

Exchanges between Japan and France in the field of fisheries science, triggered by the mass oyster die-off in France and the export of Sanriku oyster seeds to France

Yasuyuki KOIKE¹⁾* and Teruhisa KOMATSU^{1, 2)}

Abstract: In 1960, the Japanese-French Oceanographic Society (SFJO) was established and cooperation with France on oceanography began. In the late 1960s, oysters farmed in France died in large numbers due to diseases, and oyster farming was in danger of extinction. French researchers then approached SFJO member Professor Takeo Imai of Tohoku University to see if Sanriku oysters resistant to the diseases could be exported to France. The research team led by Professor Imai conducted quarantine and pathological tests to succeed in exporting 10,000 t Sanriku single-seeded oysters (spat) to France. This export brought the French oyster farming industry out of crisis. Subsequently, French-Japanese cooperation also extended to fisheries science, and SFJO France was set up in 1984. On 11 March 2011, a huge tsunami hit off the coast of Sanriku, devastating aquaculture facilities. Immediately afterwards, SFJO France and French oyster farmers including another French groups contacted SFJO to support oyster farmers in Sanriku in return for their spat export. These organisations and SFJO donated essential equipment for oyster seed collection, such as microscopes and plankton nets, to the prefectural fisheries experiment stations and prefectural fisheries cooperatives in Sanriku. This article outlines the French-Japanese exchange on these fisheries science.

Keywords : *Japanese-French Oceanographic Society, mass oyster die-off in France, Sanriku seed oysters, tsunami in Sanriku*

Introduction

In 1958, Japanese scientists invited the French submersible bathyscaphe, FNRS III, the most advanced submersible in the world at that time, to Japan and conducted joint research in the Japan

Trench and its surroundings, making many discoveries about the deep sea (KOMATSU, 2023). This led to the establishment of the Japanese-French Oceanographic Society (*Société franco-japonaise d’Océanographie*: SFJO) in 1960, led by

1) *Société franco-japonaise d’Océanographie*, Department of Marine Environment, School of Marine Resources and Environment, Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato-ku, Tokyo 108-8477, Japan

2) Japan Fisheries Resource Conservation Association, 1-1, Akashi-cho, Chuo-ku, Tokyo 104-0044, Japan

*Corresponding author: Yasuyuki Koike
TEL/FAX: + 81-3-5463-0467
E-mail: oreillemer@ybb.ne.jp

Professor Tadayoshi Sasaki of the Tokyo University of Fisheries and Professor Takeo Imai of Tohoku University. Exchanges in the field of fisheries began in the 1960s with the Japanese side's cooperation, led by Professor Imai, a member of SFJO, to save French oyster farming, which was suffering due to the mass die-off of cultured oysters in France. This article looks back at the history of exchanges between France and Japan in the field of fisheries science, particularly with regard to oysters.

Export of seed oysters from Japan to France in the 1960's

The mass production of seed oysters (spat) in Japan, started in the 1920's in Mangoku-ura Inlet, Ishinomaki City near Sendai, Miyagi Prefecture. The spat produced in Miyagi Prefecture were shipped to all regions, where oyster culture was conducted, around the Japanese coast. The export of these spat to the United States started in 1923 and continued until 1978, with the suspended period of 5 years from 1941 due to the World War II.

In the 1960's the oyster farming in France was greatly damaged by the mass mortality of *Crassostrea angulata* called Portuguese oyster due to "gill disease" outbreak in 1966 (COMPS and DUTHOIT, 1976) caused by an iridovirus (COMPS *et al.*, 1978). On the French Mediterranean coast, farming of the endemic flat oyster *Ostrea edulis* continued until 1950, when high mortality occurred, and its farming was terminated (FAUVEL, 1985). In Brittany, endemic flat oyster *Ostrea edulis* was decreased by infection of the protozoan *Marteilia refringens* broke out in 1968 and by another disease in 1979 caused by the exotic parasite *Bonamia ostreae* (BUESTEL *et al.*, 2009). Production dropped from 20,000 t to 2,000 t and remains very low despite numerous efforts to

assist its recovery (BUESTEL *et al.*, 2009).

Facing the crisis of oyster culture industry in France, Dr Trochan, the director of La Tremblade Institute (former *Institut scientifique et technique des Pêches maritimes*) contacted a member of SFJO, Professor Takeo Imai of Tohoku University to ask if spat of Japanese oyster *Crassostrea gigas* resistant to these diseases could be exported to France.

Professor Imai established the research team of which members were Professor Takeo Imai (Tohoku University), Dr Akimitsu Koganezawa (Miyagi Prefectural Fisheries Experimental Station at that time, and afterward, National Institute of Fisheries in Tohoku), Mr Kunio Goto (Miyagi Prefectural Fisheries Experimental Station) and Scientific Counselor of French Embassy in Japan (Fig. 1). The research team conducted pathological and epizootic examinations of seed oysters. They asked Japanese oyster farmers to produce single oyster seedlings in cooperation with Mangoku-ura Fisheries Cooperative because Japanese oyster culture uses clumps of oyster seedlings settled on the empty scallop shells. After the examinations and preparations, they started to export from Sanriku to France.

The first trial of mass export by air took place successfully in 1969 under the authorization of both countries (Figs. 2, 3, 4). At that time, Professor François Doumenge of Montpellier University visited Ishinomaki City Hall to discuss on the best way to export oyster spat to France with Mayor of Ishinomaki City (Fig. 5). This project was continued until 1979 (GOTO, 2012, KOGANEZAWA, 1984). According to BUESTEL *et al.* (2009), 10,000 t Sanriku spat were imported from Japan to France, and production increased quickly in France. Spat capture developed rapidly in Arcachon and Marennes along the Atlantic coast, so that further spat imports

