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A GIFT FROM THE SEA

In Japan, a total of about 100,000 tons of natural and cultured scallops are landed every year.
This photograph shows scallops (*Patinopecten yessoensis*) which are being cultivated in baskets. The interior of a long cylindrical net basket is partitioned into several compartments by racks on each of which several scallops are laid and the basket is hung under water. A calm enclosed bay is preferred as the culture ground. The culture basket is thereby kept in a stable state with the effect of waves kept as small as possible with ropes, anchors, floating balls and the like.
Mature larvae of about 300μ shell length are collected, and are reared under artificial control for two or two and a half years until they reach the marketable size of over 11 cm in shell length.
Feeding is not necessary in scallop culture. Since scallop is a filter-feeding mollusc, it grows by feeding on diatoms and protozoans drifting in the water. Therefore, scallop fishery aims to develop the basic productivity of the sea to the highest possible degree, by making best use of the ecological mechanism of the life cycle (i.e., spawning→ development of spat→ growth) just as it proceeds in the natural habitat of scallops. So, this is a typical example of "resources-cultivating type fisheries" harvesting a stock of useful aquatic animals after propagating them effectively.

Un regalo del mar

En Japón, un total de cerca de 10.000 toneladas de veneras cultivadas y naturales son desembarcadas cada año.

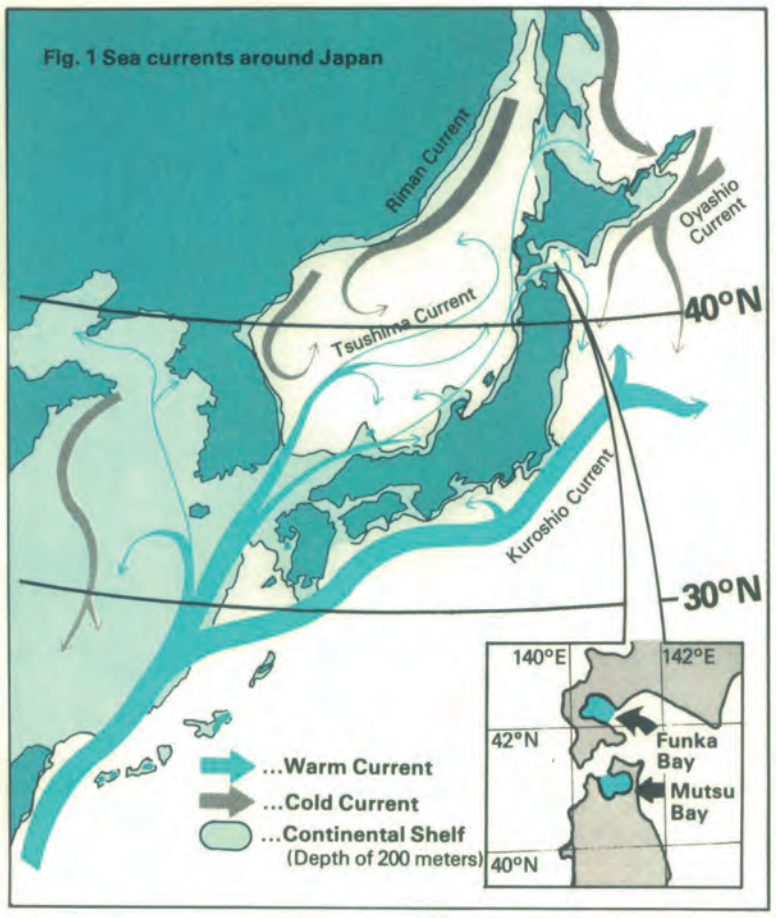
Esta fotografía muestra las veneras (Patinopecten vessoencis) que están siendo cultivadas en una cesta. En interior de la cesta-red cilíndrica está dividida en varios compartimientos por ramblas sobre las cuales varias veneras están tendidas. Esta cesta está suspendida bajo el agua. Una bahía calma y circunvalada es preferible como un campo de cultivo. La cesta cultivadora es guardada en una posición estable de manera que las olas del mar tengan el menor efecto sobre ellas, con cuerdas, anclas, pelotas flotantes y cosas por el estilo.

Un don de la mer

Chaque année la récolte des coquilles St-Jacques, naturelles ou de culture avoisine les 100,000 tonnes au Japon.

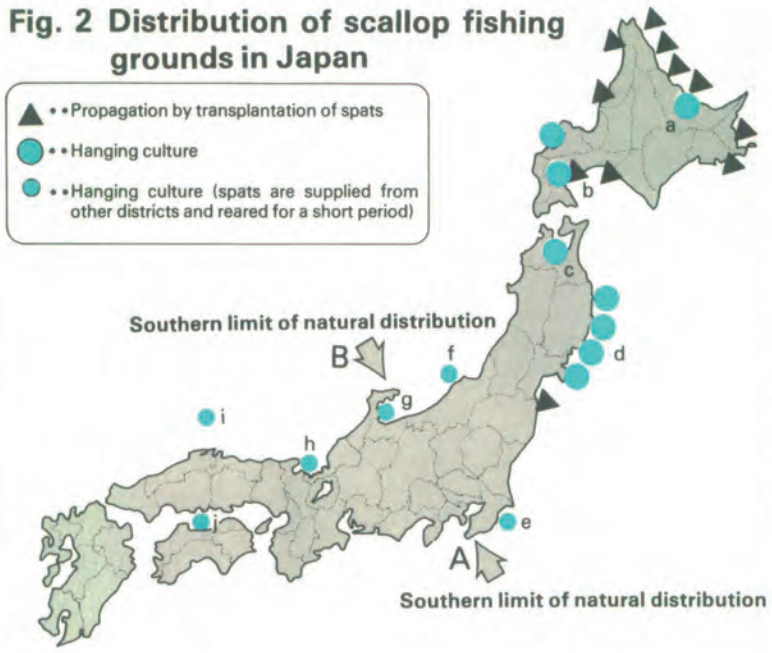
Cette photographie montre des coquilles St-Jacques (Patinopecten, vessoensis) élevées en casier. L'intérieur d'une longue nasse cylindrique en filet est divisée en compartiments par des claies supportant plusieurs coquilles. Cette nasse est alors suspendue dans l'eau, de préférence dans une baie calme et abritée fournissant un milieu favorable à cet élevage. Le mouvement des flots doit affecter le casier le moins possible; sa stabilité est assurée au moyen de cordages, d'ancres, de flotteurs etc...

Fig. 1 Sea currents around Japan



Distribution of scallop fishing grounds in Japan

Fig. 2 Distribution of scallop fishing grounds in Japan



Scallop is a cold-sea bivalve, and its natural breeding places in the Japanese Islands are distributed in (A) the Boso Peninsula and northward on the Pacific coast and (B) Noto Peninsula and northward on the coast of the Sea of Japan. Especially, in the coasts of Hokkaido and Aomori Prefecture (Mutsu Bay), good fishing grounds for catching natural scallops have existed since old times.

Based upon these natural fishing grounds, hanging culture grounds are: (a) Lake Saroma of Hokkaido, (b) Funka Bay, (c) Mutsu Bay, and (d) the coast of Sanriku.

Subsequently, with the development of seed collection and culture techniques, comparatively short-term hanging culture becomes possible by purchasing spats from Hokkaido or Mutsu Bay. Recently, this short-term culture has also been tried in (e) Chiba Prefecture, (f) Niigata Prefecture, (g) Ishikawa Prefecture, (h) Fukui Prefecture, (i) Shimane Prefecture, and (j) Kagawa Prefecture. There is a possibility that the industrial distribution of scallops will expand over the entire southern natural distribution limit in the future.

We shall begin by mentioning the "abnormal outbreak" of scallops.

It has been well known in many places since old times that the catch in scallop fishery fluctuates greatly. For example, in the case of Mutsu Bay, a careful look at the fluctuations in catch during the past several decades reveals that a sudden abnormally large catch of over 10,000 tons was recorded in one year compared to the normal annual catch of about 1,000 tons. In the succeeding several years, large catches far above that of a normal year were recorded, and then the catch finally returned to the level of 1,000 tons or less (Fig. 5).

In this kind of abnormal outbreak season, we can see a phenomenon, in some places, where the shells are piled up on one another. Among fishermen, this phenomenon is known by the expression — "Shells have bred".

"Abnormal outbreak" or "great fluctuations in resources" is a phenomenon frequently seen in many organisms, but its cause is still almost mystery. A rich or poor harvest in scallop fishery was formerly explained by the overcatch theory or cyclic breeding theory. Since the beginning of the 1960's, however, due to a survey of fishing grounds by the bathysphere and research conducted by Dr. Gotaro Yamamoto, the mysteries of the abnormal outbreak of scallop have gradually come to be solved.

"Abnormal Outbreak" Means "Mass Survival"

The ecological mechanism of "abnormal outbreak" is explained by Dr. Yamamoto as follows:

(1) A sexually matured mother shell produces one hundred million eggs at two years of age and about one hundred and fifty million eggs at four years of age. That is, the mother shell originally has a large reproductive potentiality.

(2) Fertilized eggs will develop to larvae. After hatching, the larvae will sink finally to the bottom and begin to lead a "benthic life", after passing through the "planktonic life" and "attached life" stages.

