern or bow
Hydraulic steering gear
One hydraulic lifting device (derrick boom)
(see Photos VI-11 and 12)
One tether-intake roller (automatic hydraulic type)

Among the fishing boats used, there are some with a bow engine as shown in Photos VI-11 and 12, and others with a stern engine as shown in Photos VI-14 and 15. From the aspect of work efficiency, however, the ones with a bow engine seem to be better.

The life of these fishing boats is around five years, but in reality, because the fishing grounds have extended outward in recent years and in consideration of navigational safety as well as operational convenience, they are being renewed in about two years and growing larger in size.

The construction cost of this type of fishing boat including all equipment was 10 - 12 million yen as of 1976, and the amount of fuel oil used in a year is said to be 60 drums.

B. Shore-related

a) Facilities

Warehouse: Wood construction (with foundation of concrete or blocks to prevent the entry of rats)

Size around 40 tsubo (1 tsubo = 3.305 m²)

(Unit price per tsubo around 120,000 - 130,000 yen)

Storage for ropes, baskets and other equipment

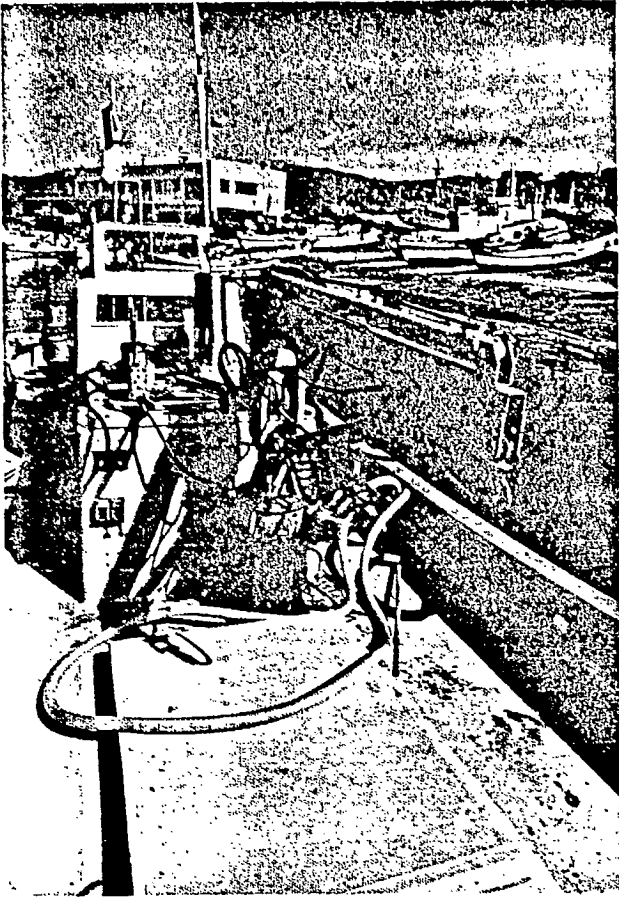


Photo VI-15. Derrick boom mounted on a fishing boat

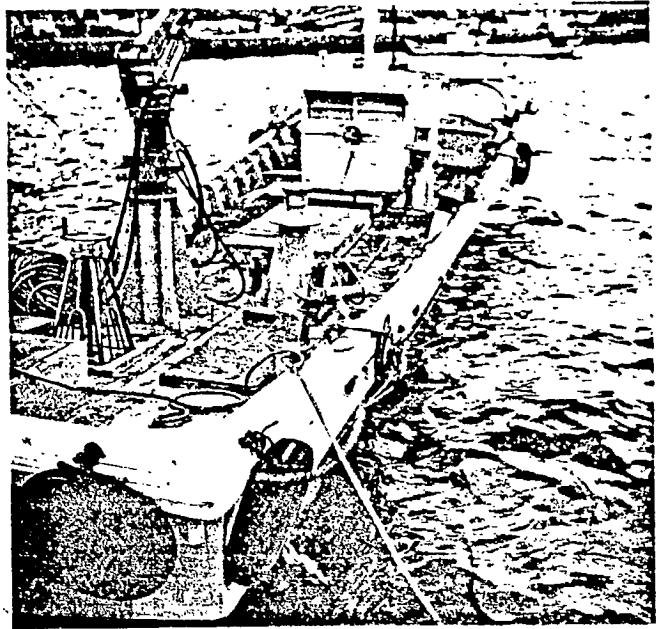


Photo VI-16. Equipment layout in stern section of a fishing boat with a bow engine

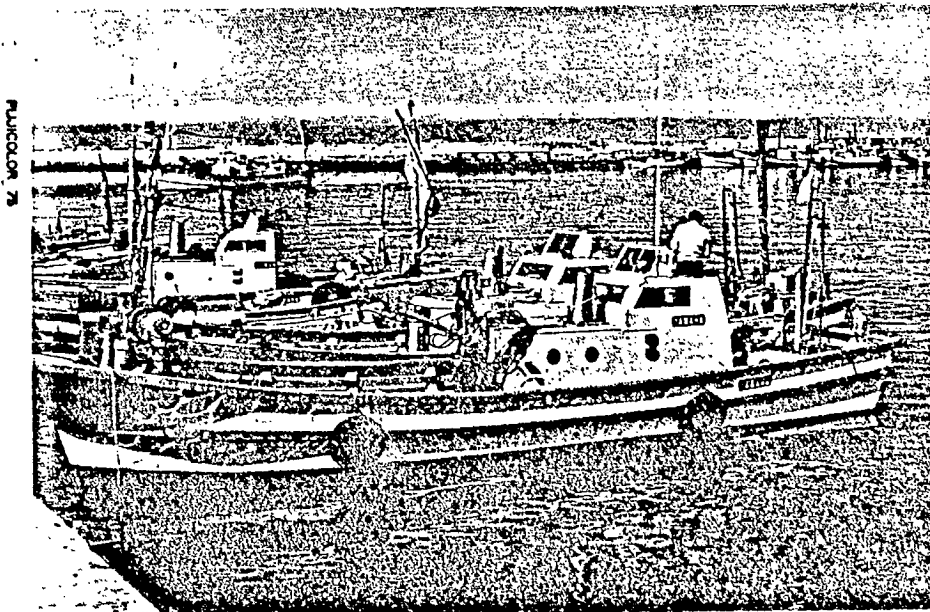


Photo VI-14. Fishing boat used in scallop culture

Workshop (co-functions as warehouse)

(105)

Water tank: 3 - 4 units of 2.73 m x 2.73 m x 0.85 m (depth)

Price per unit 80,000 - 90,000 yen

b) Machinery and equipment

1. Net and rope washer: one unit

Sea-water power sprayer model ZF or model GF manufactured by Yanmar Farm Machinery Co. Ltd. Price 150,000 - 180,000 yen; life 3 years (rapid corrosion due to use of salt water).

2. Shell cleaner: one unit

Automatic scallop cleaner manufactured by Hokuho Machinery Co. Ltd. Price 400,000 - 700,000 yen; life 20 years (in actual fact 5 - 8 years). Separate 2 h.p. motor required.

3. Scallop sizer: one unit

Fry sizer made by Sanwa Vehicle Industry Co. Ltd. Price 150,000 yen. Separate 100 V $\frac{1}{4}$ h.p. motor required.

4. Fishing boat hoisting winch: one unit

7 h.p. unit; price 320,000 yen.

5. 3 h.p. water pump: one unit

For pumping sea water into the water tank; price 350,000 yen; life 2 years.

6. Truck

Sanwa Crawlman Young made by Sanwa Vehicle Co. Ltd. Price 870,000 yen. (Dump-type Sanwa Crawlman model 1500D: 1,160,000 yen.)

These machinery and equipment are all individually owned, with no joint use being made. The reason for this is that the period of use is at one and the same time, making joint use impossible. (See Photos VI-17 to 20.)

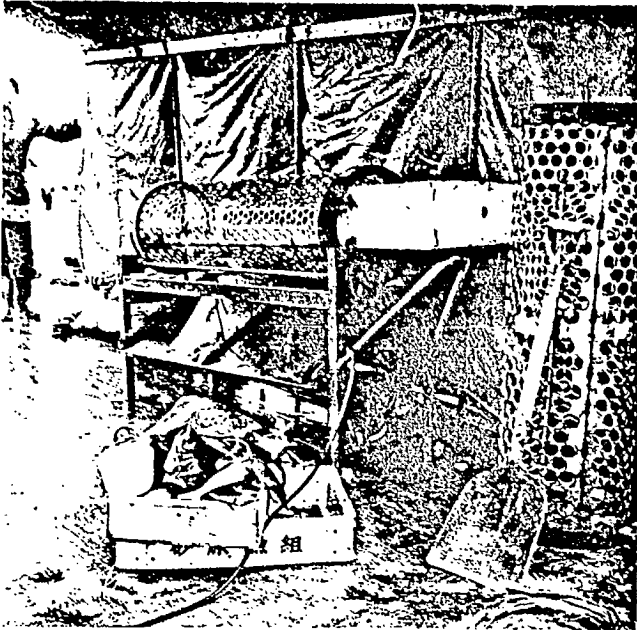


Photo VI-17. Fry sizer

There are various models with a rotating drum opening of 2.5 cm, 3.0 cm, 3.5 cm, 4.0 cm equipped with a 100 V, 200 W motor.