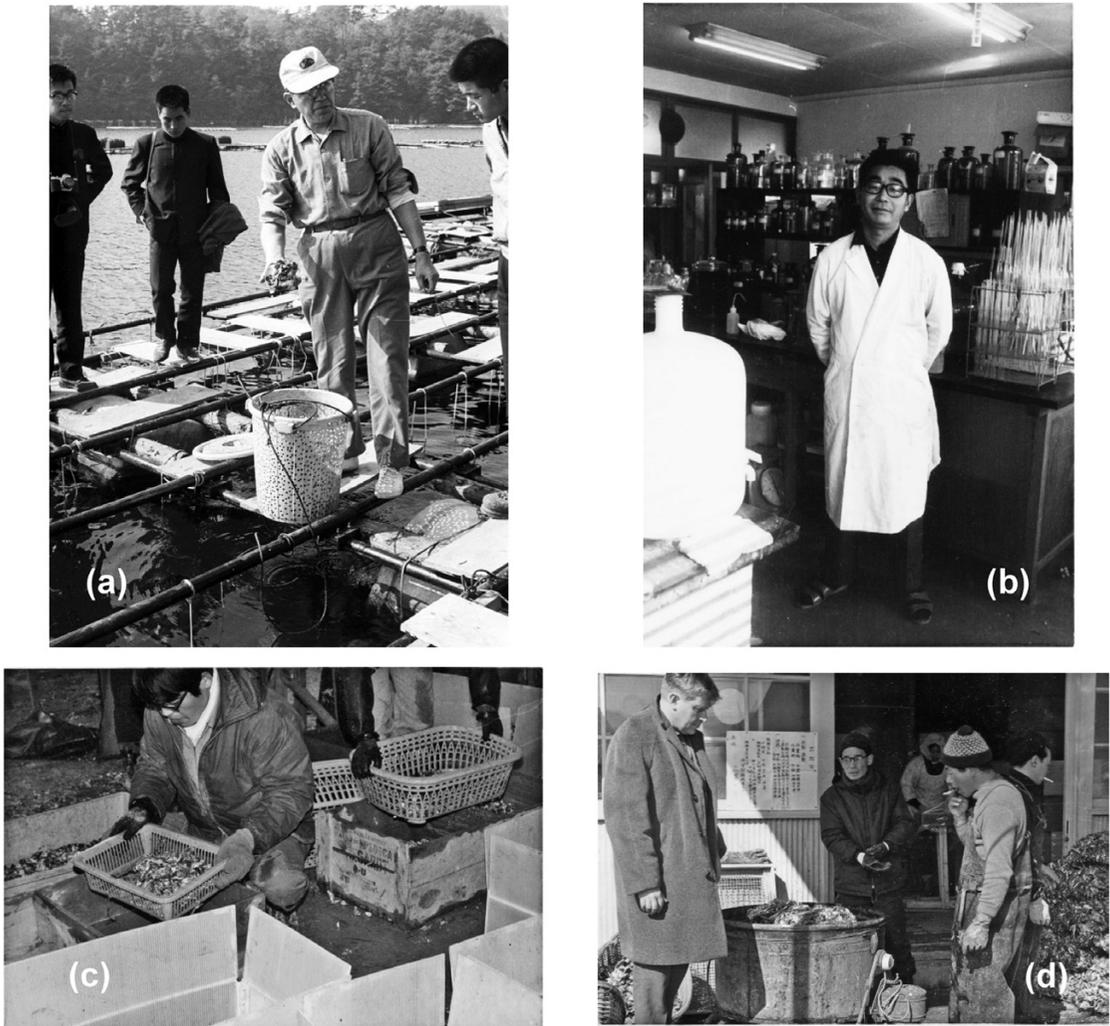


Fig. 1 Photos of Professor Takeo Imai of Tohoku University (a) provided by Yasuyuki Koike (YK), Dr Akimitsu Koganezawa of Miyagi Prefectural Fisheries Experimental Station (b) provided by Mr Kunio Goto (KG), Mr Kunio Goto of Miyagi Prefectural Fisheries Experimental Station (c) provided by KG and Scientific Counselor of French Embassy in Japan (d) provided by Mr Minji Fukuda (MF).

became unnecessary. Finally, in 1990 the oyster production in France was restored to about 140,000 t (Fig. 6).

Stimulated by this revival of the French oyster farming industry, exchanges between SFJO and France subsequently began in the field of aquaculture, and in 1984 a sister society of the French-Japanese Oceanographic Society France

(SFJO France) was established in France. Its president was Professor Dr Hubert Jean Ceccaldi of *Ecole pratique des hautes Etudes* and French President of *Maison franco-japonaise de Tokyo* at that time. Henceforth, the original SFJO is abbreviated as SFJO Japan to distinguish it from the SFJO France.

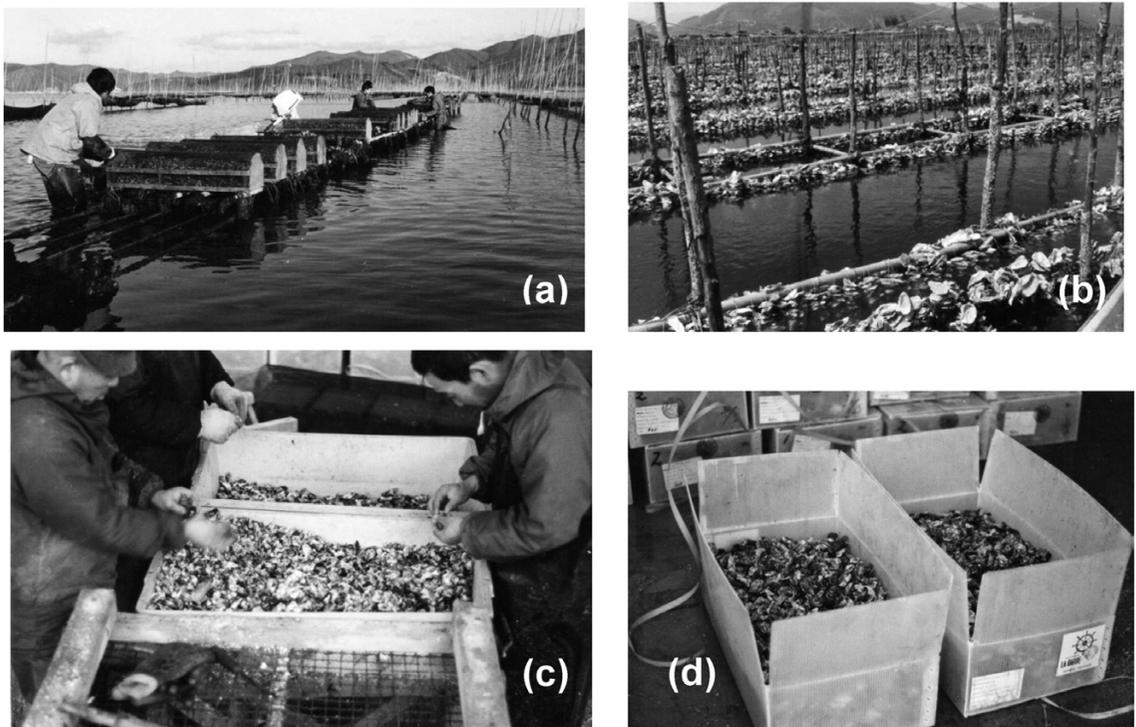


Fig. 2 Photos on preparations of Sanriku single seed oysters cultured in Mangoku-ura Inlet (a, b) and shipments of single seed oysters for France (c, d) provided by KG.

Aid from France after the Tsunami disaster in the Sanriku region

In Japan, on 11 March 2011 a huge Tsunami hit the Sanriku Coast and heavily damaged the fishery facilities, especially those of aquaculture, along the coast (Fig. 7). Just after the disaster, many French members of SFJO France contacted us to ask how the tsunami damaged the society of Sanriku Coast and offered supports for the fisheries along the Sanriku coast. Especially, Professors Hubert Jean Ceccaldi, President of SFJO France at that time and Catherine Mariojouis, President of *Association pour le Développement d'Aquaculture* (ADA), proposed to collect contributions for the Sanriku fisheries. To respond to their proposals a special committee was formed between the French and Japanese members of the two SFJOs.