(3) More than one hundred million eggs discharged by one mother shell will continue to decrease in number due to various factors caused by natural conditions. Quantitative fluctuations at each developmental stage are influenced by the time of development and the environmental factors at that time. There are several environmental factors such as water temperature, salinity, tidal current (its direction and drift), amount of plankton, amount of dissolved oxygen, substratum for attachment and bottom materials, which act intricately on one another.

(4) The following three conditions can be indicated as the causes inducing "abnormal outbreak": (a) induction of abnormally large-scale spawning, (b) survival of abnormally large numbers of attached spats, and (c) abnormally high survival rate of spats which have begun benthic life. Dr. Yamamoto inferred that among the above-mentioned three conditions, item (c) can be the trigger for "abnormal outbreak".

(5) Behavior of larvae and spats of the scallop during the period from spawning to the beginning of benthic life which have been elucidated by a close survey of the fishing grounds are as follows:

In Mutsu Bay, the major spawning season begins late in April, and the major season when larvae enter the attached life is from late May to early June. Through late July into early August when spats reach 6-10 mm in shell length, they gradually begin to enter the benthic life stage. It was found that the death rate of these spats became extremely high during the period from August to late October. When a diving survey on the behavior of benthic spats was conducted it was confirmed that in one place the survival rate of spats two months after the transfer to the benthic life was only 5-10%. Besides, similar field surveys in other places had disclosed the fact that there are some water areas where survival rate is lower or even zero in an extreme case.

The important conclusion obtained from these observational data is the fact that abnormally high death rates of benthic spats in the early stage is not caused by accident, but it is a normal and common phenomenon in the life cycle of scallops.

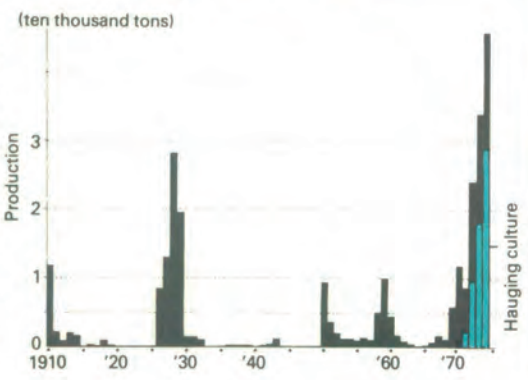
(6) The cause of high death rate in benthic spats has not yet been satisfactorily clarified. It is said, however, that the death must be closely related to a phenomenon in which the amount of dissolved oxygen near the bottom decreases greatly in relation to the rise in water temperature, for the season of the rise in water temperature coincides with the period of high death rate.

Since spats transferred to benthic life are at an important physiological turning point in their development, they have weaker resistance to environmental changes than mature shells. It can be inferred that only individuals which have succeeded in adapting to the benthic life after withstanding many trials at the cost of high death rate can survive.

(7) Dr. Yamamoto explains the "abnormal outbreak" of scallops as follows: When the larvae which have begun the attached stage of their life cycle sink to the bottom mud under especially good environmental conditions in a certain year, a great number of spats will survive. An especially good environmental condition means a case having all the following conditions: (a) the existence of a foundation for living which enables mature planktonic larvae to concentrate in a specific water area because of a slow current or eddy in the sea water, and which also facilitates the transfer of larvae to the attached life, (2) no periods of deficiency of dissolved oxygen during the period when the sinking of larvae occurs, and (3) no accumulation of marine snow on the bottom substratum where attachment occurs. In conclusion, it is reasonable to consider "abnormal outbreak" as "mass survival" under exceptionally good biological conditions.

The facts elucidated by the study of "abnormal outbreak" will not only support the possibility of conducting propagation and culture of scallops, but will also provide us with some useful clues as to effective methods for culturing scallops.

Fig. 5 Changes in production of scallops in Mutsu Bay (1910 ~ 1974)



Enlargement of Re Step-by-Step Techno

Efforts at increasing the resources of benthic aquatic animals with high commodity value such as shellfishes, shrimps and crabs will surely be considered, in the future, as one of the major tasks for promoting fisheries in many countries.

Most of these benthic animals are ranked as lower predators in the food chain, and there is a high possibility of increasing level of production of these animals. Therefore, by developing methods of effectively propagating appropriate species in selected waters suitable for breeding, a maximum of increasing level of sustained production of that species can be expected. This can be a very important measure in a nation's food production.

In Japan, the methods of reproducing aquatic resources on an enlarged scale are roughly divided into two types according to the species.

(1). "Zōshoku" (propagation) or transplantation

This is a method of releasing larvae or young animals, which have been artificially reared until a specific stage, into the sea, rivers or lakes; and to leave the succeeding growth to the care of the natural world.

(2). "Yōshoku" (culture)

This is a method of rearing seeds (larvae or young animals), collected in the natural habitat or produced artificially, in culture facilities such as ponds and net pens under artificial control until reaching the usable size, and then to land them for selling at the appropriate time.

Compound Evolution from "Natural Seed Collection" to "Hanging Culture" through "Propagation by Seeding"

In the past, fishermen possessed only self-defense measures such as waiting for the recovery of resources by restricting catch or prohibiting fishing in cases where resources decreased or exhausted.

Later, however, they began to take more active measures for the conservation of resources. This is known as the transplantation of aquatic animals.

[1]. Traditional transplantation methods with a long history

Transplantation of aquatic animals has a long history. Among the many attempts at transplantation, there have been many risky undertakings in which people tried to propagate new species of fishes and shellfishes actually brought in from other districts. However, the method which has been most widely practiced is the supplementary transplantation method, in which the same species of fish or shellfish which has become scarce or endangered is transplanted in mass from the waters of other districts to the damaged fishing ground.

If the transplanted species succeeds in adapting to the new living environment, a new group of adult fishes or shells will be formed, resulting in additional new resources.

In traditional transplantation, the life cycle of the transplanted species has not always been completely understood by the undertakers. It was actually the transfer of resources by trial and error which was undertaken based on the similarity of the fishing ground environment.

A series of research projects on scallop by many biologists began to yield various fruitful results around 1940. Fundamental research on the development, physiology and ecology of scallop and the environmental characteristics of the fishing grounds were carried out, and many applied studies such as surveys on the distribution of planktonic larvae, methods of seed collection and intermediate rearing methods were undertaken simultaneously. As a result, a foundation for developing propagation techniques with higher reliability has been established, resulting in a new situation.

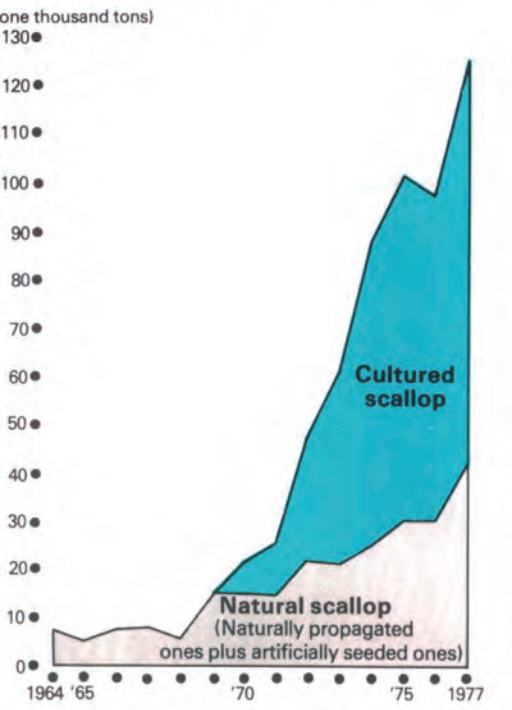
[2]. Establishment of techniques for collecting natural seeds

In Hokkaido, the task of transplanting spats collected at Lake Saroma into the waters along the coast of Abashiri has been undertaken since 1936. On the other hand, in Mutsu Bay, from the latter half of the 1940's to the 1950's, transplantation of spats collected at the site of abnormal outbreak into many other areas was tried, achieving good results. Scallop fishery, which was once dependent only on natural propagation, has been reinforced with artificial propagation methods: "seed collection in nature→ intermediate rearing→ liberation of seeds into the natural habitat".

An epoch-making event after the Second World War was the improvement of the technique for collecting natural seeds. Seed collection is done by making use of the habit of mature larvae to attach themselves to a solid body in the sea. During the early days, several types of collectors made of various kinds of materials, such as fence net made of straw rope, old fishing net made of cotton thread, or a rope screen with Japanese cedar leaves attached were hung under water to act as the substratum for attachment.

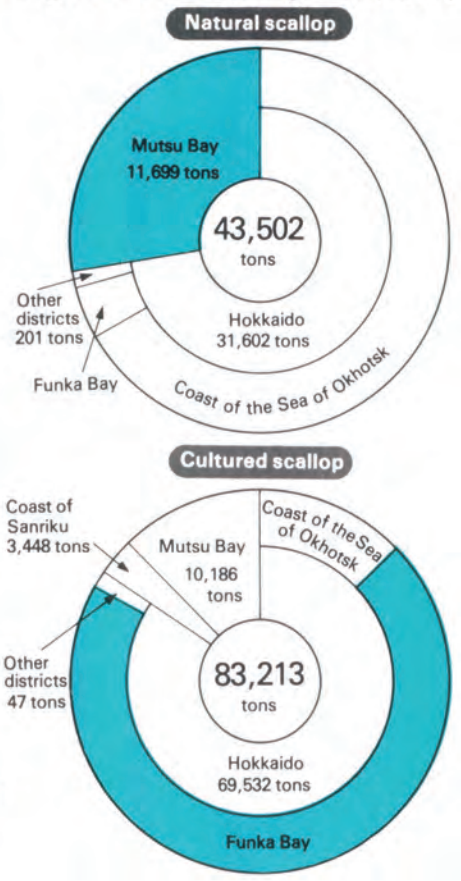
In 1963, however, a new type of seed collector devised by a fisherman of Aomori Prefecture achieved remarkable success. This collector is a simple device which is made by hanging a small bag made of synthetic fiber net used for

Fig. 3 Nationwide catch of scallops



emarks: Since only a very few "cultured scallops" were pro-ced before 1969, they are included in "naturally propagated d artificially seeded scallops" in this statistics.