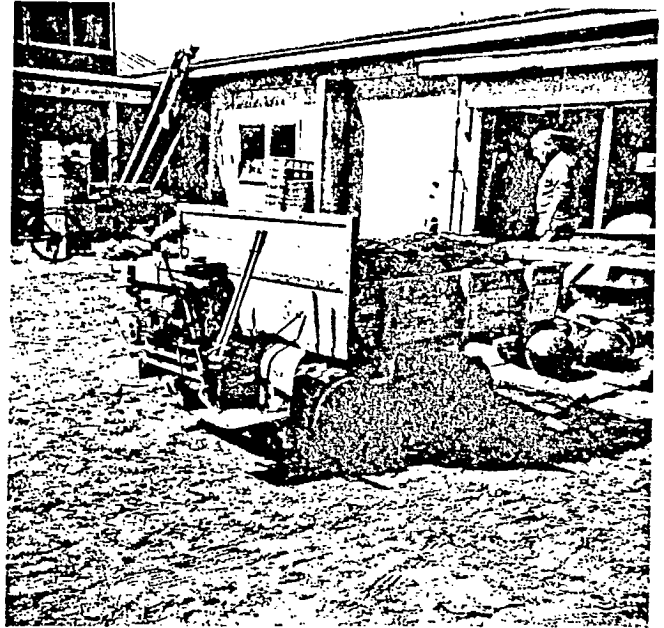


Photo VI-18. Truck

Sanwa Crawlman Young model
Load capacity: 500 kg
Overall length: 2.115 m Engine: 6.5 ps
Width: 1.555 m
Height: 1.148 m

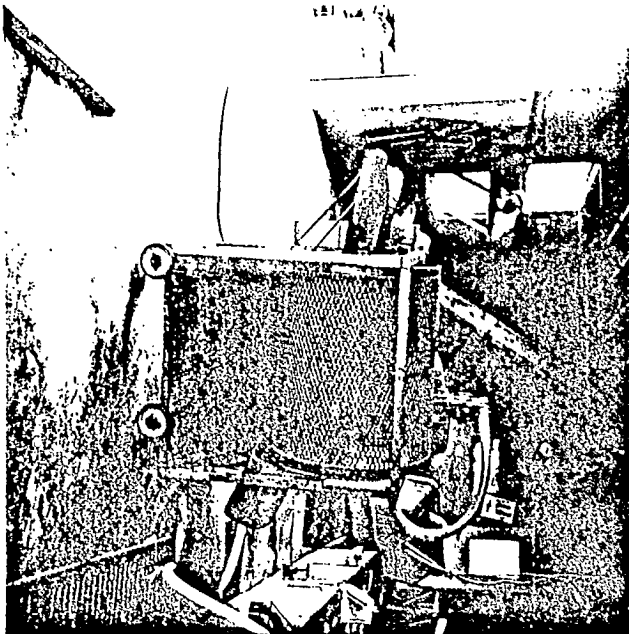


Photo VI-19. Shell cleaner

Since this type of shell cleaner involves putting the shells inside a rotating drum and letting them rub against each other to remove the attached substances, the shells are frequently damaged so it is falling into disuse.

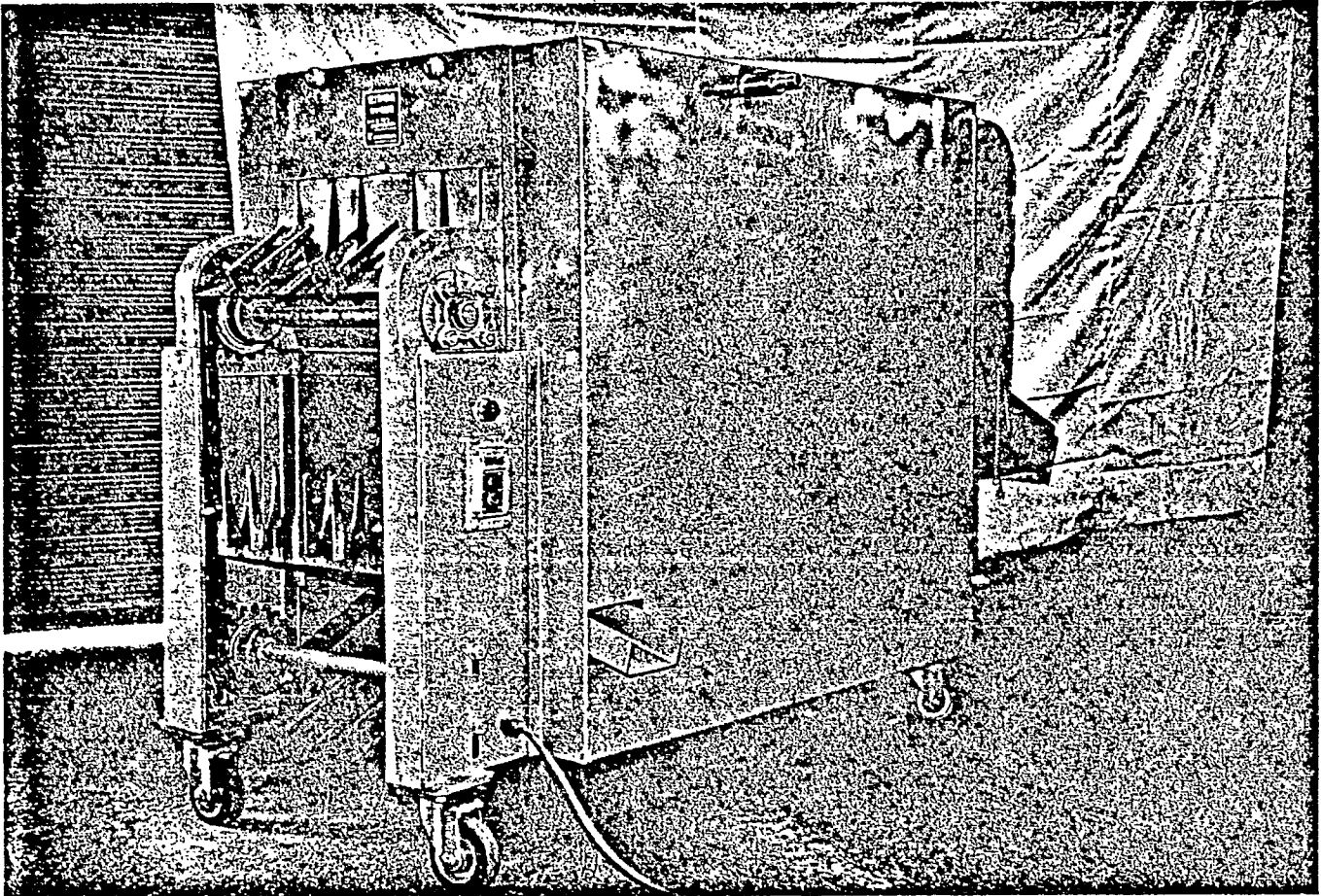


Photo VI-20. Shell cleaner

Washing capacity: 4,800 shells per hour

A 3 phase 200 V, 1.5 KW motor is used.

If engine is employed, a Yanmar model G 25 is used.

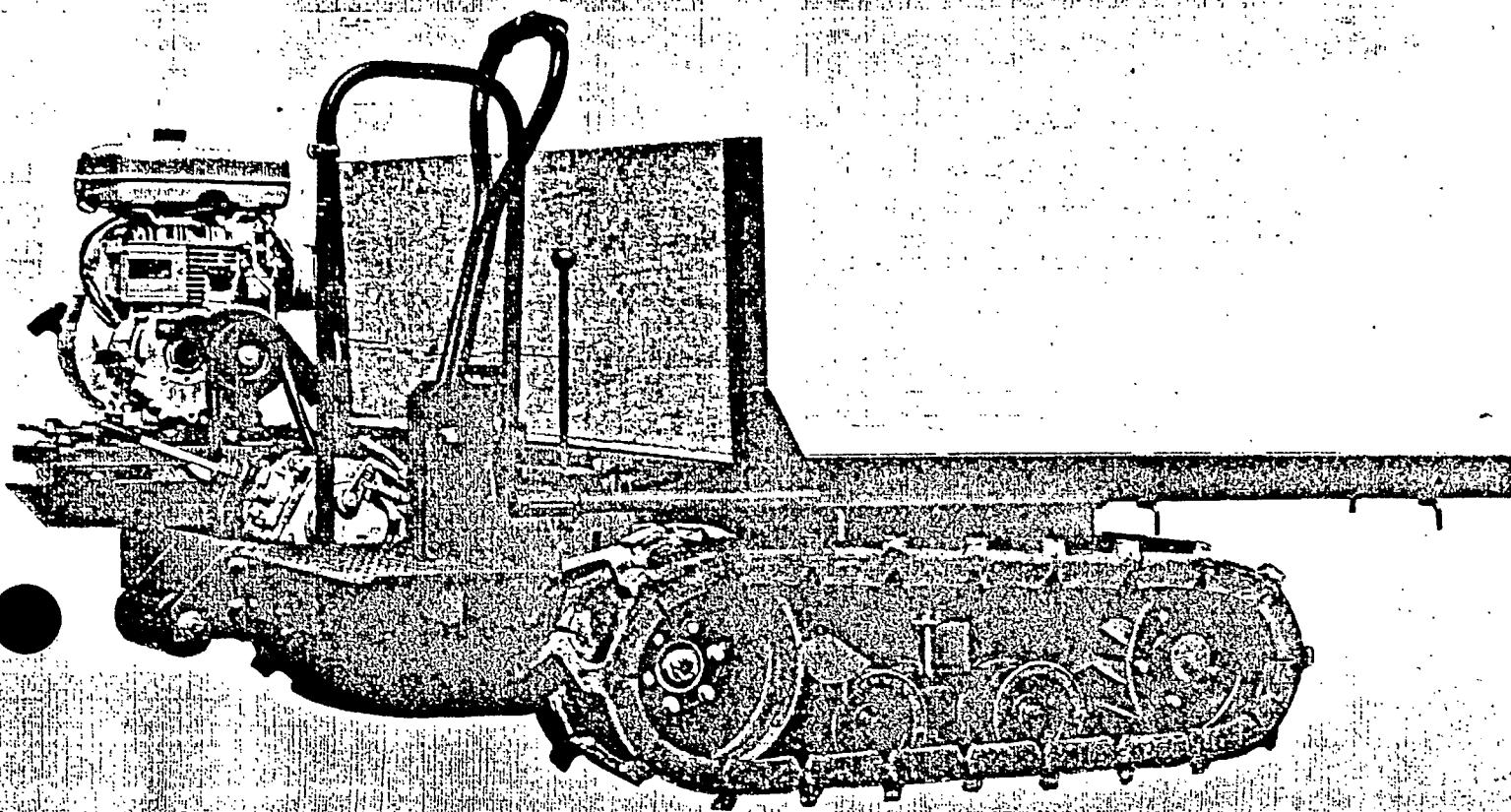
Manufacturer's pamphlets of the various foregoing machinery and equipment are presented on the following pages.