Japanese oyster farmers collect in the sea in summer when oyster larvae settle on the hard substrate by deploying the scallop shells in the sea. The timing to deploy the empty scallop shells is very important for collecting oyster seedlings because other shell seedlings settle on the scallop shell in the case of the deployment when the number of oyster larvae just before settlement are less. Oyster farmers measure water temperature to examine whether the water temperature is suitable for oyster settlement, and count the number of oyster larvae sampled with a plankton net using a microscope by themselves in cooperation with prefectural fisheries research organisations. Therefore, the special committee decided to donate microscopes and plankton nets to examine the density of oyster larvae in sample waters in the first spawning

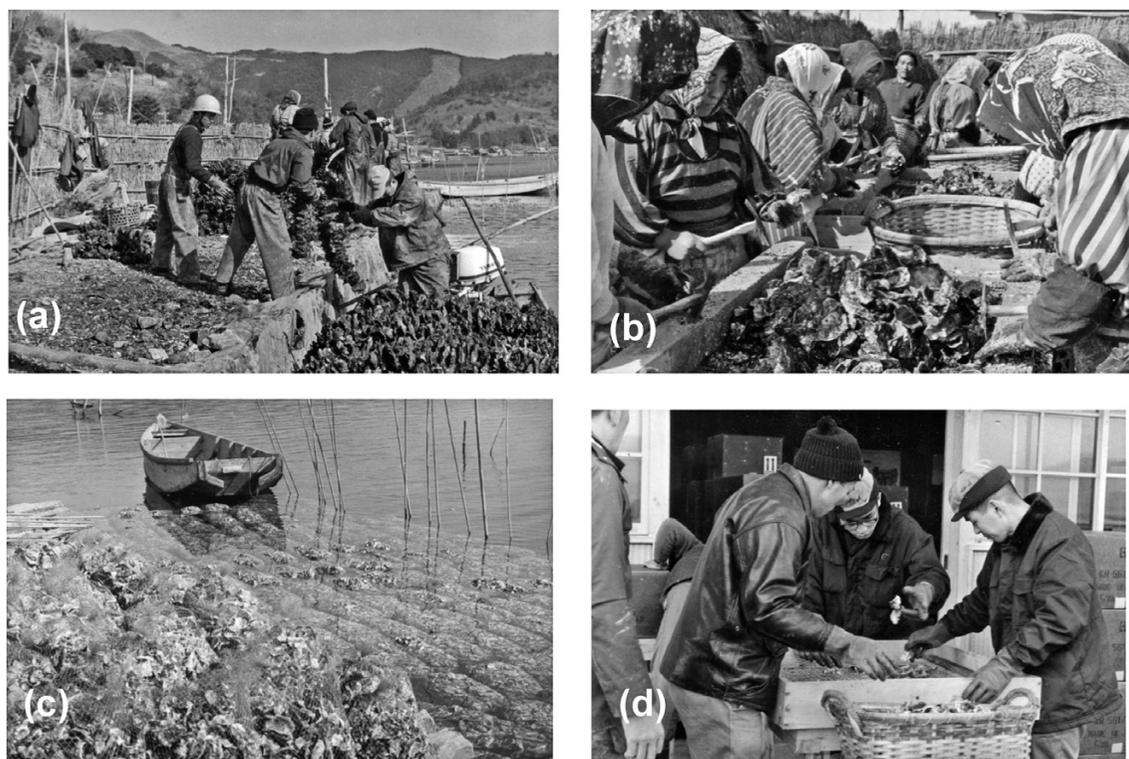


Fig. 3 Photos on harvesting (a), cleaning (b), culturing (d) and preparing shipment on land Sanriku oyster single seeds at Mangoku-ura Fisheries Cooperative provided by MF.

season of oyster during the summer just after the Tsunami through discussion with researchers and members of fisheries cooperatives of Sanriku coast. These materials are essential for scientific surveys to collect oyster seedlings in the sea that had been lost by the Tsunami and were urgently needed in summer of 2011.

The organizations that supported this collaboration are as follows:

1. *Société franco-japonaise d'Océanographie-France* (SFJO France),
2. *Association pour le Développement de l'Aquaculture* (ADA),
3. *La Fondation d'Entreprise Air Liquide / Teisan*,
4. Rotary Club Saint-Jean Marseille,
5. Gambalo Japan Project: Region of Bretagne,

6. Okaeshi Project: Marennes-Oléron area and
7. *Société franco-japonaise d'Océanographie du Japon* (SFJO Japan)

(ex-President Shiro Imawaki, President Teruhisa Komatsu, Secretary Yasuyuki Koike and Tsutomu Morinaga).

These organisations started the donations as one group from July 2011 and continued until October 2012. The list of donations was as follows:

1. Nine microscopes and five plankton-nets for Miyagi Prefecture,
2. Eight microscopes and five plankton-nets for Iwate Prefecture,
3. Life jackets for Taro Cooperative (Iwate Prefecture) by Gambalo Japan Project and
4. Buoys and ropes for Cooperatives of Miyagi

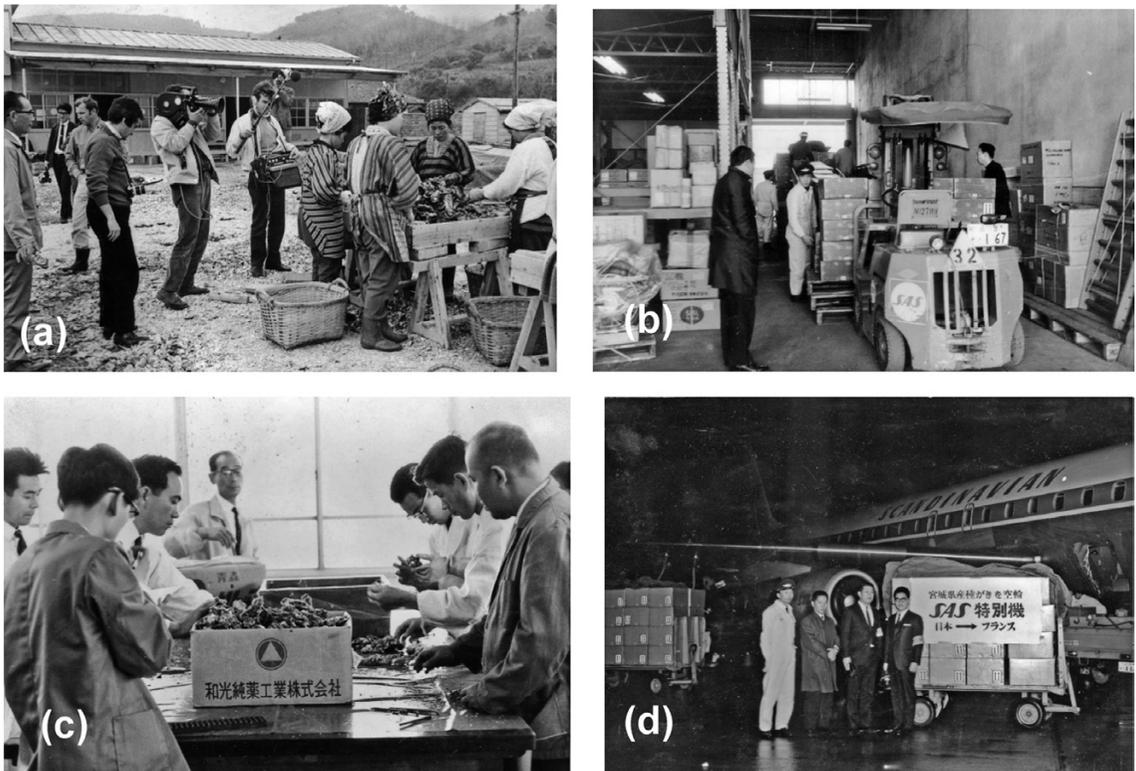


Fig. 4 Photos on the French TV crew filming women cleaning Sanriku single seed oysters (a), view of boxes containing Sanriku single seed oysters being transported from the Mangoku-ura Fisheries Cooperative to the airport (b), sanitary and pathological check (c) and boxes containing Sanriku single seed oysters with a banner saying "SAS Special Aircraft from Japan to France for the airlift of seed oysters from Miyagi Prefecture" (d). Photo (a) is provided by MF.