Fig 4. Catch by regions (1977)



sources through logical Development

packing vegetables and fruits into the water with a small piece of fishing net inserted in this bag. This method makes it possible to keep almost all the fallen spats in the net bag even though attached spats continue to fall away one by one during the period of seed collection. It can indeed be said that this was "an achievement that seems impossible until it has been actually tried and easily accomplished (this is generally expressed as "An Egg of Columbus" in Japan). The method of seed collection was thus established in this way, and the amount of seeds collected has increased in leaps and bounds.

[3]. Development of hanging-type culture
Mass seed collection immediately made it possible to commercialize the hanging-type culture which was formerly conducted only on an experimental basis. Especially in Mutsu Bay and Funka Bay, a number of fishermen intending to begin culture following the success by the pioneers appeared one after another, and the production of cultured scallops has increased rapidly year after year since 1970, resulting in the formation of a powerful home industry.
The high commodity value of scallops has attracted many fishermen, but at the same time, some other factors, e.g., the ease of obtaining seeds and the ease in caring for the culture, because feeding is not necessary, gave impetus to the increase in the number of fishermen beginning this culture fishery.

[4]. Three-dimensional utilization of the sea
In parallel with the development of hanging-type culture, utilizing the surface and middle layer of the sea, a part of the spats collected in mass by the method of collecting natural seeds have begun to be released to appropriate sites on the bottom of the same sea area. These spats will continue to grow with the aid of the natural productivity of the sea, reaching commercial size in 3-4 years, when they will be caught by trawlers.
This is a good example of highly effective three-dimensional utilization of the sea by means of a sound overall plan and the cooperation of the fishermen involved.

[5]. Development of short-term culture fishery exceeding the range of natural distribution
As a result of improvement in techniques for collecting natural seeds, it became possible to obtain a amount of spats and sell the surplus spats to places outside the home fishing ground. Moreover, it became possible to ship spats of 3-4 cm in shell length past the southern geographical limit of natural distribution in the Japanese Islands (see Fig. 2) and to conduct hanging-type culture there as well. In these areas, however, since there are several problems such as the suitability of the fishing grounds and their productivity and the effects of high water temperature in the summer season, a plan to land and sell the scallops after a shortened culture period has been adopted.
As explained above, scallop fishery in Japan has developed step by step into its present condition. The present geographical distribution of fishing grounds is as shown in Fig. 6, and a relation between the life history of scallop and fishing activities is shown in Fig. 7.
Establishment of modern propagation and culture methods has not only stabilized scallop fishery, in which heavy natural fluctuations in harvest are inevitable, but has also contributed in creating a new home industry. The districts along Mutsu Bay and Funka Bay being snowy and cold traditionally had few sources of income during the winter season. As regards fisheries, with the decline of fixed shore net and beach seine in recent years, fishermen were making their livings by engaging in small-scale fishing of miscellaneous low-price fishes or else working away from home in other prefectures. However, with the rise of scallop culture fishery since the 1970's, people in both districts have begun to engage in fishery for a greater part of the year and the number of both male and female workers engaged in home industries has increased. Moreover, the development of related industries such as a scallop processing industry is being promoted.

Fig. 6 Scallop fishing ground in Mutsu Bay

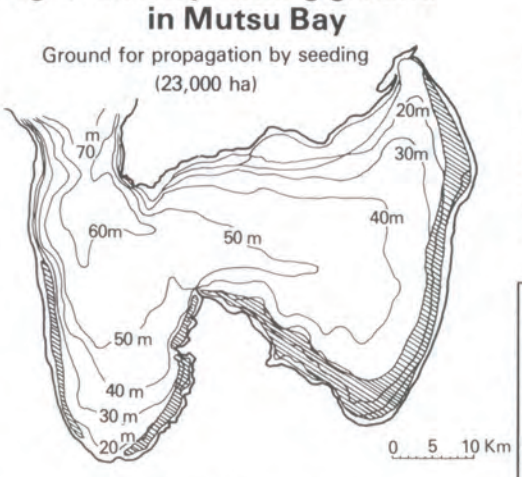
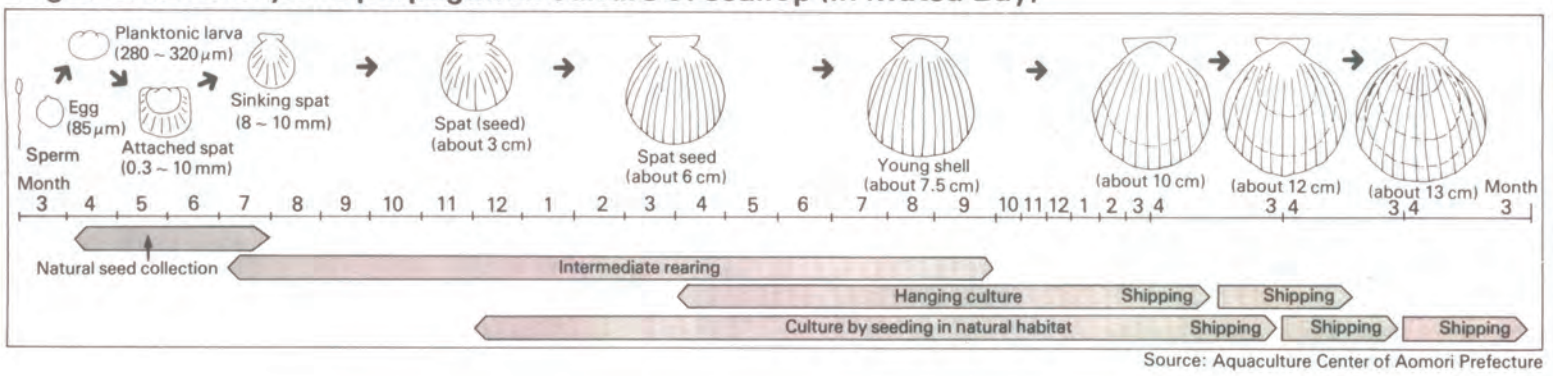


Fig. 6
Habitat of scallop: The habitat of scallop is limited to coastal waters shallower than 40 m deep. The population density is high in the bottom areas consisting of coarse bottom materials. It is observed that scallops lie on top of the ridges formed by tidal currents. This seems to indicate that strong tidal current is a limiting factor for local distribution of scallops, and they select, preferably, places consisting of coarse bottom materials.
Fig. 6 (upper) shows the ground for propagation by seeding in Mutsu Bay. The obliquely lined part is the original habitat where natural breeding occurs constantly.
On the other hand, since the hanging culture ground is not influenced by bottom materials, culture is possible any place within the bay, as long as strong wind and waves can be avoided; however, the ground is partitioned into small areas from the standpoint of fishery cooperation as shown in Fig. 6 (lower).

Fig.7
(Remarks) As regards artificial seed collection of the scallop: the technique of artificial seed collection including the induction of spawning in the mother shell, artificial fertilization and hatching has already been developed. However, this technique has not been put to practical use for the following reasons: (1) Mutsu Bay, Funka Bay and Lake Saroma are excellent fishing grounds for scallops, (2) natural seeds are steadily supplied in large quantities, and (3) since the annual demand for seeds is not exceedingly large, artificial seed collection method is of no commercial value.

Fig. 7 Life history and propagation culture of scallop (in Mutsu Bay)



Source: Aquaculture Center of Aomori Prefecture

[Reference books]

* Gotaro Yamamoto: "Propagation of Scallop in Mutsu Bay" (1964).
* Gotaro Yamamoto et al. (ed.): "Complete Culture in Shallow Waters" (1971).
* Aomori Prefecture: "Report of Survey on the Basic Plan for Developing Fisheries in Mutsu Bay" (1976).

Brote anormal significa "Supervivencia de las masas"

El "Brote anormal" o la gran fluctuación de recursos" es un fenómeno visto muy frecuentemente en muchos organismos, pero sus causas son aún desconocidas. La redada abundante o escasa en la pesca de las veneras, era explicada antes por la teoría del exceso de pesca o por la teoría del ciclo de crianza. Desde el principio de los mil novecientos sesentas, sin embargo, los estudios hechos en los campos de pesca por medio de batisferas e investigaciones por el doctor Gotaro Yamamoto, han comenzado a llevarse a cabo. Como un resultado, los misterios del brote anormal de las veneras han también comenzado a resolverse gradualmente.

Los casos dilucidados en el "brote anormal" apoyarán no solamente a las posibilidades de propagación y cultivo de las veneras, sino que también nos derán algunos indicios para un método efectivo en el cultivo de las veneras.