SANWA CRAWLMAN YOUNG

(108)

Transports with power where trucks cannot run.

Displays mighty power on steep hills, snowy roads, wet rice paddies and sandy terrain!



870,000 yen

Rubber crawler system which can even run on paved roads.

Sanwa Crawlman Young specifications

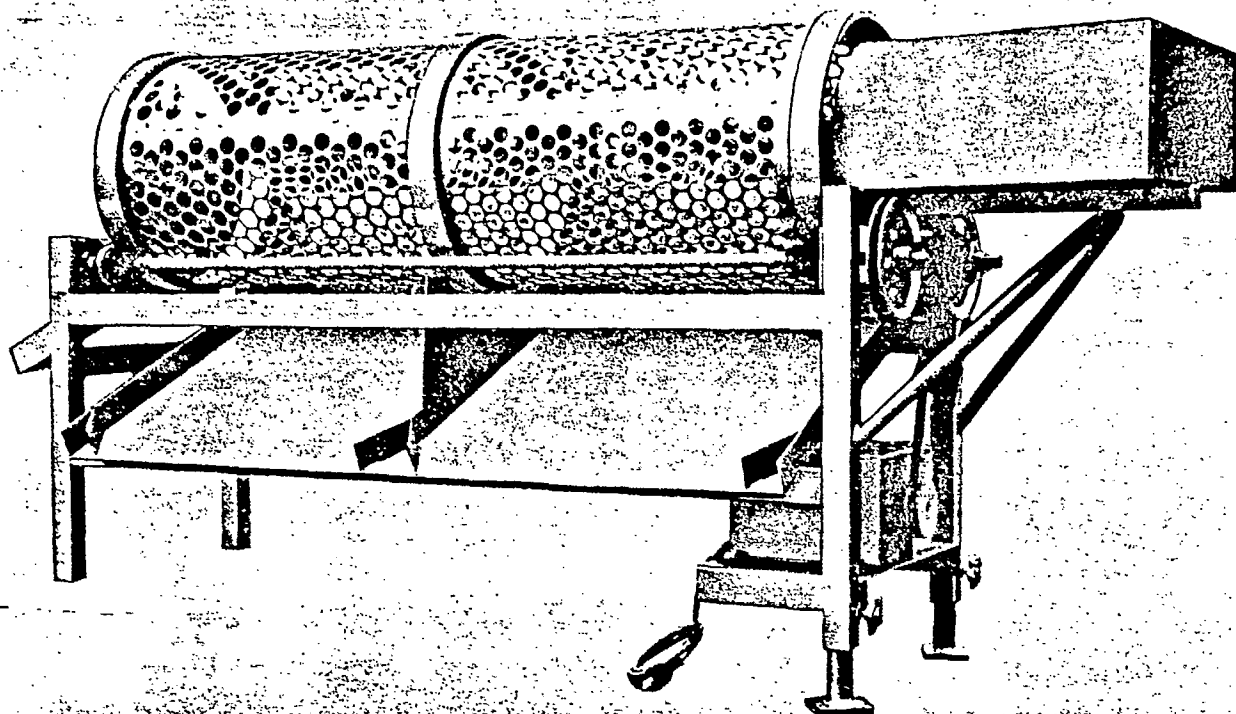
| | | | | | |
|-------------------------------|--------------------|---------|--------------------------|--------------------------------|----------|
| Vehicle weight | 400 kg (no engine) | | Floor board elevation | 508 mm | |
| Maximum load capacity | 500 kg | | Speed * | Forward speed 1 | 1.6 km/h |
| Overall length | 2115 mm | | | speed 2 | 3.5 km/h |
| Overall width | 1555 mm | | | speed 3 | 7.0 km/h |
| Overall height | 1148 mm | | | Reverse speed 1 | 1.6 km/h |
| Inner dimensions of truck box | Length | 1340 mm | Hill-climbing capability | 30° (with 500 kg load) | |
| | Width | 1440 mm | Ground contact pressure | 0.223 kg/cm ² (") | |
| | Height | 450 mm | Engine | 6.5 ps (maximum) | |
| Minimum ground clearance | 110 mm | | Minimum turning radius | 1150 mm | |

* Speed using engine pulley diameter of 5" ϕ for gasoline engine (1,800 rpm) or 4" ϕ for diesel engine (2,200 rpm).

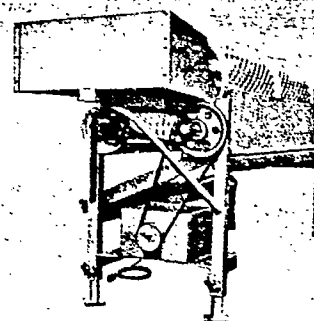
SCALLOP FRY SIZER

(109)

Equipped with 2 drums, providing the largest handling capacity in Japan.



- Large drum: Diameter 39 cm, length 126 cm
- Drum opening: 2.5 cm and 3.0 cm, 3.5 cm and 4.0 cm
Other openings manufactured as desired
- Drum exchange: One touch; takes less than 10 seconds
- Powerful motor: Uses a 200 W, 100 V condenser starter system powerful at starting time
- Motor cover: Made of completely waterproof vinyl leather
- Sizing tilt angle: Unlimited



Structure is simple and trouble-free.

SANWA VEHICLE CO. LTD

- Sendai Branch: 13 Aza Ishida, Kamitanikari, Izumi City, Miyagi Prefecture 981-31
Telephone Sendai 02237(2)2436
- Aomori Office: 77 Aza Kamiuhara, Oaza Harabetsu, Aomori City, Aomori Prefecture 030
Telephone Aomori 0177(36)3025
- Head Office: Tokyo Plant: Saitama

The store with all replacement parts.

IWASA ENTERPRISES CO. LTD.

Hakodate Office: Tel. 41-6746
No. 23, 18 3-chome, Minato-cho, Hakodate City

In step with the fisherman

(110)

Hokkaido Fisheries Association Designated Product

A New Product

(Two patents pending)

Uroko's Shower-type AUTOMATIC SCALLOP CLEANER

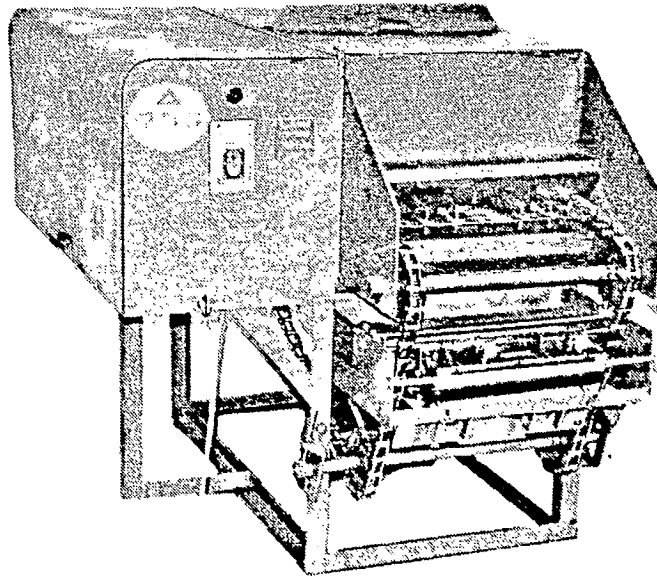
Main parts of stainless make

Specifications

Models: 2 CM (motor-driven)
2 CE (engine-driven)
Capacity: Average 4800/hr (variable speed)
Power: 3 phase - 200 V - 1.5 KW
(Yanmar model G 25)
Weight: 250 kg
External dimensions: Width 85 cm x length
130 cm x height 110 cm
Price: 400,000 - 700,000 yen
Life: 20 years

Features

1. Does not select size of shells.
2. Does not damage edge of shells.
3. Can completely remove all types of attached substances.
4. Shells and removed substances are completely separated.
5. Removal process is done instantaneously so that no dead scallops occur.
6. Noise during operation is low.