Prefecture by Okaeshi Project.

The organisations greatly appreciate Olympus Medical Science Co. Ltd. and Rigosha Co. Ltd. for the reduction of their prices and all members belonging to their own organisations for their contributions (Fig. 8).

At the end of the year 2011, Professor Dr Catherine Mariojouis of AgroParis Tech, President of ADA visited the Sanriku region, related organizations and regional fisheries cooperatives to encourage them (Fig. 9). In the beginning of February 2012, Professor Dr Hubert-Jean Ceccaldi, President of SFJO France, and Dr Georges Stora of *Centre d'Océanologie de*

Marseille, Vice-Secretary of SFJO France, visited there also (Fig. 10).

Visit of French delegation to Sanriku Coast and French-Japanese joint Seminar on restoration of oyster culture in Sanriku

In September 2012, about one and a half years after the disaster, thanks to a donation of *Maison franco-japonaise de Tokyo*, a joint seminar was held in the Sanriku region with a French delegation. Members of the delegation consisted of French researchers invited by SFJO Japan with the funds provided by *Maison franco-japonaise de Tokyo* and *Fondation Sasakawa franco-*



Fig. 5 Photo on the newspaper taken when French fisheries expert Professor François Doumonge (right), who negotiated to import Mangoku-ura single seed oysters as an agent, visited Ishinomaki City and met Mayor Chiba (left). Professor Doumonge said, "France wants to increase the import of Mangoku-ura single seed oysters by using the return flights of French glass eels that are airlifted to Japan".

japonaise, Professor Dr D. Bailly of *Université de Bretagne Occidentale*, Professor Dr Catherine Mariojouis, Dr Jean Prou, Director of laboratory in La Tremblade belonging to *Institut français pour l'Exploitation de la Mer*, Ifremer, Mr Olivier Laban, President of Aquitaine and Arcachon Regional Committee of Shellfish Culture, two researchers of *Université de Bretagne Occidentale* and eight oyster farmers funded by the French Government.

The French delegation first visited Iwate Prefecture to observe the areas ravaged by the tsunami at Taro, Yamada and Otsuchi fisheries

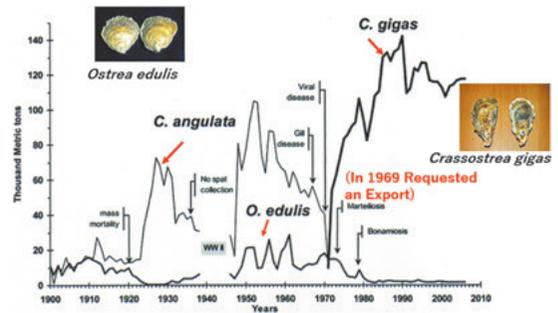


Fig. 6 Historical trend of French oyster production modified from BUESTEL *et al.* (2009). *Crassostrea angulata* shown with a thin line is Portuguese oyster in UK or "les huîtres portugaises" in France. *Ostrea edulis* shown with an intermediate thickness line is common oyster in UK or "les huîtres plates européennes" in France. *Crassostrea gigas* shown with a fat line is Pacific oyster in UK or "les huîtres creuses du Pacifique" or "les huîtres japonaises" in France.

cooperatives. At the Iwate Fisheries Technology Center in Kamaishi, a ceremony of last donation of microscopes was realized by Professor Catherine Mariojouis (Fig. 11). Then, they visited Shizugawa and Ishinomaki fisheries cooperatives (Fig. 12) and Miyagi Prefectural Fisheries Technology Institute. On the third day of the visit to Sanriku coast, a joint seminar was held at Tohoku National Fisheries Research Institute at Shiogama with participations of the members of the two SFJO and Iwate Fisheries Technology Center of Iwate and Miyagi Prefectural Fisheries Technology Institute, researchers of universities and oyster farmers of Sanriku coast (Fig. 13a, b, c). After returning to Tokyo, another open Seminar was carried out at the Maison franco-japonaise de Tokyo at Ebisu quarter (Fig. 13d). The visit of French delegation and their encouragement to Sanriku oyster farmers and fishermen, and exchange between oyster farmers in France and Sanriku have been highly appreciated by both countries.



Fig. 7 Photos on the hit of huge tsunami at the coast of Sanriku on 11 March 2011 (a) and debris of aquaculture facilities stranded on land just after the hit of tsunami (b) provided by RS.



Fig. 8 Photos on the donation of microscopes and plankton-nets additionally purchased by the groups from Professors Yasuyuki Koike (left) and Teruhisa Komatsu (centre) of SFJO Japan to Director Akira Kemuyama (right) of Iwate Prefectural Fisheries Research Center (a) and donated plankton nets and microscopes (b) on 1 May 2012. Photos are provided by YK.

Participation of Japanese delegation to the Oyster World Congress at Arcachon and site visit to oyster farms on the Atlantic Coast

After the joint seminar in Japan, Mr Olivier Laban, the president of the First Oyster World Congress, proposed the Japanese members to attend the World Congress and they presented information on the cooperation for oyster culture between Japan and France (Fig. 14). This congress was an epoch-marking event because of

the organiser was not researchers but the group of French oyster farmers associated with several research institutes. The date was from 28 November to 2 December 2012. About 250 participants from 27 countries attended. The members of the Japanese delegation were Dr Tetsuo Seki, a member of SFJO Japan and a board member of Japan Fisheries Science and Technology Association, Mr Kunio Goto, Adviser of Fisheries Cooperative of Shiogama City, Messrs



Fig. 9 Visit of Professor Dr Catherine Mariojouis to workshops of Matsushima Bay in Miyagi Prefecture to discuss with oyster farmers (a) and with an oyster farmer, Mr Watanabe (b) on 28 December 2011. Photos are provided by YK.