Aumentando los recursos con sabias medidas en el desarrollo de técnicas

La promoción en el aumento de recursos de animales de la flora y fauna del fondo del mar con altos precios de comodidades tales como los mariscos, crustáceos, camarones, y cangrejos, será considerada en el futuro como una de las materias principales más importantes para el desarrollo de la pesca en muchos paises.

La mayoría de estos animales de la flora y fauna del mar, están catalogados como presas de baja calidad en la cadena de alimentos y existe la gran probabilidad de que la producción de éstos animales pueda ser aumentada. Por lo tanto, desarrollando un método de una propagación efectiva de ciertas especies apropiadas en una región adecuada para crianza, nosotros podemos esperar ganar una producción sustancial máxima de esas especies. Este es un verdadero atento en la política de alimentación.

Chez les coquilles St-Jacques, "foisonnement anormal" signifie "survie de masse".

Un "foisonnement soudain et anormal", entraînant la "fluctuation excessive des ressources" constitue un phénomène courant chez beaucoup d'organismes, mais les causes en sont encore presque inconnues. Autrefois, on avait coutume d'expliquer les récoltes bonnes ou mauvaises de la pêche aux coquilles St-Jacques au moyen de considérations théoriques sur l'appauvrissement par prises excessives ou sur le cycle de reproduction. Cependant, depuis le début des années soixante, l'étude systématique des fonds de pêche par le bathysphère et les recherches du Dr. Gotaro Yamamoto se poursuivent. En conséquence, le phénomène mystérieux du foisonnement anormal des coquilles commence à être élucidé.

Ces nouveaux éléments de compréhension viendront renforcer les possibilités de propagation et d'élevage des coquilles, tout, en nous offrant des suggestions utiles à l'amélioration de nos méthodes.

L'augmentation des ressources par un développement graduel des techniques

Dans le futur, la promotion de l'augmentation des ressources en animaux marins à habitat benthique tels que coquillages et crustacés, crevettes et crabes va devenir un des principaux centres d'intérêt concernant le développement de la pêche en de nombreux pays.

La plupart des ces animaux benthiques sont classifiés comme prédateurs inférieurs dans la chaîne de subsistance, et les possibilités d'augmenter leur production sont élevées. En conséquence, nous pouvons nous attendre à bénéficier d'une production maximum durable de ces espèces par la mise au point de méthodes efficaces permettant de propager les espèces adéquates dans une zone convenant à l'élevage. Cette tentative revêt une grande importance dans le cadre d'une politique alimentaire générale.

Hanging Culture

The actual work involved in hanging culture can be divided into three steps: (1) seed collection, (2) intermediate rearing, and (3) main culture.

For collecting seeds of scallop, various types of collectors have been devised in many districts, but at present the "onion bag" method (Fig. 3) is commonly used.

In the intermediate rearing step, spats taken out from the seed collector are put in a small net basket (called a "pearl net") which is hung in the water.

In this state, spats are reared until a size of about 3 cm in shell length is reached.

In the main culture step, in which spats are reared into mature shells, the spats are transferred into a large cylindrical net basket (called an "Andon") which is also hung in the water. This net basket is generally partitioned into ten compartments, and 50-100 baskets linked like long-line are hung in the water. The buoyant force for the baskets is provided by floating balls which are set in the middle layer of the sea, whill floating balls on the surface only function as markers. It is devised this way so that the effect of waves to baskets will be minimized.

Transition in the style of seed collector

Fig.1 Seed collector (cedar leaf attached type)

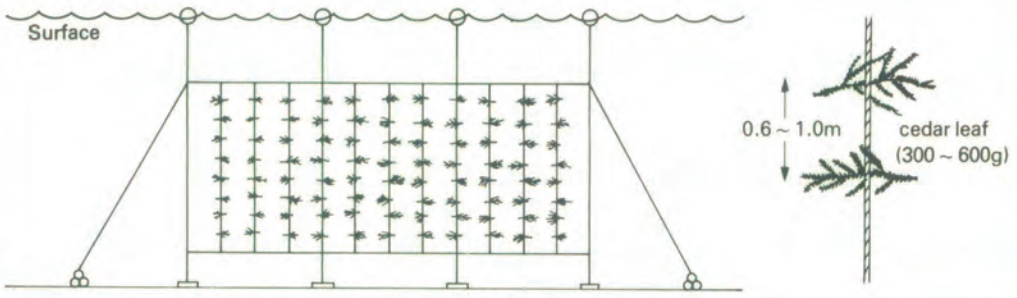


Fig.2 Fence net type

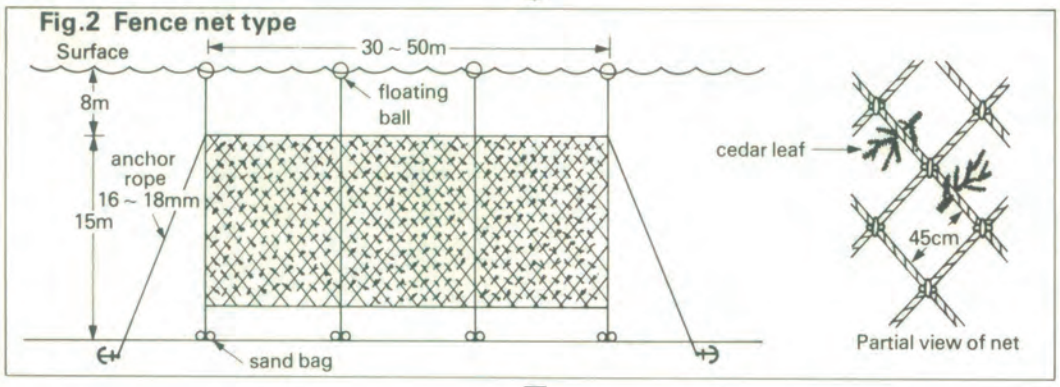


Fig.3 Long-line type (in current use)