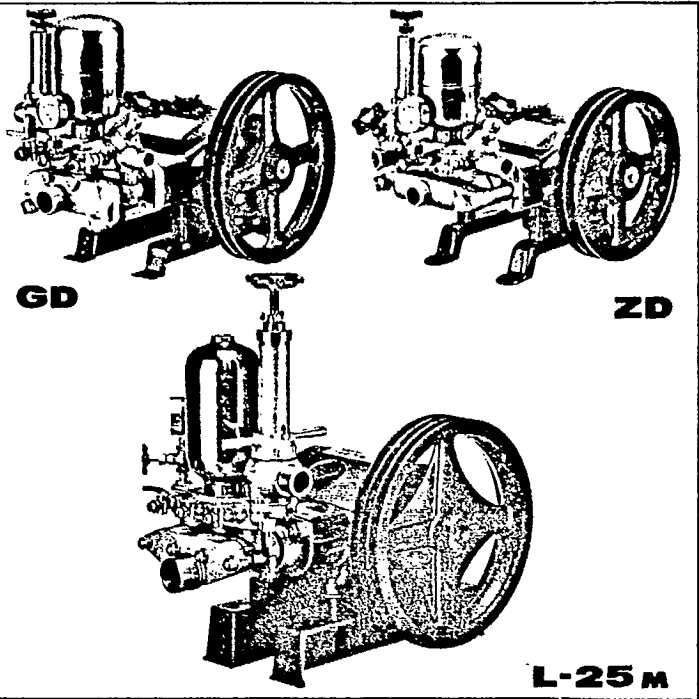
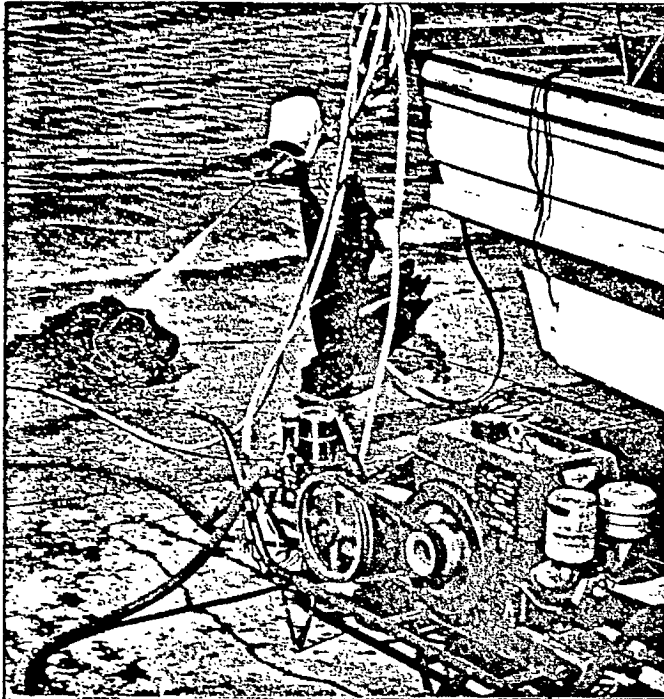
General Sales Agent: Uroko Hakodate Net-Making and Boat Equipment Co. Ltd.
14-17 Suehiro-cho, Hakodate City
Tel (0138) 22-3131

Manufacturer: Hokuho Machinery Co. Ltd.
13-3 Oiwake-cho, Hakodate City
Tel (0138) 41-4268

Yanmar marches with the sun
towards energy-saving agriculture.

SEA-WATER POWER SPRAYER

Cleaner ZD, GD, L-25M



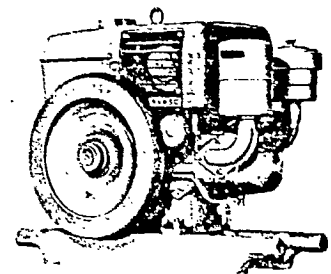
SUMMARY

¥143,500 ¥175,200

| Model | | Cleaner ZF | Cleaner GF | L-25M | | | |
|---|--------------------------------|------------|------------|----------|-----|-----|-----|
| Chassis dimensions | Overall length (mm) | 444 | 510 | 626 | | | |
| | Overall width (mm) | 324 | 342 | 444 | | | |
| | Overall height (mm) | 385 | 412 | 666 | | | |
| Weight (kg) | | 17.8 | 26.7 | 83 | | | |
| Plunger | Number (series) | 3 | 3 | 3 | | | |
| | Diameter (φ mm) | 30 | 34 | 40 | | | |
| | Stroke (mm) | 25 | 38 | 41 | | | |
| Discharge capacity | Pressure (kg/cm ²) | 40 | 30 | 40 | 30 | | |
| | Rotation speed (rpm) | 600 | 800 | 600 | 800 | 450 | 600 |
| | Displacement (L/min) | 31 | 42 | 60 | 80 | 69 | 92 |
| Maximum used pressure (kg/cm ²) | | 40 | 40 | 40 | | | |
| Required horsepower (PS) | | 4 | 7 | 9 | | | |
| Discharge aperture x no. (φ x no.) | | 16 φ x 2 | 16 φ x 2 | 16 φ x 3 | | | |
| Main axle pulley diameter (φ mm) | | 250 | 305 | 380 | | | |
| Main axle V-belt type x no. (no.) | | B x 2 | B x 2 | B x 3 | | | |
| Suction joint diameter (φ mm) | | 1 inch | 1¼ inch | 1½ inch | | | |
| Lubricant capacity (L) | | 1.5 | 2.2 | 3.5 | | | |

Let a Yanmar diesel engine which excels in horsepower, economy and durability be the motor!

Please use as a set with the engine.



Due to improvements, etc., the specifications may change without notice. The suction hose is not involved.

YANMAR FARM MACHINERY CO. LTD.

Head Office: No. 62 Chaya-machi, Kita-ku, Osaka City

Branches: Sapporo, Sendai, Tokyo, Kanazawa, Nagoya, Osaka, Okayama, Takamatsu, Hiroshima, Fukuoka

Office: Nagaoka

- c) Dealers and manufacturers of scallop culture machinery (112)
1. Tether-intake roller (cultivation purpose broadside roller)
Sawada Iron Works, 2-1 Aza Hiratsuka, Oaza Okuuchi, Aomori City
 2. Scallop culture baskets, various ropes and floats
Uroko Hakodate Net-Making and Boat Equipment Co. Ltd.
14-17 Suehiro-cho, Hakodate City. Tel 0138-22-3131
Sukiya Rope Materials Co. Ltd.
9-15-3 Matsubara, Aomori City. Tel 0177-76-4864
Kami Fishnet Co. Ltd. Toiya-machi, Aomori City. Tel 0177-38-4411
 3. Shell cleaner, basket washer
Aomori Cultivation Equipment Co. Ltd.
23-1-1 Yasukata, Aomori City. Tel 0177-22-2481, 0177-23-1021
Terashima Enterprises Co. Ltd.
36-29 Kameta Honmachi, Hakodate City. Tel 0138-43-3271, 0138-41-1709
Iwasa Enterprises Co. Ltd.
32-18-3 Minato-cho, Hakodate City. Tel 0138-41-6746
 4. Truck
Sanwa Vehicle Co. Ltd.
571 Negishi, Sayama City, Saitama Prefecture. Tel 0429-52-7151
 5. Basket washer
Yanmar Farm Machinery Co. Ltd. 62 Chaya-machi, Kita-ku, Osaka City.
 6. Shell cleaner
Hokuho Machinery Co. Ltd. 13-3 Oiwake-cho, Hakodate City. Tel 0138-48-4268
 7. Shell sizer
Sanwa Vehicle Co. Ltd. Sendai Branch Tel 02237-2-2436
13 Aza Ishida, Tanikari, Izumi City, Miyagi Prefecture.
 8. Floats
Sanshin Chemical Industry Co. Ltd. Kanda Shambi Building,
1-8-2 Sakuma-cho, Kanda, Chiyoda-ku, Tokyo City. Tel 03-861-4331

9. Management Aspects

A. Sales and distribution flow

Harvesting and shipment by the cultivators in the Mori district are not done seasonally but are carried out throughout the year, and twice a month on the 15th and 29th which have been fixed as harvesting days, shipments are made to the union.

The Fisheries Cooperative Union collects the harvests of the union members and sells them in bulk at the market owned by the union.

Price determination is by tender, with the shippers and processors carrying out bidding twice a month on the 10th and 25th. After each successful bid, the deliveries are made at that price for a half-month following the bidding day.

In contrast to the practice in Aomori whereby the producer representatives and processor representatives get together under the auspices of the Prefectural Fisheries Association at the end of each month to carry out the bidding for the following month's shipment, at Mori the price is determined every half-month.

Since the successful bidders do not necessarily take delivery of the entire volume of shipment, the left-over portion is put up for bid among the unsuccessful bidders each time and sold.

The sales commission for the union is 4.5% of the amount of sales, so the net amount after this is deducted becomes the net income for the producing fishermen.

The distribution flow down to the consumer of the scallops produced in Hokkaido is as shown in Fig. VI-21.

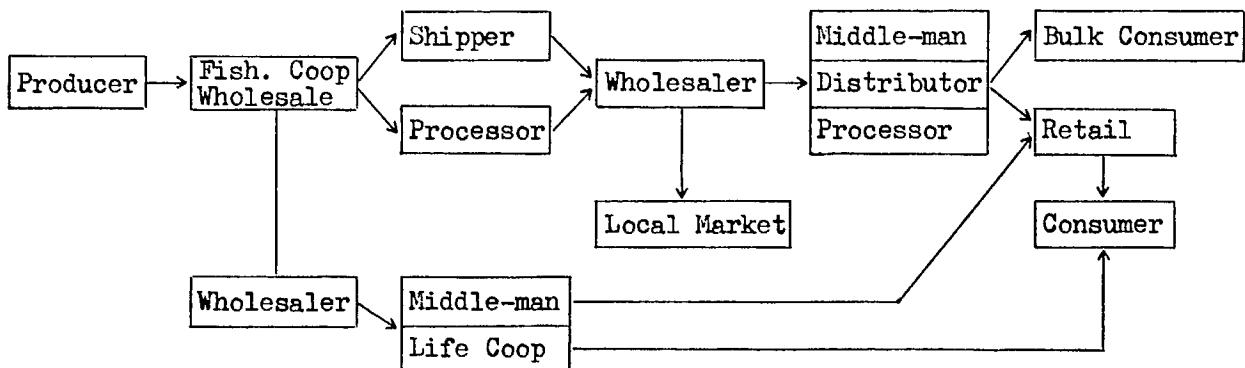


Fig. VI-21. Distribution flow of fresh scallops

While the prices at the consumers' market are as shown in Tables III-5 and 6, (114) the producers' prices in terms of the yearly averages transacted by the Mori Fisheries Cooperative Union are as shown in Table VI-8.