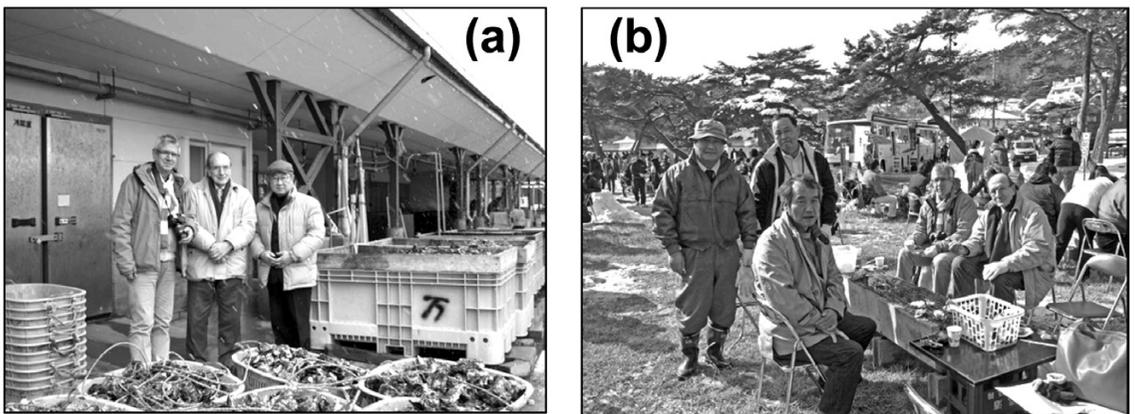


Fig. 10 Visit of Professor Dr George Stora (left), Professor H.J. Ceccaldi (centre) and Professor Yasuyuki Koike (right) in front of the workshops of Ishinomaki Bay in Miyagi Prefecture (a) and discussion with oyster farmers of Matsushima Bay tasting oysters on 5 February 2012 when Matsushima Oyster Festival took place at Green Square in front of Japan Railway East Matsushima Beach Station (b). Photos are provided by YK.

Yoshimasa Koizumi and Tamotsu Suzuki, members of the Miyagi Fisheries Cooperatives, Urato Branch, Shiogama City and the author, Dr Yasuyuki Koike, ex-Professor of Tokyo University of Marine Science and Technology and a counselor of SFJO Japan.

The visit of Japanese delegation yielded fruit-

ful results (Fig. 15). Technical information from various countries were good reference for Japanese oyster culture. Especially, recent pathological information was very important for the seed culture of each country. Our party, including Mr Goto, was widely introduced by the local newspaper under the title of "Revival by



Fig. 11 Visit of French delegation to Iwate Fisheries Technology Center (left) and donation of microscopes additionally purchased by the groups to the director of the station (right) on 2 October 2012. Photos are provided by YK.



Fig. 12 Visit of French delegation to Shizugawa (left) and Mangoku-ura Inlet (right) to see oyster culture and discuss with Japanese oyster farmers on 3 October 2012. Photos are provided by YK.

Japan" (Fig. 15).

After the Congress, the Japanese delegation visited several oyster farms along the Atlantic coast, Arcachon-Aquitaine, Marennes, Bretagne Sud and the stations of Ifremer. In Marennes, Mr Kunio Goto who examined seed oysters before exporting in 1968, was guided to the seabed in Mouillelande where the first seed from Japan were deployed (Fig. 15). Then, he could exchange information with the first oyster farmer

who transported the first Sanriku oyster seeds that arrived in Paris to Marennes. It was just an historical moment to recall the memories of 40 years ago.

After the site visit to oyster culture grounds, the delegation visited two stations of Ifremer, La Tremblade and La Trinité sur Mer to exchange important pathological information about the disease and herpes of oysters with specialists of two institutes (Fig. 15d). In the last 5 years in



Fig. 13 Views of "Japanese-French symposium on the recovery of coastal fisheries in Sanriku - in particular the recovery of oyster farming from the tsunami damage" at Tohoku National Fisheries Research Institute (a, b), the reception after the symposium where President of Japanese-French Oceanographic Society, Professor Shiro Imawaki, delivered a speech welcoming the French delegation to Sanriku at Hotel Taikanso, Matsushima City on 4 October 2012 (c) and the seminar for the public on "Franco-Japanese oyster culture: towards the reconstruction of Sanriku" at the Maison franco-japonaise on 6 October 2012. Photos are provided by YK.

France there are the very serious problem of disease in oysters again. The conclusion of the discussion was that seed oysters should not be exchanged from one region to another if there has been risk of pathogens being transferred. It is concluded that the results of research and information about the disease must be open and readily disseminated to related countries (KOIKE, 2015).

As a result of the exchanges resulting from these events, including joint seminars in Japan,

the World Oyster Congress and site visits, the French and Japanese oyster farmers and researchers who attended the events were able to obtain important information on French and Japanese oyster farming methods and diseases, understand the differences between the two countries and get tips for new approaches in their own countries.

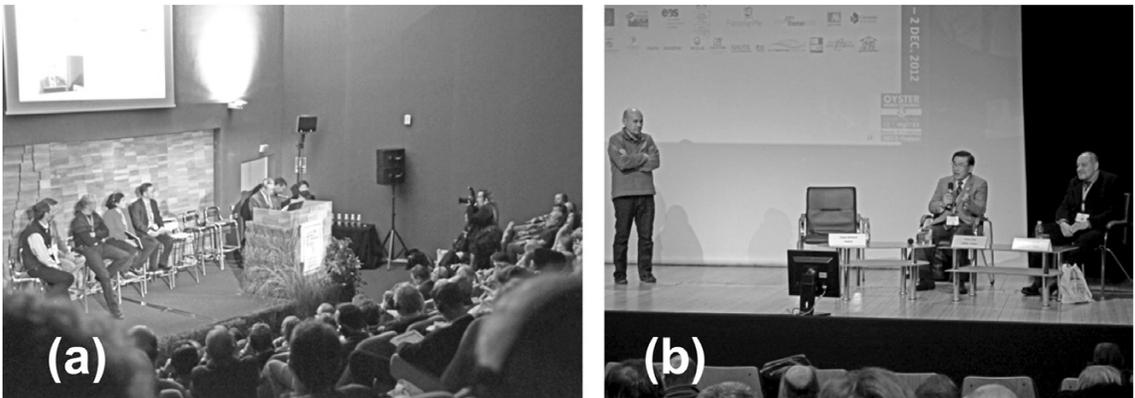


Fig. 14 Opening presentation by Professor Yasuyuki Koike, SFJO Japan in front of the podium (a) and discussion on the pathological problems of cultured oysters among experts including Dr Tetsuo Seki, SFJO Japan, second from the right (b) at the First World Oyster Congress held in Arcachon on 3 December 2012. Photos are provided by YK.



Fig. 15 Newspaper article reporting on Japanese researchers and oyster farmers visiting oyster farms in Marrennes-Oléron (a); that on visit of Dr Kunio Goto, researcher at the Miyagi Prefectural Fisheries Experiment Station (1960–1970) who prepared the export of Sanriku oyster seeds to France (b); Dr Goto and TV team covering his visit to Moillelande where the first Sanriku oyster seeds arrived in France were cultured in 1967 (c); French and Japanese experts exchange views on oyster diseases at Ifremer's laboratory in Tremblade (d) after the First World Oyster Congress on 6 December 2012. Photos are provided by YK.