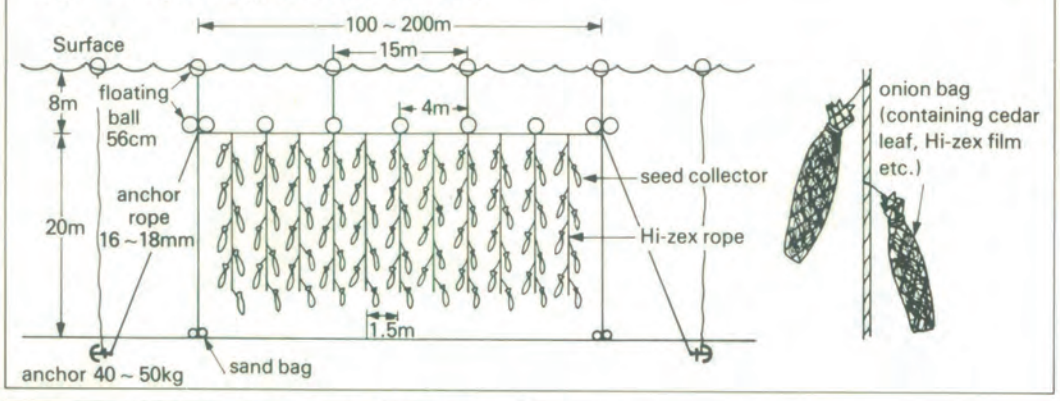


Fig.4 Middle layer type scallop culture long-line

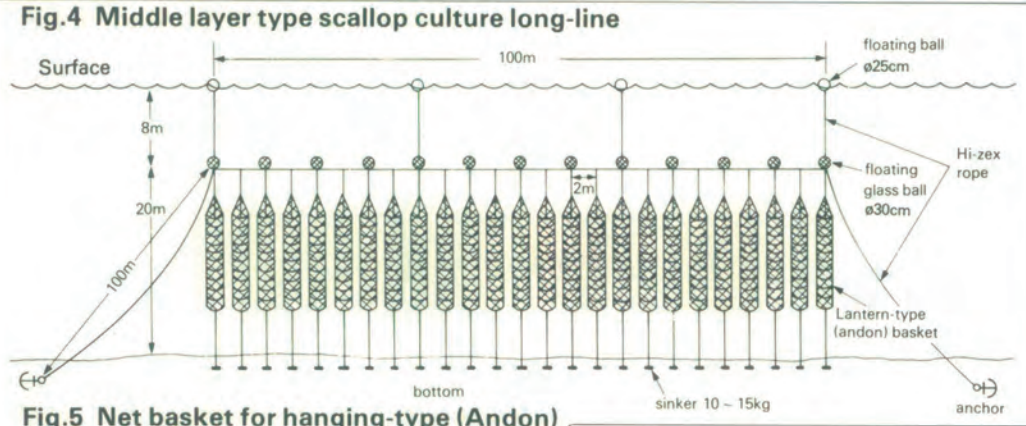


Fig.5 Net basket for hanging-type (Andon) culture

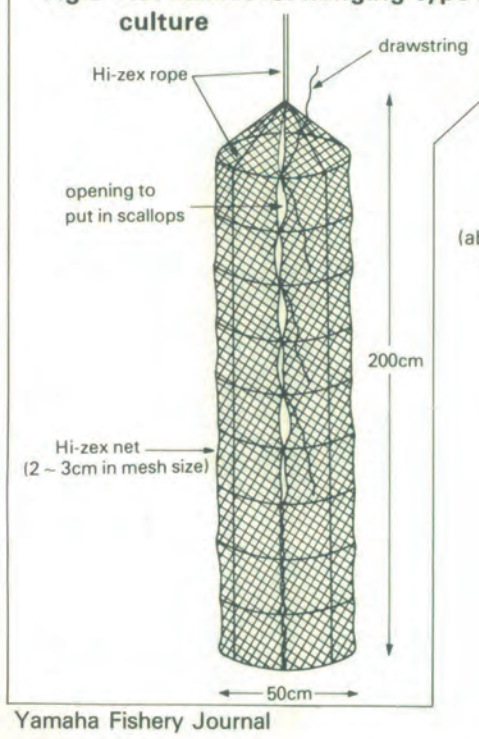
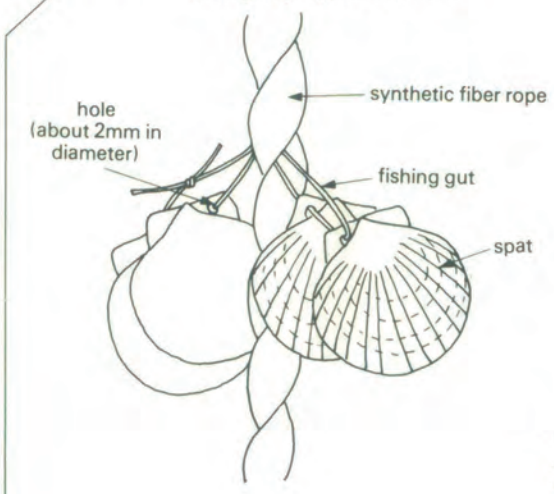
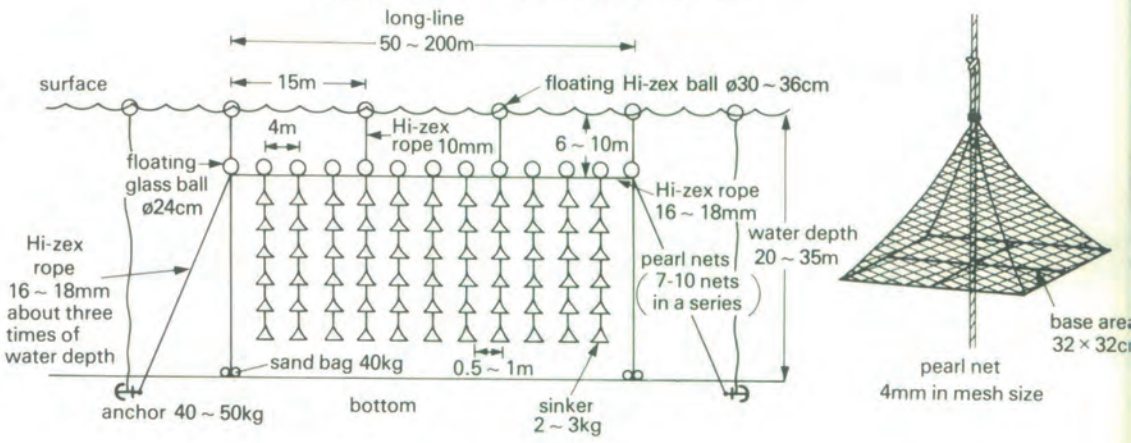


Fig.6 Ear-hanging method in hanging-type culture



Hanging culture

Fig.7 Intermediate rearing facility



Propagation by Seeding in A Natural Habitat

For catching scallops, a small-sized power trawler equipped with a shell dredge net is used. In the fishing ground, the net is thrown into the sea and towed at a slow speed of a few knots. While towing forward, the net creeps along the bottom and sandy mud is scraped up by iron teeth fitted at the lower part of the mouth of net and scallops are caught in the net bag. Net hauling is conducted with a drum-type net hauler driven by the main engine.

In the past there were fishing grounds where competitive fishing resulted in overcatching; however, at present under the guidance of the prefectural office, fisheries cooperative associations are endeavoring to take measures such as those mentioned below for the conservation and propagation of resources:

(1) Seeds are to be collected systematically every year and a fixed quantity is to be released to the main fishing ground under the guidance of fisheries cooperative association.

(2) The Fisheries Cooperative Association is to estimate the amount of resources, based upon the catch, and decide the total annual catch target and catch rotation system.

(3) Fishing methods (fishing season, operation area, daily catch limit, minimum shell length of the shells caught etc.) are to be restricted. Further, in some districts, catching is to be carried out by cooperative operation by a unit of several families.

(4) The management of fishing grounds, such as extermination of destructive animals is to be conducted cooperatively.

Fig. 9 Fishing method with dredge net

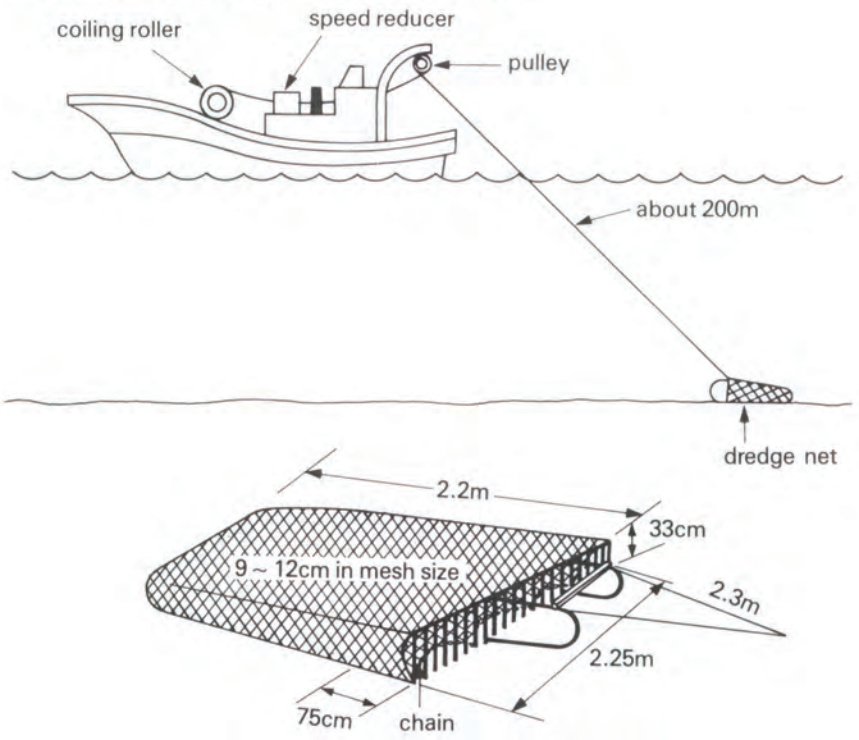
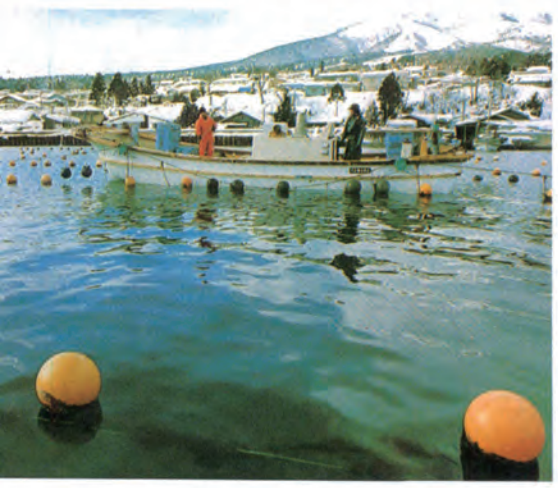


Fig. 10 Dredge net



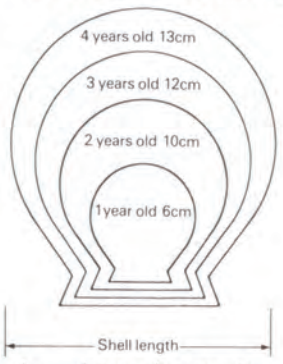


Fig. 8 The growth pattern of scallop is as shown in this figure

Data and cooperation offered by: Aquaculture Center of Aomori Prefecture.

Propagation by seeding in a natural habitat

Cultivo Colgante"

Los trabajos actuales en el cultivo colgante consisten en tres medidas: (1) colección de la (siembra); (2) crianza intermediaria; y (3) cultivo principal.

Para la colección de la siembra de la venera, varios tipos de recaudadores de siembra han sido inventados en varios distritos, pero actualmente el tipo "bolsacebolla" (figura No. 3) es usado conúnmente.

En la medida de crianza intermediaria, las veneras tiernas son sacadas del recaudador de siembra y son puestas en una pequeña cestared (llamada red de perlas) la cual es colgada bajo el agua. En este estado, las veneras tiernas son criadas en una concha de cerca 3 centímetros de largo en tamaño.

En la medida de cultivo principal, donde las veneras tiernas son criadas para ser adultas, ellas son transferidas a una cesta redonda grande (llamada Andon), la cual también se suspende bajo el agua.