Table VI-8. Scallop sales prices transacted by the Mori Fisheries Cooperative Union (yen per kg)

| Year | Shucked scallops | Scallops in shell | Mid-growth scallops | Fry (per piece) |
|-----------------|------------------|-------------------|---------------------|-----------------|
| Apr 75 - Mar 76 | 742.11 | 246.04 | 254.14 | 1.57 |
| Apr 74 - Mar 75 | 634.90 | 211.75 | 242.75 | 1.91 |

Source: Mori Fisheries Cooperative Union Business Report

Note: Fry refers to the sales price for transplantation-purpose seedlings.

The price ceiling for the processors to purchase scallops for processing is 340 yen per kg in the case of boiled canning, with the desired price being 300 yen or less. While the frozen products of boiled scallops with ovaries are for export, the price ceiling for this raw material is said to be 210 yen per kg, which at present is impossible to produce. (Study by the Mori Plant of Nichiro Fisheries.)

B. Price of machinery and equipment (1976 survey)

1. Onion bag 30 yen each
2. Cushion basket (pearl net)
 - 3 mm mesh 100 yen each
 - 4.5 mm mesh 80 yen each
 - 6 mm mesh 75 yen each
 - 9 mm mesh 78 yen each (for winter use)
3. Round basket (lantern basket)
 - 12 - 15 mm mesh 1,200 yen each (with 10 layers)
 - 12 - 15 mm mesh 1,700 yen each (with 15 layers)
 - 21 mm mesh 1,300 yen each (with 10 layers)
 - 30 mm mesh 1,400 yen each

4. Mansion basket (substitute for 30 mm mesh round basket)

400 yen each (with 10 cubicles)



The scallops are placed upright individually in each cubicle, and normally 10 layers of these are stacked and used in place of a 30 mm mesh round basket.

The life span of the foregoing baskets for tax purposes is three years, but (115) in actual practice their useful life is anywhere from three years up to 10 years.

5. Resistance board (Hypanel foam H.Z. board)

33 cm x 33 cm x 1.2 cm

800 yen each

6. For ear-hanging

Vinyl chloride-coated wire #12 (3.2 mm) 3 yen apiece (life 2-3 years)

Stainless wire #16-18 (soft) 3 yen apiece (")

7. Seedling sizing sieve

Stainless wire mesh on wooden frame 2,500 - 4,000 yen apiece

(both 3 mm and 6 mm mesh)

8. ABC float

Diameter 360 mm 1,800 yen each

300 mm 1,500 yen each

390 mm 2,200 yen each

9. Lytak float Diameter 300 mm 1,700 yen each

10. Trunk rope P.P. rope 22 mm 140 yen per m (life 4 years)

" Dunline rope 26 mm 280 yen per m (")

11. Float rope 30 g (H.Z. 6 mm diameter) 36 yen per m (life 3 years)

12. Tether 30 g (H.Z. 6 mm diameter) 36 yen per m (")

13. Trunk rope P.P. rope 30 mm 173 yen per m (life 4 years)

14. Anchor rope P.P. rope 36 mm 248 yen per m (")

15. Outer frame rope P.P. rope 30 mm 173 yen per m (")

16. Mid-tension rope P.P. rope 24 mm 111 yen per m (life 4 years)

17. Concrete block

| | |
|--------|----------------------------------|
| 3 ton | 19,150 yen apiece (life 4 years) |
| 4 ton | 25,000 yen apiece (") |
| 5 ton | 30,050 yen apiece (") |
| 7 ton | 42,000 yen apiece (") |
| 8 ton | 47,000 yen apiece (") |
| 10 ton | 58,400 yen apiece (") |

(1976 contract bid prices of Kudo Construction Co. Ltd., 90 Aza Tokiwa, Mori Town)

18. Concrete block fittings (116)

| | |
|---------------------------------|---------------------------------------|
| └┘ shaped iron rod 50 mm diam. | 6,600 yen apiece (for 7-10 ton block) |
| Split rings 50 mm diam. | 4,650 yen per set |
| Grand course 36 mm | 2,920 yen each |
| Anchor rope finishing fee 36 mm | 3,440 yen apiece |

(Fee for manufacture and fitting of split rings, grand course and clamp on block)

| | |
|---------------------------------|--------------------------------------|
| └┘ shaped iron rod 44 mm diam. | 4,360 yen (for 5 ton block) |
| Split rings 44 mm (2 pcs) | 3,410 yen per set |
| Grand course 30 mm | 1,750 yen each |
| Anchor rope finishing fee 30 mm | 2,910 yen apiece |
| └┘ shaped iron rod 38 mm diam. | 2,570 yen apiece (for 3-4 ton block) |
| Split rings 38 mm (2 pcs) | 2,540 yen per set |
| Grand course 24 mm | 1,080 yen each |
| Anchor rope finishing fee 24 mm | 2,355 yen apiece |

19. Concrete block emplacement contract fee (1976)

| | |
|-------|------------------|
| 3 ton | 2,745 yen apiece |
| 4 ton | 3,660 yen apiece |

- | | | |
|--------|------------------|--|
| 5 ton | 4,575 yen apiece | |
| 7 ton | 6,405 yen apiece | |
| 8 ton | 7,320 yen apiece | |
| 10 ton | 9,150 yen apiece | |
20. Derrick boom (mini-crane)
(For raising girder ropes and culture baskets)
Hydraulic equipment (with main engine direct-driven hydraulic pump),
vertical drum and plumbing included 2,500,000 yen per set (life 5-7 years)
21. Tether-intake roller (automatic hydraulic type)
20,000 - 50,000 yen per unit (life 5-10 years)
22. Net-washing sea-water power sprayer
150,000 - 180,000 yen per unit (life 3 years)
23. Shell cleaner 400,000 - 700,000 yen per unit (life 20 years)
24. Scallop sizer (with 100 V, $\frac{1}{4}$ h.p. motor) 150,000 yen per unit
25. Boat winding winch (7 h.p.) 320,000 yen per unit
26. Sea-water pump (3 h.p.) 350,000 yen per unit (life 2 years)
27. Truck 870,000 - 1,160,000 yen per unit
28. Workshop-warehouse (without land) 120,000 - 130,000 yen per tsubo
(1 tsubo = 3,305 m²)
29. Concrete water tank 80,000 - 90,000 yen per unit (117)
(2.73 m x 2.73 m x 0.85 m excluding water pipes)
30. Air pump per unit
31. For scallop culture
F.R.P. fishing boat, 3 ton model 10 - 12 million yen per boat
(Complete with mini-crane and other equipment) (life 2 years)
While the life span as a fishing boat is around five years, because of
extremely rapid advances in fishing boats they become out-dated and
new boats get purchased in about two years.

32. Labour costs (1976)

| | |
|--|-----------------------|
| Wages of hired labourers per 10-hour day | 150,000 yen per male |
| | 70,000 yen per female |
| Temporarily hired females on hourly pay | 300 yen per hour |

C. Cost of materials for each seedling collection facility

The seedling collection facility is laid out to collect seedlings in June, and at the same time that seedling collection gets completed in July it carries on being used for the suspension of cushion baskets for intermediate breeding until September, upon completion of which at the end of September it is dismantled.

Assuming a goal of one million seedlings, including 700,000 seedlings of 6 mm or more, the required materials are as listed below.

| | |
|---|---------------|
| Onion bags - assuming 2,000 seedlings collected per bag | 500 bags |
| Cushion baskets, 3 mm mesh - to accommodate 1,000,000 seedlings | |
| at 2,000 per basket | 500 baskets |
| " 6 mm mesh - to accommodate 700,000 seedlings | |
| at 500 per basket | 1,400 baskets |
| Onion bag suspension ropes, 6 mm, 10 m in length | |
| To suspend 500 bags at 15 bags per rope | 35 pieces |
| Cushion basket suspension ropes, 6 mm, 5 m in length | |
| To suspend 1,400 baskets at 15 baskets per rope | 95 pieces |
| Float ropes, 6 mm, 7 m in length | |
| One per 12 m interval on a 60 m trunk rope | 6 pieces |

The structure of a facility based on the foregoing is depicted in Fig. VI-22, with the required materials and material costs being listed in Table VI-9.