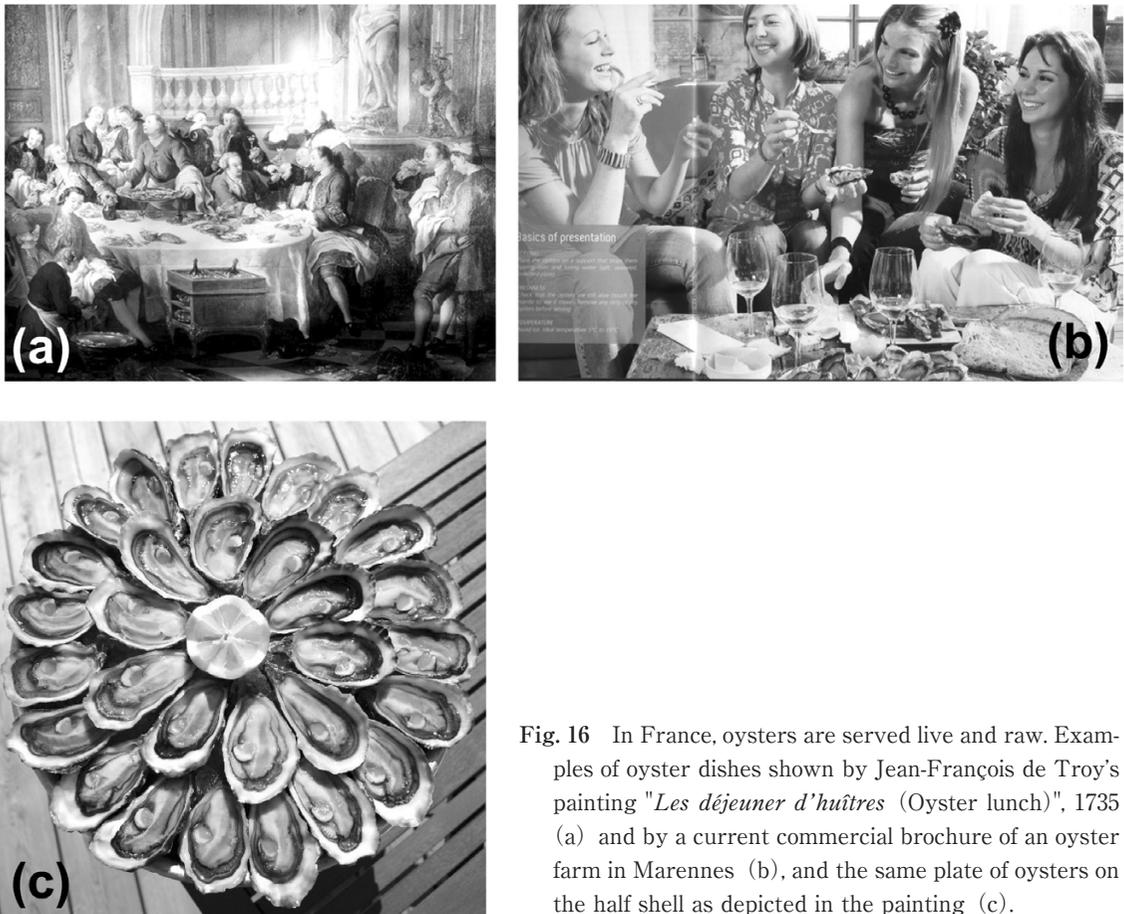


Fig. 16 In France, oysters are served live and raw. Examples of oyster dishes shown by Jean-François de Troy's painting "*Les déjeuner d'huîtres* (Oyster lunch)", 1735 (a) and by a current commercial brochure of an oyster farm in Marennes (b), and the same plate of oysters on the half shell as depicted in the painting (c).

History of oyster eating and farming methods in France and Japan

The cuisine of seafood is traditional and very old. Knowing when and how oysters were eaten is very important for deepening the exchange between Japan and France on oysters. Two countries have a long history of oysters as a food source. In Japan and France, oysters have been consumed in the Jomon period from about 16,000 BC to 3000 BC and in the Roman period from 753 BC to 476 AD, respectively. Oysters have also been cultured since the middle of the 17th century in Japan and the middle of the 19th century in France (OGASAWARA, 1980; QUERO, 2016).

The painting "*Déjeuner de huître*", Oyster

lunch in English, which once hung in the dining room of the Palace of Versailles, was painted in 1735 by the artist Jean-François de Troy at the request of King Louis XV of France. Raw oysters are served on a silver plate, the china is made in Japan, and the accompanying drink is identified as champagne from the cork flying in the air, depicting a luxurious lunch for the aristocracy (Fig. 16). The photo in Figure 16b is borrowed from a brochure of an oyster farm in Marennes. It shows that raw oysters have been eaten in France at least for 300 years.

Figure 17 shows a typical Japanese oyster dishes, which are often cooked. In Japan, oysters, an ingredient in dishes in which they are usually



Fig. 17 Typical Japanese oyster dishes, most of which are cooked. Oyster pot (a), oyster soba (b), fried oysters (c) and oyster farmers working on shucking oysters (d).

cooked, have come to be regarded as a luxury foodstuff due to the widespread use of raw oysters with shells. Over the past decade or so, the distribution of raw oysters on the shell has gradually increased. However, many oyster farmers still produce oysters without shells as the norm, in line with our traditional cooking (Fig 17d). The differences between the French and Japanese oyster-preparation methods are closely related to the environment of natural oyster habitat and the oyster farming methods adapted to their environments. The natural habitat of

Pacific oysters in Japan is the middle level of the intertidal zone, where they fix on rocks and other hard substrates (Fig. 18). On the Atlantic coast of France, where the tidal range is very large (4-14 m), oyster farmers can use the huge intertidal zone horizontally as the culture ground. In Japan, where the tidal range is not so large (2-4 m), oyster farmers must use the coastal water vertically by hanging culture to increase oyster production (Fig. 19). The tidal range relating to the intertidal zone is the most significant difference in the oyster culture



Fig. 18 Typical landscape on the Atlantic side of France comprising natural oyster beds (light area) and seaweed (dark area) in the wide intertidal zone taken at Ile d'Aix (left) and typical landscape in Japan comprising dispersed oyster individuals and rock in the narrow intertidal zone at Kenzaki, Miura Peninsula, Kanagawa (right). Photos are provided by YK.

environment between the two countries (Fig. 19). However, on the French Mediterranean side, oyster farming is similar to that in Japan because the tidal range is small (less than 1 m).

In France, oysters cultured in the intertidal zone take about 3 years to shipping size because oysters which are a filter feeder under the sea cannot feed in the air during the low tide. Their shells are hard and stronger since they are exposed to the air at the period of low tide and need to endure such a condition in the air. Thus, in France, oysters have strong vitality in the air and their edible parts are crunchy and muscular. In the case of Japan, oysters cultured always under the sea grow to shipping size only in 1.5 - 2 y, because they can spend 24 h to feed and grow fast. As they are always farmed underwater, they do not have to withstand airborne conditions and their shells are not as hard. The edible parts of such oysters are soft and fat, and muscle development is weak. Thus, Japanese

oysters cannot survive in the air for as long as French oysters. However, shell-less oysters are not expensive and can easily be prepared as a home-cooked dish. This difference between French and Japanese oysters actually brings the eating habit of oysters in each country.