Propagación en un campo sembrado

Para atrapar veneras, un pequeño barco rastreador motriz equipado con una red rastreadora de mariscos, es usado. En el campo de pesca, la red es lanzada dentro del mar y es remolcada a una velocidad lenta de pocos nudos. Mientras la red que se arrastra por el fondo se mueve hacia adelante, la arena lodosa es acumulada poco a poco por los dientes de hierro que están adaptados en la parte baja de la boca de la red y las veneras son agarradas dentro de la bolsa de la red. El alza de la red es conducida por un halador de tipo tambor manejado por la máquina principal del barco.

L'élevage en suspension

Pratiquement, l'élevage en suspension se décompose en trois stages:

(1) le ramassage de la semence
(2) Les soins intermédiaires
(3) L'élevage principal.

Plusieurs types de réceptacles ont été mis au point dans différentes zones pour le ramassage de la semence, mais à présent le modèle "onion bag" (sac d'onion) est communément utilisé.

Lors du stage des soins intermédiaires, les jeunes coquilles passent du réceptacle à semence dans une petite nasse en filet (type "filet à perle") suspendue dans l'eau. Elles y demeurent jusqu'à ce que leurs coquilles atteignent une taille de 3 cm.

Les jeunes ayant atteint le stage de la maturité sont transférés dans une grande nasse ronde appelée "Andon", également suspendue dans l'eau.

La propagation en terrain ensemencé

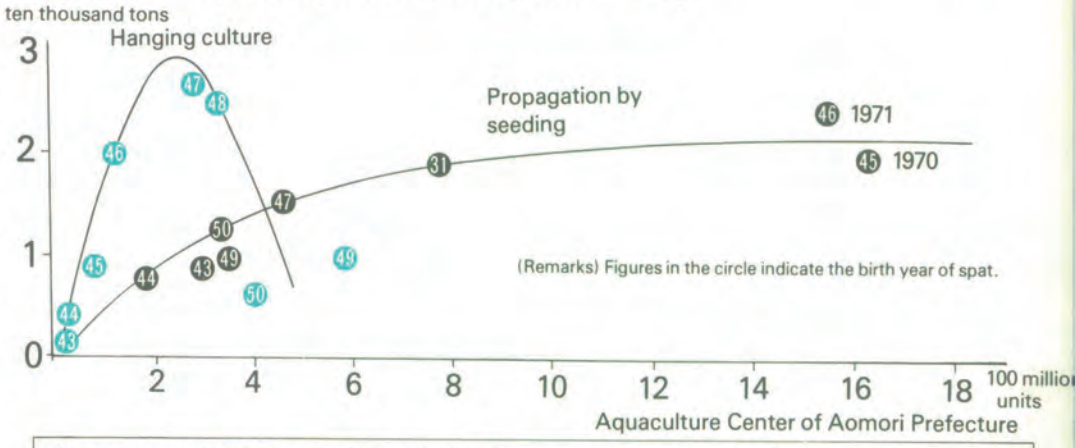
De petits chalutiers à moteur équipés de filets de drague à coquillages sont utilisés pour la pêche aux coquilles. Sur les fonds de pêche, le filet est mis à l'eau et remorqué à vitesse réduite, quelques nœuds à peine. Il rampe lentement sur le fond, râclant la boue mêlée de sable grâce à des dents de fer fixées sous son embouchure et les coquilles St-Jacques sont prises dans la poche formée par le filet. Le halage est réalisé au moyen d'un hâleur à tambour actionné par le moteur principal.

Faced by Two Severe Trials

In both cases, constant countermeasures were required

Scallop culture, a fishery which seemed to be growing rapidly without any problems, was actually faced with two serious crises. Those were the two problems of "mass death" and "shell poison".
Since old times, the death of scallops had sometimes been seen in artificially seeded fishing grounds. However, mass death in hanging culture grounds happened successively in each culture ground along the coast of Sanriku in 1972, in Mutsu Bay in 1975, and in Funka Bay in 1977, causing serious debate. "Shell poison" also came to the fore in around 1973 in Funka Bay, and such countermeasures as the suspension of shipment during summer season were taken.
Hard hit by each of these crises, many fishermen have abandoned their culture fisheries. Both "mass death" and "shell poison" should not be considered as one-time incidents, but as abnormal situations originating from the biological characteristics of scallops.
Now, we shall explain the details of these problems, the causes elucidated so far, and the countermeasures that have been taken in the fishing grounds, in order that this problem can be understood properly.

Fig. 2 Relation between the amount of propagated or cultured scallops and production in Mutsu Bay



Primary productivity of fishing grounds is not limitless. In case the number of released scallops and that of cultured scallops have increased excessively in a specific water area, the growth rate would decrease and the total population would reach the uppermost limit even if the death is not induced. The figure shows the relation between the number of propagated or cultured scallops and the final production of those scallops. It is considered that, in Mutsu Bay, the limit of production is 30,000 tons in culture and 20,000 tons in propagation.

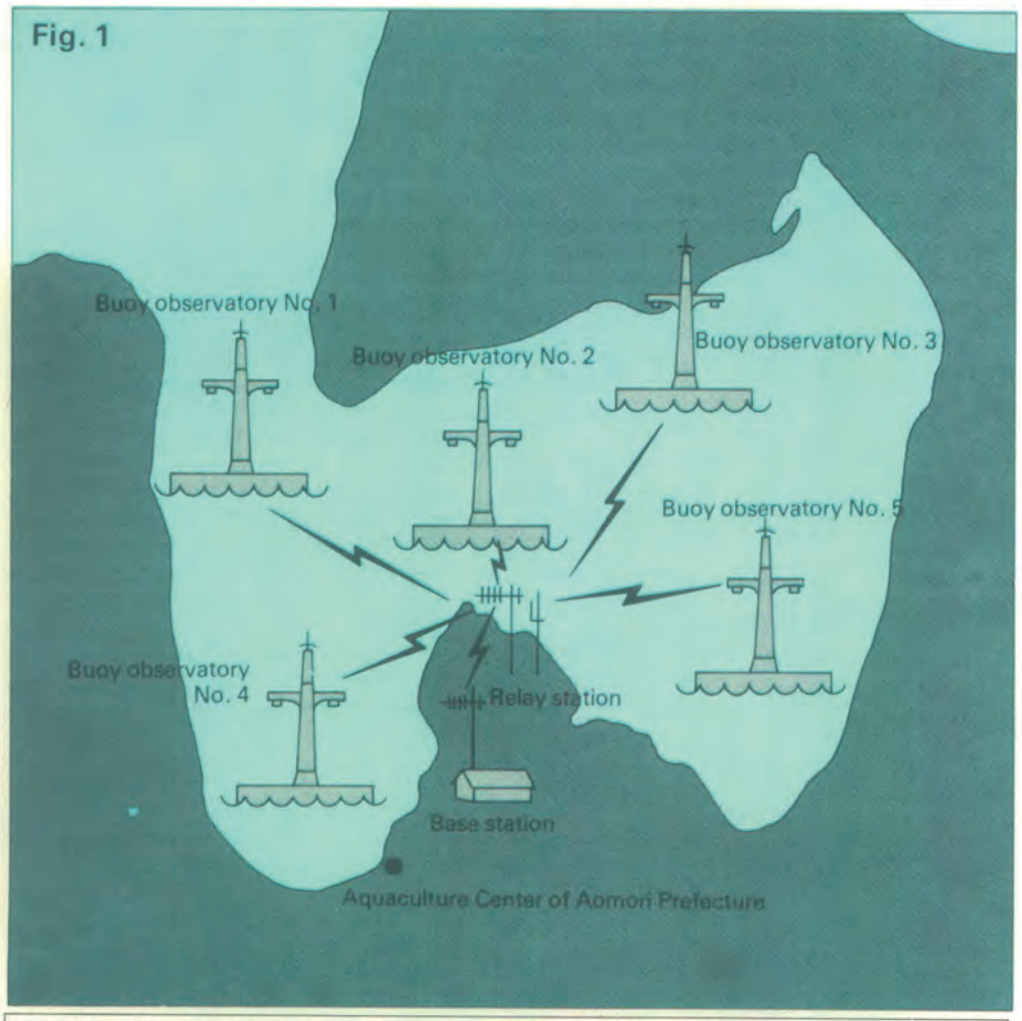
Mass death

The mass death which occurred in Mutsu Bay in 1975 will be explained here as an example.
For scallops, it is commonly believed that the total death rate during the period from seed collection in the sea to harvest through culture can be held down to 40 — 60% in the case of propagation by seeding, and 5 — 10% in hanging culture. Therefore, when a death rate higher than this level occurs, it is called "mass death".
In Mutsu Bay, "mass death" occurred in the hanging culture grounds throughout the entire bay from May 1975 to September of the same year. The sum total as of the end of March, 1976 shows that the number of damaged semi-mature shells (those under the cultivation in main culture baskets after the completion of intermediate rearing and still smaller than the commercial size) and mature shells (those of the commercial size) is as follows:

Shells born in 1973
...Amount of death, about 90 million shells (Death rate: 31%)
Shells born in 1974
...Amount of death, about 350 million shells (Death rate: 56%)
Shells born in 1975
...Amount of death, about 610 million shells (Death rate: 57%)

In some districts, the death rate reached 100%. The appearance of abnormal shells was observed as an accompanying phenomenon of the death. The abnormalities included: (1) the deformation or defect of the marginal part of the shell, (2) a coloration of the inner surface of the shell at the attachment of membranous substance, and (3) the atrophy of the mantle; and all of these can be considered as premonitory symptoms of death.
Among the local fishermen, who were surprised at the situation, various conjectural theories as to its cause, such as an infectious disease theory, a theory of sudden change in fishing ground environment, a theory of pollution of the fishing ground by poisons from inland water, and abnormal water temperature theory were tossed about. But no single theory was able to satisfactorily explain the phenomenon which occurred over such a wide area. Some fishermen administrated medicine without any effect.