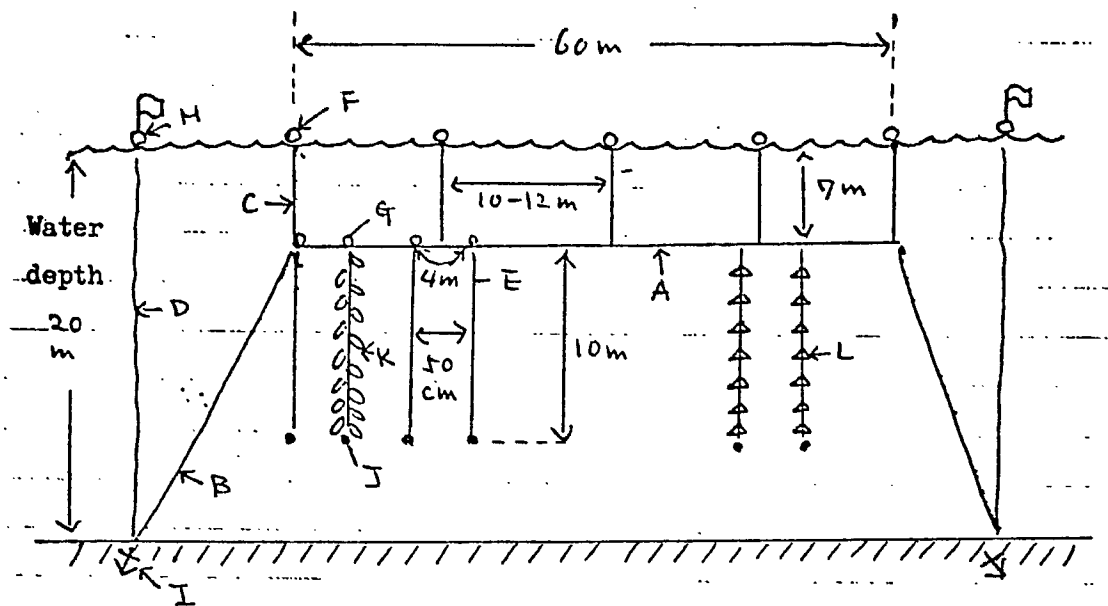


Fig. VI-22. Structure of seedling collection facility

Table VI-9. Cost of materials for seedling collection facility

| Item | Size | Quantity | Unit price (yen) | Total price (yen) | Durable life (yrs) | Annualized cost (yen) | Remarks |
|-------------------|-------------|----------|------------------|-------------------|--------------------|-----------------------|----------------------|
| A Trunk rope | 18 mm diam. | 60 m | 65 | 3,900 | 5 | 780 | Based on 1976 prices |
| B Anchor rope | " | 60 m | 65 | 3,900 | 5 | 780 | |
| C Float rope | 6 mm H.Z. | 42 m | 36 | 1,512 | 5 | 302 | |
| D Lead rope | 12 mm H.Z. | 40 m | 70 | 2,800 | 5 | 560 | |
| E Suspension rope | 6 mm H.Z. | 350 m | 36 | 30,700 | 3 | 91,800 | |
| F Float | 30 cm diam. | 6 | 1,500 | 9,000 | 5 | 1,800 | |
| G Intermed. float | 36 cm diam. | 15 | 1,800 | 27,000 | 5 | 5,400 | |
| H Lead float | 24 cm diam. | 2 | 460 | 920 | 5 | 184 | |
| I Anchor | 40 kg | 2 | 16,000 | 32,000 | 5 | 6,400 | |
| J Sinker | 1 kg | 1400 | 5 | 7,000 | 5 | 1,400 | |
| K Onion bag | | 500 | 30 | 15,000 | 3 | 5,000 | |
| L Pearl net | 3 mm mesh | 500 | 100 | 50,000 | 3 | 16,670 | |
| " | 6 mm mesh | 1400 | 75 | 105,000 | 3 | 35,000 | |
| Total | | | | 288,632 | | 166,076 | |

Supposing that the ultimate volume of collected seedlings based on the above facility, taking into account the sizing process and yield rate, is approximately one-third of the one million collected fry or 350,000, then the cost of materials per seedling figures out to be $166,076 \text{ yen} \div 350,000 = 0.47 \text{ yen}$.

Since seedling production involves everything from the commencement of preparations for seedling collection in May, layout of the seedling collection facility, collection of fry and various processes such as sizing, thinning, basket exchange, etc., which last until the end of September, the production cost for such seedlings must necessarily include the cost of labour for this period and the depreciation cost of the various machinery and equipment needed for work. Looked at in this way, the fact that the sale price of transplantation-purpose seedlings (first fry) grown to around 2.5 cm in size by early November was 1.80 yen apiece in 1975, is surmised to be generally appropriate as prices go. (119)

Table VI-10. Cost of materials (trial balance) per unit of regular scallop culture facility --- Unit price: 1976 price

| Item | Size | Quantity | Unit price (yen) | Total price (yen) | Remarks |
|----------------|--|----------|------------------|-------------------|------------------|
| Trunk rope | 26 mm Dunline | 125 m | 280 | 35,000 | 40 m water depth |
| Anchor rope | " | 210 m | 280 | 58,800 | |
| Float rope | 30 g (6 mm) | 200 m | 36 | 7,200 | 2 m x 100 pieces |
| Float | 30 cm diameter | 30 | 1,300 | 39,000 | |
| " | 36 cm diameter | 50 | 1,800 | 90,000 | |
| Cushion basket | 3 mm mesh | 500 | 100 | 50,000 | |
| " | 6 mm mesh | 500 | 80 | 40,000 | |
| Round basket | 12-15 mm mesh | 50 | 1,200 | 60,000 | |
| " | 21 mm mesh | 100 | 1,300 | 130,000 | |
| Concrete block | 5 ton (emplacement fee included) | 2 | 45,000 | 90,000 | |
| Tether | H.Z. 6 mm (30 g) | 600 m | | 21,600 | |
| Total | | | | 621,600 | |

Note: Anchor rope is twice the water depth.

D. Cost of materials and production level (standard) per unit of culture facility (120 m)

While some of the fry collected as seedlings in early November are sold for transplantation purposes, the rest are suspended in the culture facility for breeding as mid-growth scallops and subjected to regular culture for shipment as second-year or third-year scallops. The cost of materials for the facility for this regular culture is as shown in Table VI-10.

Given a durable life of three years, the annualized cost is (120)

$$621,600 \div 3 = 207,200 \text{ yen.}$$

The girder rope layout materials cost exclusive of the cushion baskets and round baskets is 320,000 yen. The annualized materials cost per 120 m unit is

$$320,000 \div 3 = 106,666 \text{ yen.}$$

The corresponding production level and sales value are as shown in Table VI-11.

Table VI-11. Production level and corresponding sales value (trial balance) per unit of scallop culture facility (120 m)

| June - September Seedling collection | Standard per unit | | Scallop sales (yen) | | | Remarks |
|---|-------------------------------|---------------------------|---------------------|------------------------|------------------|---------------------------------|
| | Holding basket | Quantity | Volume | Unit price (apiece) | Value (yen) | |
| October - April Seedling breeding | Cushion basket 3-6 mm mesh | 200 x 100 sets 200,000 | 100,000 | 1.70 | 170,000 | Some sold as seedlings |
| May - October | Round basket 12-15 mm mesh | 100 x 10 x 100 100,000 | 75,000 | 6.00 | 450,000 | Some sold as seedlings |
| Nov - Next Mar-Apr | Round basket 21 mm mesh | 25 x 10 x 100 25,000 | 10,000 | 25.000 | 250,000 | Sold as mid- growth scallops |
| Regular culture | | 15 x 10 x 100 15,000 | 15,000 | 40.000 | 600,000 | |
| Total | | | | | 1,470,000 | |

Note: Sale price of mature scallops is 1976 agreed price.

Since the total value is the sales value for 3 years or 2.5 years, the annualized sales value becomes

$$1,470,000 \div 3 = 490,000 \text{ yen (for 3 years)}$$

$$1,470,000 \div 2.5 = 588,000 \text{ yen (for 2.5 years)}$$

Deducting the cost of materials from the sales value, the gross income is
 $588,000 - 207,200 = 380,800$ yen.

The actual income would be this gross income less the cost of labour, boat depreciation, the depreciation on various shore facilities, machinery and equipment, electricity costs and fuel costs, etc., but this computation is difficult. However, with the gross income being 1.8 times the materials cost, a sizable net profit is surmised to emerge.

E. Layout cost of girder rope (regular culture facility) (121)

The girder rope is not laid out by each individual fisherman alone, but is laid out as a joint operation of the union members within each community affiliated with the union. This is in consideration of the efficient use of the designated joint fishing rights area owned by the union as well as the fair distribution to union members of the rights to use the girder ropes.

This girder rope layout cost and the materials cost are borne collectively by the union, and subsequently collected from each union member according to the amount of girder rope allocated.

In this way, the layout cost of the girder rope varies among communities even within the same union because of different fishing ground conditions, but as an example the cost breakdown for the Oshironai community in Mori Town is shown in Table VI-12. However, this does not include the cost of labour nor the boat rental.

Looking at Table VI-12, the annualized materials cost per 300 m unit of girder rope comes to 116,050 yen, and comparing this with the annualized materials cost of 106,666 yen for an individual layout of a 120 m unit of girder rope as computed in Table VI-10, there is not much difference in the materials cost despite the fact that the girder rope length of the former is more than twice that of the latter. This indicates the fact that by intensive layout of the girder rope, the cost of materials can be saved by approximately one-half.

Table VI-12. Girder rope layout cost in the Oshironai district (1976)

Represents cost of materials required in laying out 74 units of girder rope with a length per unit of 300 m.

| Item | Item name | Size | Quantity | Unit price (yen) | Total price (yen) | Remarks |
|------------------|--------------------|--------|----------|------------------|-------------------|---|
| Anchor | Concrete block | 10 ton | 172 | 58,400 | 10,044,800 | Manufacturing cost |
| " | " | 8 ton | 18 | 47,000 | 846,000 | " |
| " | " | 10 ton | 172 | 9,150 | 1,573,800 | Emplacement cost |
| " | " | 8 ton | 18 | 7,320 | 131,760 | " |
| Trunk rope | P.P. rope | 30 mm | 22,496 m | 173 | 3,891,808 | 304 m x 74 pieces |
| Anchor rope | " | 36 mm | 38,760 m | 248 | 9,612,480 | 204 m x 190 pieces |
| Outer frame rope | " | 30 mm | 7,598 m | 173 | 1,314,454 | 304m x 6, 939m x 2 974m x 4 |
| Mid-tension rope | " | 24 mm | 8,661 m | 111 | 961,371 | 974m x 6, 939m x 3 |
| Metal fitting | └┘ shaped iron rod | 50 mm | 190 | 6,600 | 1,254,000 | |
| " | Split rings | 50 mm | 190 sets | 4,650 | 883,500 | |
| " | Grand course | 36 mm | 190 | 2,920 | 554,800 | |
| Float | ABS float | 36 cm | 1,080 | 1,550 | 1,674,000 | Attachment cost (manufacturing cost) of block split rings, grand course, clamp |
| " | " | 39 cm | 444 | 2,150 | 954,600 | |
| Anchor rope | Finishing fee | 36 mm | 190 | 3,440 | 653,600 | |
| Total | | | | | 34,350,973 | |
| Average per unit | | | | | 464,202 | |

The durable life for tax purposes being four years, the annualized cost per unit (300 m) is 116,050 yen. In actual fact, however, the durable life varies depending on the item.