In France, almost all oysters are sold on the shell and eaten raw straight from the shell. Oysters are considered a special dish for parties at the end of the year such as Christmas and New Year's Day. Therefore, most oyster consumption in France occurs in December and January (BUESTEL *et al.*, 2009). As such, the eating habits and method of preparation depend on oysters and culinary tradition between the two countries. To change or increase the quality of the products, consumers' tastes must be well reflected.

It is necessary for Japanese and French to learn the differences in the history and background of oyster consumption and farming



Fig. 19 Oyster farming using the intertidal zone in Brittany on the Atlantic side of France (a) by placing nets containing oysters on shelves on the seabed there (b). Oyster farming using the subtidal zone in Matsushima, Japan (c) to suspend lumps of oysters on the vertical ropes (d). Photos are provided by YK.

for mutually understanding the difference in food cultures.

Technical exchanges between the two countries in aquaculture

Technology learned from France

In the Mediterranean Sea, Lake Tho, where the tidal range is exceptionally small in France, a method of growing single oysters by attaching them to ropes with cement was developed (Fig. 20). In Japan, where hanging culture is very popular, this efficient method has been adopted in the disaster areas of Sanriku and is proving ef-

fective.

Under the guidance of Dr Tetsuo Seki and Mr Kunio Goto mentioned above, a test oyster culture was conducted on Urato Island in Shioyama City. In this pilot culture, the French method of placing oysters in the intertidal zone has been modified by suspending nets containing oysters at a depth that is intertidal (Fig. 20). In Japan, scallop shells are used as a substrate for collecting oyster seedlings, while in France, a highly efficient plastic collector called "*coupelle*" in French is used. It has now been imported from France to Japan and used for farming

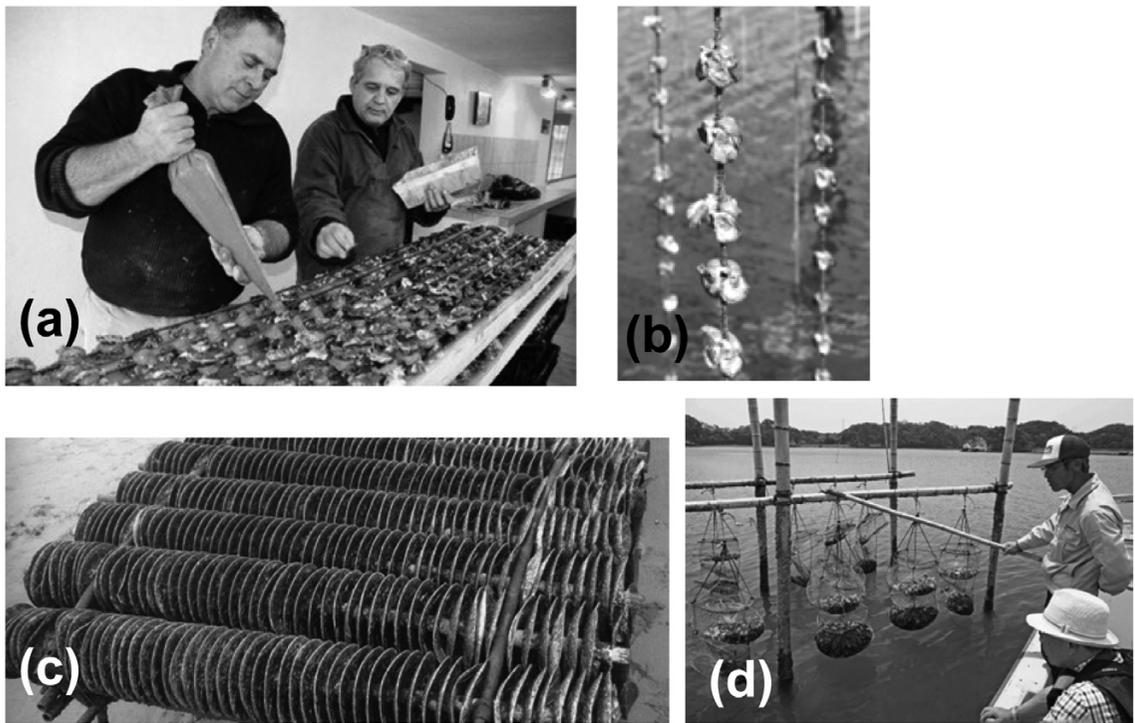


Fig. 20 Two oyster farmers fixing oysters to the rope with cement (a), oysters secured to a rope emerging from the sea during low tide in the Thau Lagoon facing on the Mediterranean side of France (b), oyster seed collectors, which were imported from France to Japan, placed on the seabed in the intertidal zone (c) and nets containing single seed oysters placed in the intertidal zone in Matsushima Bay, Japan (d). Photos are provided by YK.

single seed oysters (Fig. 20) because oysters with shell are more valuable than those without shell. The oysters raised in the intertidal zone are now commercialised as raw oysters with shell under the brand "Atamako-gaki" (Fig. 20).

In the case of Manila clams, the traditional method of Manila clam culture in Japan relies on natural seed collection but overfishing and degradation of the marine environment have necessitated artificial seedlings. In France, the technology, called the up-welling system, uses cylindrical rearing tanks with water flowing from the bottom to overflow from the top of the tank enabling to accommodate rearing seed clams at a higher density than with conventional methods

(Fig. 21). The water flow is evenly distributed to the juveniles, thus increasing the feeding efficiency. Researchers in Chiba Prefecture have adopted this latest technology from France.

Technology learned from Japan

In 1977, Dr Dao and Dr Buestel from the *Centre Océanologique de Bretagne* (COB) visited Japan and introduced scallop culture materials of the Tohoku region to France (Fig. 22). In France, these materials are also used for oyster culture (Fig. 22).

In 1989, researchers and oyster farmers from France visited Japan, and after visiting aquaculture facilities in various regions, a

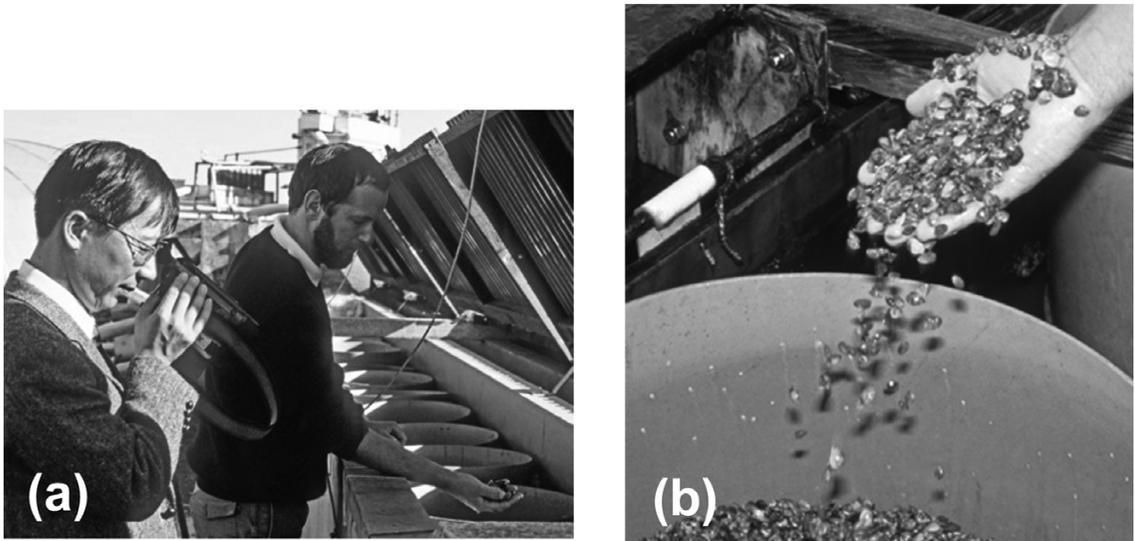


Fig. 21 Seed production system of Manila clam (a) and seeds of Manila clam produced (b) in Normandy. Photos are provided by YK.