Fig. 1



In Mutsu Bay, a scientific control system very unique in Japan is under operation. That is, continuous automatic observations on the sea conditions are made by five buoy robots allocated within the bay. The water temperature, salinity, dissolved oxygen, and direction and drift of current are measured periodically every day, and those data are transmitted by wireless to the base station at which data processing is conducted with a computer to make hourly report, daily report, and monthly report. These are used for (1) the survey of appropriate fishery site, (2) forecast of the time suitable for collecting the seeds of scallop, (3) monitoring of the outbreak of pest animals and water pollution, and (4) forecast of various kinds of fishing conditions.

In those days, research on the diseases of scallop were only starting, and thus faced with such a situation, the researchers of universities, national and regional fishery research laboratories and prefectural fisheries experimental stations have endeavored to find clues as to the cause by trying to reproduce a similar type of death through experiment.
The results of this research obtained so far indicate that there are two main factors inducing the mass death of scallops although many hypothetical explanations are included, i.e., (1) the acceleration of sexual maturity induced by abnormal oceanographic conditions such as high water temperature, and the resulting decline in physiological activity; and (2) the increase of stress between individuals and various metabolic defects originating from high density culture.
Scallop originally inhabits a point of fixed orientation at the bottom. Therefore, in a method where the scallops are detached from the bottom, put into a basket, and cultured by hanging under a slightly swinging condition; one must pay close attention to creating the best possible rearing environment corresponding to the natural condition of original bottom life. Since the hanging culture has thus far been operated by individual management, the brilliant success during its early stages induced many fishermen to become engaged in it, resulting in a sudden high-density transplantation exceeding the permissible limits of the fishing grounds.
In Aomori Prefecture, based upon the data of experimental studies performed under the guidance of the Aquaculture Center, practical methods for both propagation by seeding and hanging culture were formulated to provide guidance for fishermen in the prefecture. The main points of instruction were: (1) propagation and culture in a proper density, (2) effective utilization of seeds by selecting only the healthy spats from those over 3cm in shell length, and (3) adoption of more stable mid-layer or bottom type culture facilities. These improvement measures for fishing grounds have begun to be put into practice since 1977. Thereafter, as their effectivness has been recognized, fishermen have begun to gain a proper understanding of these measures, thus broadening their use throughout the entire bay.
Although death and the outbreak of abnormal scallops continued at a higher rate from 1976 to 1977, they began to decrease in 1978 and further, they decreased greatly in 1979.

Shell poison

For scallops, two kinds of poison have so far been identified; i.e., a watersoluble paralytic shell poison and a fat-soluble shell poison. Although the former is not lethal, the latter causes muscle paralysis or respiratory failure, sometimes resulting in death.
On June 28, 1978, paralytic shell poison was detected in the hanging culture ground of Funka Bay, Hokkaido, and the shipment of scallops was suspended in all producing areas. This suspension of shipment continued for 105 days from July 1 to October 13. On April 12, 1979, shell poison was detected again. This time, appearance of scallops having toxicity was also limited to hanging culture grounds, and it appeared more than two months earlier than the previous year.
When the shell poison was detected last summer, the Fishery Agency resorted administrative guidance, issuing a Director General's circular notice establishing the following distribution standards:
(a) intensification of the poison watch and inspections, (b) suspension of the shipment of scallops if a toxin level of more than 4 MU above the temporary standard is detected in the edible parts and (c) application of these standards to both cultured scallops and those propagated by seeding.
There are only a few cases of studies on these toxin(s) and the cause of the scallop becoming poisonous, and much remains to be clarified. Therefore, the Fishery Agency has entrusted the main producing prefectures of Hokkaido and Aomori with the necessary research since last year, and has instructed to further conduct ongoing research, including also Iwate Prefecture this year.
The mechanisms of occurrence of shell poison clarified so far are summarized in the following two points:
(1) Paralytic shell poison is induced by a toxin called "saxitoxin" which originates from the plankton called Gonyaulax, a kind of dinoflagellates, eaten by scallops.
(2) The saxitoxin is accumulated selectively in the mid-gut gland, and thus the adductor muscle and the mantle are not poisonous.
It has so far been thought that this plankton appears at a water temperature of around 10°C, but in 1979 it appeared at 4 — 5°C. Therefore, it is difficult to decide the exact temperature at which this plankton appears. With the facts that shell poison is almost entirely limited to the hanging culture grounds and not found in the scallops propagated by seeding in the natural habitat, we can deduce that the poison is related to the floating layer of planktons; however, this has not yet been confirmed.
The fishing ground in Funka Bay where the shell poison incident occurred last year looked slightly different from the previous year. Since shell poison exceeding the standard value was detected on April 12, ten related fisheries cooperative associations voluntarily began to suspend shipment. At the same time, under the direction of the federation of fisheries cooperative associations of Hokkaido, an emergency meeting to decide on countermeasures was held;

and as a result, a petition was presented to the Government requesting it to take measures to officially recognize the safety of scallop with the mid-gut removed gland. On the other hand, the Fishery Agency continued to collect and examine data concerning the shell poison. As a result, it was judged that the shipment of only the adductor muscle of the scallop was safe if a satisfactory inspection system was furnished, and thus the Fishery Agency issued a new policy to "admit the shipment after appropriately removing the mid-gut gland", revising the circular notice issued in 1978. Moreover, to insure future safety, a decision was made to official regulations indicating the points of treatment to the organisation responsible for shipment.

After passing through the process mentioned above, the shipment of scallops produced in Funka Bay was reopened on May 20. But, it lasted only for 40 days before they were forced to suspend the shipment again shortly after July 1. This was due to decreased consumption caused by the unfavorable image created by the shell poison and to the hesitation by the markets of consuming areas to deal with the product. Under such conditions, it was difficult to see any way in which the summer shipment of cultured scallops produced in Funka Bay could be resumed. Scallop fishery in Hokkaido brought gross sales of 33.9 billion yen in 1977, about 60% of which were attributed to cultured scallops produced in Funka Bay; thus making it a key fishery accounting for 9.3% of the overall fisheries production of Hokkaido of 362.1 billion yen. The people of the fisheries industry in Hokkaido are now trying to promote all-round countermeasures for the shell poison of scallop such as the shell poison removed experiment, tests for purifying the bottom materials in fishing grounds and development of new processed goods from scallop; but the most important problems among these various countermeasures seem to be the following two points:

(1) establishment of a method of appropriate treatment and inspection.

(2) spreading proper knowledge about shell poison among the consumers.

Table 1 Comparison of paralytic and fat-soluble shell poisons

	Paralytic shell posion	Fat-soluble shell poison
Case of poisoning	In the world: 1,200 persons Japan: 74 persons (including 2 deaths)	Japan: 42 persons in 1976 116 persons in 1977
Kind of shell	short-necked clam, oyster, akazara (Chlamysfarreri nipponensis), blue sea mussel, scallop, round clam	oyster, blue sea mussel, akazara (Chlamys farreri niponensis), scallop
Symptoms	Initial stage (5 ~ 30 min. after meal) **pain in the lip, face and finger tip* Late stage (12 ~ 24 hr.) **muscle paralysis, respiratory failure → death*	several to 24 hrs. after meal *getting sickish vomiting, diarrhea and stomachache
Characteristic of poison	water-soluble	fat-soluble
Name of poison	Saxitoxin, and five other toxins	unknown (x)
Plankton having poison	Gonyaulax sp.	unknown (Poisonous flagellate)
Preliminary permissible amount of toxicity at shipment indicated by the Government	less than 4 MU/g in edible part (Remarks) 1 MU means the amount of toxin contained in 1g of the soft part which can kill a mouse (20g) within 15 min	less than 0.05 MU/g in edible part. (Remarks) 1 MU means the amount of toxin contained in 1g of mid-gut gland which can kill a mouse (20g) within 48 hrs.
Organ in which poison accumulates	mainly mid-gut gland	mainly mid-gut gland
Season of high toxicity	mainly May to July	mainly June to July

(Source: Aquaculture Center of Aomori Prefecture)

Golpeadas por dos desgracias severas

El cultivo de las veneras que parecía ir creciendo paulatinamente, fué golpeado por dos serias crisis. Estos fueron dos accidentes: "muerte en masa" y "envenamiento de la concha".

Desde tiempos anteriores, la muerte de la venera fué vista en los campos de cultivo artificial, sin embargo, la muerte en masa en el campo del cultivo colgante ocurrió sucesivamente en cada campo de cultivo a lo largo de la costa de Sanriku en 1972, en la bahia Mutsu en 1975 y en la bahia Funka en 1977, causando un serio debate. El problema de "envenamiento de la concha", vino a luz alrededor del año 1973 en la bahía Funka, y algunas medidas tales como la suspensión de embarques en la estación de verano, han sido tomadas.