Table VI-13. Comparison of girder rope layout materials cost by community affiliated with the Mori Fisheries Cooperative Union (1976)

(122)

| Community | | Total cost (yen) | Cost per unit (yen) | Annualized cost per unit (yen) |
|------------|----------------|------------------|---------------------|--------------------------------|
| Oshironai | 300 m 74 units | 34,350,973 | 464,202 | 116,050 |
| Minato-cho | 300 m 25 " | 11,172,048 | 446,882 | 111,720 |
| Arakawa | 300 m 29 " | 11,126,782 | 383,682 | 95,920 |
| Shimazaki | 300 m 26 " | 6,632,652 | 255,102 | 63,775 |
| Ebitani | 300 m 26 " | 7,724,127 | 297,082 | 74,270 |
| Honkayabe | 150 m 24 " | 3,108,480 | 129,520 | 32,380 |
| Ishikura | 150 m 42 " | 5,662,224 | 134,815 | 33,703 |

Annualized cost was computed using a durable life of four years.

Source: Northern Oshima District Fisheries Improvement Propagation Centre.

While there are considerable differences in the girder rope layout cost among communities as shown in Table VI-13, this is due to variations in the fishing ground conditions, the design of the girder rope layout and the degree of intensification involved.

As is clear from Table VI-13, the materials cost per unit of girder rope (300 m) varies according to the community from approximately 250,000 yen to almost double that or 460,000 yen. The reason for this is attributable to variations in the required materials owing to differences in water depth at the layout grounds and tidal current conditions as well as differences in the layout scale, and under such circumstances it is difficult to estimate a standard materials cost for the girder rope layout. It is nevertheless clear that by undertaking intensive layout as shown in Fig. VI-14, a considerable cost saving can be achieved over solo layouts by individual fishermen.

F. Management pattern of culture fishermen

(123)

Apart from the wide variation between communities in the layout cost of girder ropes as mentioned above, the various shore facilities (such as warehouse, workshop, water tank, etc.) and machinery and equipment (net washer, shell cleaner, truck, etc.) owned by the fishermen also vary according to their scale of operation and production level, so that it is difficult to standardize the relationship between production and cost.

Nevertheless, if we look at the management pattern of fishermen classified into three levels of scale - large, medium and small - in the five unions of Sunahara, Mori, Otoshibe, Yakumo and Oshamanbe, we get the results shown in Table VI-14. Looking at this, the following five points become clear.

- 1) The facility cost per unit of culture facility (girder rope) varies with the union.
- 2) The proportion of disbursed costs to total sales value (cost ratio) is generally within a certain range regardless of the size of the scale of

management, ranging from a minimum of 58% to a maximum of 65%.

- 3) Even large-scale operations do not necessarily bring about reduced costs or higher profit ratios.
- 4) The production level per unit of girder rope varies, irrespective of the magnitude of the scale of management, from a minimum of 922 kg to a maximum of 3,813 kg, a variation of more than four times.
- 5) The operating cost per unit of girder rope varies widely from a minimum of 35,000 yen to a maximum of 471,000 yen, a 13-fold variation.

Looking now at the relationship between the production level per unit of girder rope and its operating cost, as shown in Fig. VI-23, the two are found to be in direct proportion, whereby if the operating cost is increased by 100,000 yen the production level may be surmised to increase by 700 kg.

The make-up of this operating cost includes all costs except the girder rope facility cost (including materials cost and layout cost), and taking the median case of 160,000 yen, it consists of:

| | |
|----------------|-------------------------------------|
| Fuel cost | 13.5% |
| Repair cost | 15.2% (boats, baskets, etc.) |
| Marketing cost | 16.9% (boxes, transportation, etc.) |
| Utilities cost | 7.4% |
| Personnel cost | 45.7% |
| Fishing fee | 1.2% (paid to union). |

As long as the operating cost and production level are in direct proportion, however, (124) any incurrence of operating cost should mean an increase in the number of suspension baskets required for increased production and an increase in various incidental costs. Therefore, any increase in operating cost referred to here may be deemed to signify an increase in the number of cultivated scallops per unit of girder rope.

Trying now to ascertain from Fig. VI-23 the limit of possible increase in operating cost which would be reflected in an increase in production level, the limit

cannot be ascertained in this figure, but up to about 500,000 yen or so the production does not seem to fall off. In other words, up to this level, the sales value increases by 175,000 yen for every 100,000 yen increase in operating cost, resulting in a net profit increase of 75,000 yen. (As shown in Table VI-8, if scallops in the shell are assumed to be worth 250 yen per kg, then 700 kg comes to 175,000 yen.)

From this fact, for efficient utilization of girder ropes, it is surmised that the incurrence of up to about 500,000 yen in operating cost is necessary.

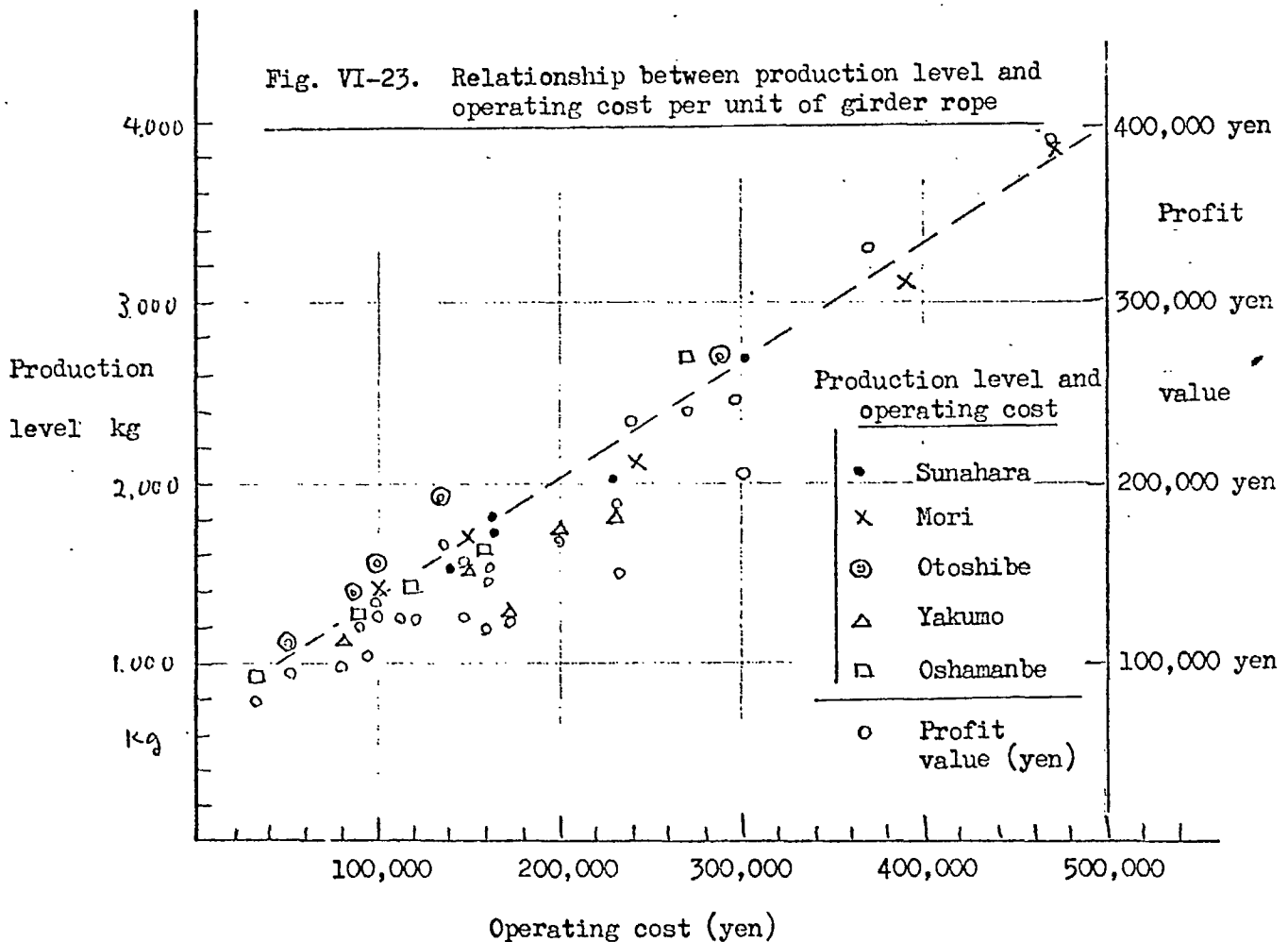


Table VI-14. 1975 scallop fishermen management survey (April 1975 - March 1976)

| Name of union | Scale | Number of families | No. of workers | | Production volume | | Production value | | Number of culture facilities | Cost per unit | Total cost of culture facility | Culture facil. deprec. | Operating cost | | Dis-bursed cost | Profit | | Prod'n per person | Cost ratio | Profit ratio |
|--------------------------|----------------------|--------------------|------------------|------------|-------------------|----------|------------------|-------------|------------------------------|---------------|--------------------------------|------------------------|----------------|-----------|-----------------|-------------|-----------|-------------------|------------|--------------|
| | | | Family | Hired | Total vol. | Per unit | Unit value | Total value | | | | | Total cost | Per unit | | Total value | Per. unit | | | |
| | | | (pers) | (pers) | (kg) | (kg) | kg/¥ | 1,000 ¥ | | | | | (1,000 ¥) | (1,000 ¥) | | 1/2 (A) | (B) | | | |
| Sunahara Fisheries Coop. | A | 6 | Male 2 Fem. 1 | M 1 F 2 | 53704 | 1993 | 210 | 11,344 | 30 | 363 | 10,290 | 2,170 | 4056 | 162 | 7034 | 4310 | 144 | 10,756 | 62 | 38 |
| | A | 6 | M 2 F 2 | F 3 | 41,011 | 2,734 | 210 | 8,621 | 15 | " | 4,445 | 1,009 | 4515 | 301 | 5,604 | 3,017 | 201 | 8,202 | 65 | 35 |
| | B | 6 | M 2 F 1 | F 2 | 30,096 | 2,006 | 245 | 7,402 | 15 | " | " | " | 3501 | 233 | 4590 | 2,812 | 187 | 7,524 | 62 | 38 |
| | B | 7 | M 1 F 1 | M 1 F 2 | 22,488 | 1,499 | 209 | 4,712 | 15 | " | " | " | 1,789 | 119 | 2,078 | 1,834 | 122 | 7,496 | 60 | 40 |
| | C | 10 | M 1 F 1 | F 2 | 26,150 | 1,744 | 218 | 5,720 | 15 | " | " | " | 2,458 | 164 | 3,547 | 2,173 | 145 | 8,719 | 62 | 38 |
| | Mori Fisheries Coop. | A | 2 | M 1 F 1 | M 3 F 3 | 60,633 | 3,813 | 245 | 16,833 | 18 | 356 | 6,413 | 1,283 | 8,481 | 471 | 9,764 | 7,069 | 342 | 13,727 | 58 |
| A | | 6 | M 1 F 1 | M 1 F 2 | 56,403 | 3,136 | 249 | 14,017 | 18 | " | " | " | 6,707 | 373 | 7,490 | 6,027 | 335 | 14,100 | 57 | 43 |
| B | | 5 | M 3 F 3 | O | 33,298 | 2,120 | 247 | 8,208 | 15 | " | 5,344 | 1,068 | 3,611 | 241 | 4,679 | 3,529 | 235 | 8,325 | 57 | 43 |
| B | | 10 | M 1 F 1 | F 2 | 25,557 | 1,704 | 216 | 5,528 | 15 | " | " | " | 2,249 | 150 | 3,317 | 2,211 | 147 | 8,519 | 60 | 40 |
| C | | 2 | M 1 F 1 | O | 8,453 | 1,409 | 209 | 1,764 | 6 | " | 2,138 | 423 | 601 | 100 | 1,024 | 740 | 123 | 4,229 | 58 | 42 |
| Otoshibe Fisheries Coop. | | A | 4 | M 1 F 1 | F 2 | 54,131 | 2,707 | 237 | 12,805 | 20 | 506 | 10,000 | 2,000 | 5,940 | 247 | 7,440 | 4,865 | 243 | 13,533 | 62 |
| | A | 4 | M 1 F 1 | F 2 | 47,913 | 1,917 | 220 | 10,540 | 25 | " | 15,100 | 3,000 | 3,430 | 137 | 6,430 | 4,110 | 164 | 15,971 | 61 | 39 |
| | B | 3 | M 1 F 1 | F 2 | 39,267 | 1,571 | 226 | 8,872 | 25 | " | 15,000 | 3,000 | 2,501 | 100 | 5,501 | 3,371 | 135 | 13,267 | 62 | 38 |
| | B | 8 | M 2 F 1 | F 1 | 26,991 | 1,099 | 225 | 4,447 | 20 | " | 10,000 | 2,000 | 1,068 | 53 | 3,068 | 1,879 | 94 | 1,597 | 62 | 38 |
| | C | 3 | M 1 F 1 | F 2 | 13,934 | 1,393 | 224 | 3,119 | 10 | " | 5,000 | 1,000 | 903 | 90 | 1,903 | 1,216 | 121 | 4,644 | 61 | 39 |
| | | | | | | | | | | | | | | | | | | | | |

| Name of union | Scale | Number of families | No. of workers | | Production volume | | Production value | | Number of culture facilities | Cost per unit | Total cost of culture facility | Culture of culture facil. denrec. | Operating cost | | Dis-bursed cost | Profit | | Prod'n per person | Cost ratio | Profit ratio |
|---------------------------|-------|--------------------|----------------|--------|-------------------|----------|------------------|-------------|------------------------------|---------------|--------------------------------|-----------------------------------|----------------|----------|-----------------|-------------|------------|-------------------|------------|--------------|
| | | | Family | Hired | Total vol. | Per unit | Unit value | Total value | | | | | Total cost | Per unit | | Total value | Per unit | | | |
| | | | (pers) | (pers) | (kg) | (kg) | kg/¥ | (1,000¥) | | | | | (1,000¥) | (1,000¥) | | 1/5 (A) | (B) 1,000¥ | | | |
| Yakumo Fisheries Coop. | A | 6 | M | 2 | 46,981 | 1,176 | 205 | 9,648 | 40 | 316 | 12,640 | 2,528 | 3,165 | 79 | 5,693 | 3,955 | 99 | 7,830 | 59 | 41 |
| | | | F | 3 | | | | | | | | | | | | | | | | |
| | A | 8 | M | 1 | 14,236 | 1,736 | 243 | 15,622 | 37 | " | 10,427 | 2,086 | 7,444 | 201 | 9,530 | 6,092 | 165 | 14,059 | 61 | 39 |
| | | | F | 1 | | | | | | | | | | | | | | | | |
| | B | 5 | M | 1 | 36,952 | 1,760 | 218 | 8,052 | 21 | " | 6,136 | 1,327 | 4,993 | 237 | 3,059 | 3,059 | 146 | 12,317 | 62 | 38 |
| | | | F | 1 | | | | | | | | | | | | | | | | |
| | B | 7 | M | 1 | 47,883 | 1,228 | 236 | 11,297 | 39 | " | 12,224 | 2,464 | 6,892 | 177 | 4,405 | 4,405 | 113 | 15,961 | 61 | 39 |
| | | | F | 1 | | | | | | | | | | | | | | | | |
| | C | 7 | M | 3 | 34,693 | 1,506 | 216 | 7,499 | 23 | " | 4,768 | 993 | 3,524 | 153 | 4,724 | 2,775 | 121 | 6,934 | 63 | 37 |
| | | | F | 2 | | | | | | | | | | | | | | | | |
| Oshamanbe Fisheries Coop. | A | 5 | M | 3 | 161,864 | 1,618 | 230 | 37,177 | 100 | 457 | 45,700 | 9,140 | 16,141 | 161 | 25,281 | 11,896 | 119 | 17,984 | 65 | 35 |
| | | | F | 2 | | | | | | | | | | | | | | | | |
| | A | 9 | M | 2 | 67,566 | 2,702 | 223 | 15,089 | 25 | " | 11,425 | 2,285 | 6,769 | 271 | 9,054 | 6,035 | 241 | 16,892 | 60 | 40 |
| | | | F | 1 | | | | | | | | | | | | | | | | |
| | B | 5 | M | 1 | 28,003 | 1,400 | 230 | 6,440 | 20 | " | 9,40 | 1,825 | 2,356 | 118 | 4,181 | 2,254 | 113 | 14,001 | 65 | 35 |
| | | | F | 1 | | | | | | | | | | | | | | | | |
| | B | 3 | M | 1 | 25,464 | 1,273 | 230 | 5,861 | 20 | " | 9,140 | 1,825 | 1,927 | 96 | 3,752 | 2,109 | 105 | 12,732 | 64 | 36 |
| | | | F | 1 | | | | | | | | | | | | | | | | |
| | C | 6 | M | 1 | 18,440 | 922 | 221 | 4,082 | 20 | " | 9,140 | 1,825 | 706 | 35 | 2,531 | 1,551 | 78 | 9,220 | 62 | 38 |
| | | | F | 1 | | | | | | | | | | | | | | | | |

Source: Hokkaido's Northern Oshima District Fisheries Improvement Propagation Centre

10. Conclusion

(127)

Because the sea environment in Hokkaido's Uchiura Bay is fairly oceanic in characteristic, the scallop culture methodology and management conditions in the Mori district of Uchiura Bay are clearly different from those in Mutsu Bay where it is fully enclosed, even though we may speak of the same suspension-type culture.

The main points may be summarized as follows:

- 1) From the structural aspect of the facilities, to cope with the big waves, deep water depths and rapid tidal currents, the facilities are large-scaled and solidly structured, the girder ropes are heavy and the concrete blocks which anchor them are large-sized.
- 2) As part of the breeding process, in addition to shell sizing and shell cleaning, double-tiered suspension of baskets and the ear-hanging method are employed, with the suspended level of the baskets being deep.
- 3) From the work aspect, the collection of seedlings, basket exchange and all such work are carried out ashore and never done on board as in Mutsu Bay.
- 4) Due to the necessity of shore work, there is a workshop on shore, and associated with this are used a variety of shore facilities, processing machinery and equipment.
- 5) From the operating aspect, the fixed costs go up due to the large-scale facilities and the need for various processing machinery and equipment.

In the event of planning and conducting scallop culture in new areas in the future, considering the difficulty of obtaining waters in an inner bay blessed with such favourable conditions for scallop culture as Mutsu Bay, the culture methodology being followed in Uchiura Bay is thought to be more suitable as a model.

Also, with regard to management, while legally the establishability of zoned fishing rights becomes an indispensable condition, assuming this is possible, then the pattern in Uchiura Bay would again be instrumental in providing the basic reference for the formulation of business plans and revenue and expenditure forecasts.

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