Une industrie frappée par deux épreuves redoutables

L'élevage des coquilles St-Jacques, qui connaissait une progression régulière, a souffert de deux crises accidentelles graves, la "mort collective" et l'empoisonnement".

Depuis toujours, on rapportait des cas occasionnels de "mort collective" sur les fonds d'élevage ensemencés artificiellement; mais ce phénomène a frappé successivement tous les fonds d'élevage en suspension situés le long de la côte de Sanriku en 1972, puis ceux de la baie de Mutsu en 1975, puis de la baie de Funka en 1977 donnant lieu à des débats passionnés. Le problème de l'empoisonnement des coquilles s'est également imposé depuis 1973 dans la baie de Funka, entraînant certaines mesures telles que la suspension des expéditions en été.

Scallop is a food that nutritionally contains much protein but little fat. The adductor muscle has high food value, as 35% of its total wet weight is said to be protein. Moreover, the succinic acid content of the adductor muscle is ten times as much as in abalone, three times as much as in ark shell and hard clam, and fifty times as much as in beef, and this is what gives it a special flavor. Almost all of the carbohydrate in scallop is glycogen.
Therefore, the scallop is a fairly sweet food among shellfishes.
Besides being consumed as a fresh shell, scallop has so far been consumed also as processed products such as dried adductor muscle, canned plain boiled scallop, smoked scallop and frozen adductor muscle. With the advance of mass production resulting from the spread of propagation and culture fisheries in recent years, processed boiled scallops have increased in production and they have become a main distribution form for scallop.
There is a slight difference in the distribution patterns between Hokkaido and Aomori, which are the two main producing districts of scallop. But throughout the country, the distribution of scallops is carried out by two channels, one as "fresh shell" and the other as processed (boiled) products".

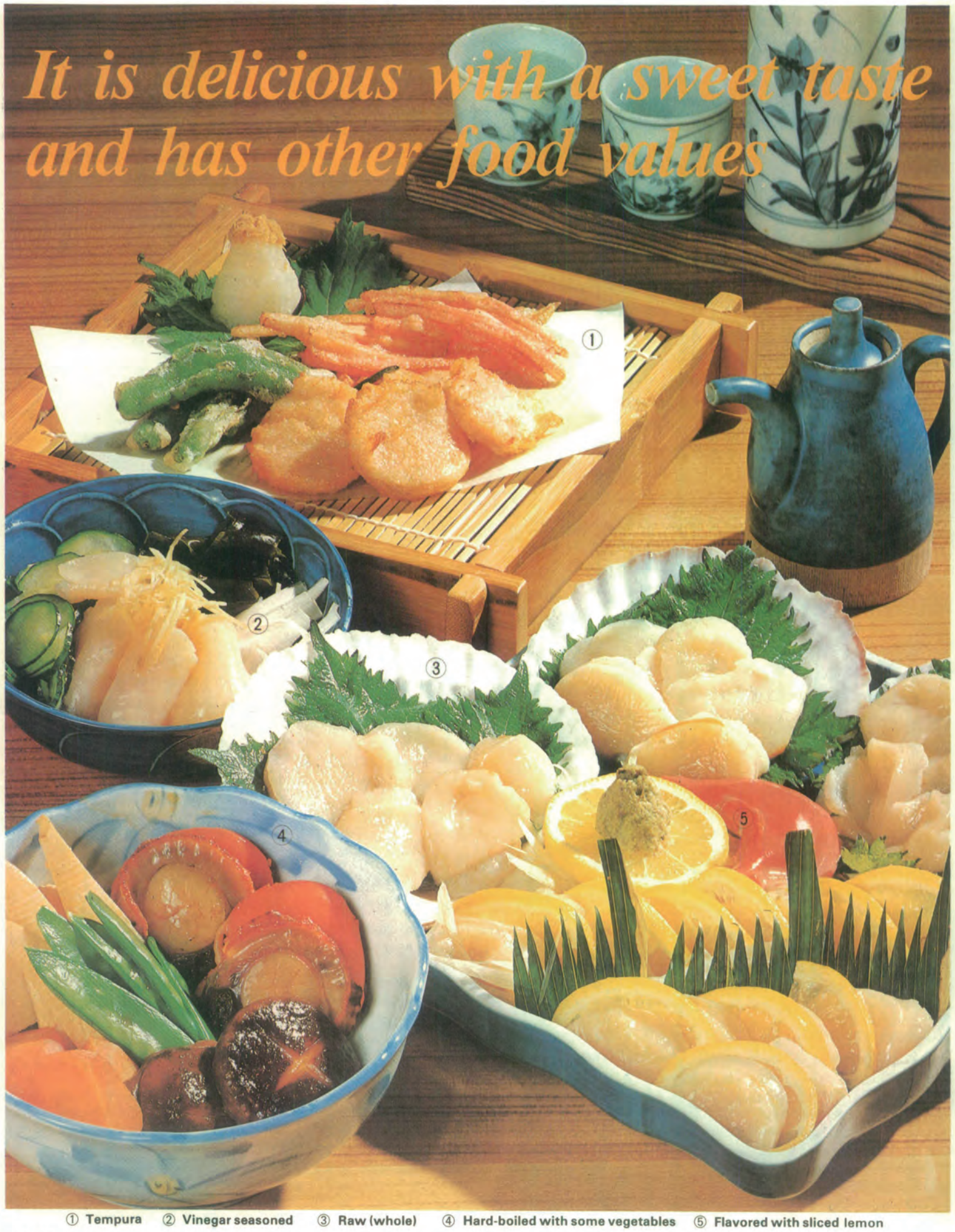
Sabor delicioso y dulce con mucho valor nutritivo

Las veneras contienen mucha proteína pero poca grasa como ingredientes químicos. El músculo aductor tiene un gran valor como alimento y el 35% de su peso bruto total consiste en proteínas. Además ácido succínico contenido en el músculo aductor es diez veces tanto como en la oreja marina (abalone), tres veces tanto como en la concha arqueada y en la almeja dura, y cincuenta veces tanto como en la carne vacuna, y esto le da un sabor especial. Casi toda la cantidad de carbohidratos consiste de glucógenos. Por eso, el músculo aductor de la venera tiene el sabor más dulce entre los mariscos.

Un goût d'une délicatesse exquise combiné à une excellente valeur nutritive.

Les coquilles St-Jacques sont riches en protéines mais pauvres en graisses et produits chimiques. Le muscle adducteur possède une haute valeur nutritive; les protéines constituent 35% de son poids humide total. Pour ce qui est de l'acide succinique, il en contient dix fois plus que l'abalone, ou oreille de mer, trois fois plus que la coque arquée et que la palourde dure, et cinquante fois plus que le bœuf; c'est ce qui lui confère une saveur spéciale. Les hydrates de carbone consistent presque entièrement en glycogène. C'est pourquoi le muscle adducteur de la coquille St-Jacques est réputé pour son goût succulent qui la met au premier rang des coquillages.

It is delicious with a sweet taste and has other food values

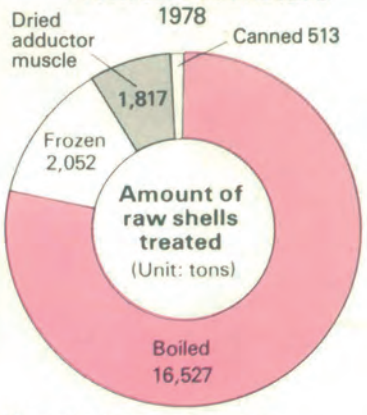


① Tempura ② Vinegar seasoned ③ Raw (whole) ④ Hard-boiled with some vegetables ⑤ Flavored with sliced lemon

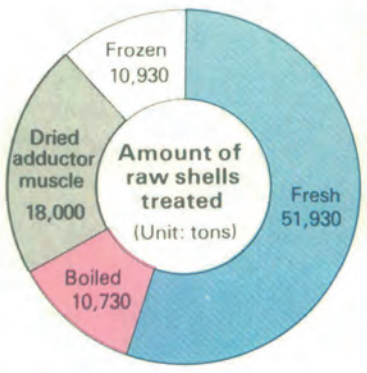
Nutritional breakdown of scallop (In 100g of edible portion)

Kind / Ingredient	Raw shucked scallop	Raw adductor muscle	Dried adductor muscle
Calory	100cal	129cal	311cal
Water	74.2g	66.5g	17.2g
Protein	20.8g	30.1g	72.2g
Lipid	0.8g	1.0g	2.5g
Carbohydrate	2.4g		
Ash	1.8g	1.3g	6.0g
Calcium	18mg	6.0mg	14.0mg
Phosphorus	130mg	24.0mg	833.0mg
Iron	1.2mg	6.0mg	13.0mg
Salt	488mg	312mg	2,611.0mg
Vitamin A	8iu		
Vitamin B_1	0.04mg		0.04mg
Vitamin B_2	0.1mg		0.05mg
Vitamin C	3.0mg		
Niacin	1.4mg		

Aomori Prefecture
1978



Hokkaido
1978



① Pickled in sake lees ② Sweet-boiled ③ Salted & fermented guts ④ Pickled in sake lees ⑤ Canned ⑥ Boiled ⑦ Dried ⑧ Smoked ⑨ Frozen ⑩ Pasted with miso

Photos: courtesy by The Aomori Prefectural Scallop Distribution Promotional Association.

Yamaha Fishery Journal