Fig. 22 Two researchers, Dr J. C. Dao and Dr D. Buestel of *Centre Océanologique de Bretagne* (COB) belonging to *Centre National pour l'Exploitation des Océans* (CNEXO), the forerunner of Ifremer, visiting to Mōura facing Mutsu Bay, Aomori Prefecture in Tohoku Region for surveying shellfish culture methods in Japan in 1977 (a), the same types of scallop farming materials they imported from Japan to France (b) and the baskets used for scallop farming in Japan are used for oyster farming in Brittany, France (c). Photos are provided by YK.



Fig. 23 French-Japanese seminar on aquaculture held in 1989 at the *Maison franco-japonaise* de Tokyo at Ochanomizu, Tokyo. On the far left is Professor H. J. Ceccaldi, then French President of the *Maison franco-japonaise de Tokyo*, and on his right Professor Yutaka Uno of the Tokyo University of Fisheries. Photo is provided by YK.

technical seminar was held at the *Maison franco-japonaise de Tokyo* with Professor H. J. Ceccaldi, French President of MFJ, and Professor Y. Uno of Tokyo University of Fisheries (Fig. 23).

Finally, as for the first author's achievements, from 1973 to 1976, the author stayed at the COB in Bretagne, and succeeded in producing the first seedlings of French abalone (*Ormer*), *Haliotis tuberculata*, by applying Japanese technology, and was able to release many juveniles in a closed fishing zone (Fig. 24).

Conclusion

The history of technological exchange between Japan and France in the field of shellfish culture since the founding of the Society was reviewed. At the time of its establishment, Japan was one step ahead of France in terms of history and development in this field. Since the 1980s, France has made remarkable progress in technological development. Since the 1990s, techno-

logical exchanges between the two countries have flourished, and they have been studying each other's technologies. In the oyster farming, in particular, there is a history of mutual assistance between the two countries as mentioned above, which has resulted in mutual overcoming crises. At a time when there is concern about the impact of global climate change on the coast and the ocean, exchanges between the two countries in various fields of fisheries science and oceanography including fisheries cooperatives, fishermen and oyster farmers are crucial to overcome future problems caused by global warming and to develop sustainable shellfish culture and other fisheries. Further cooperation between the two countries is strongly desired.

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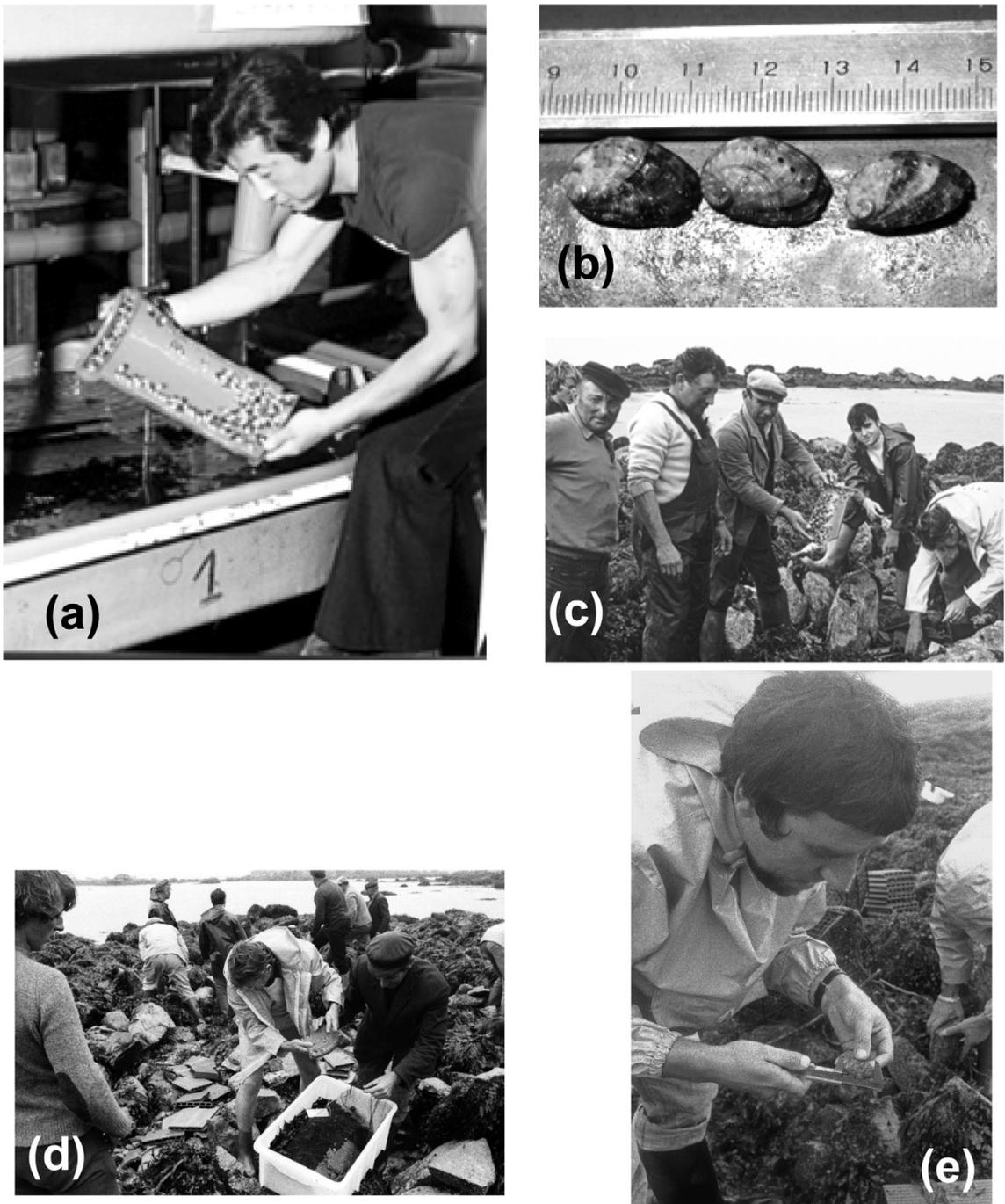


Fig. 24 Professor Yasuyuki Koike who was the first to apply the Japanese abalone aquaculture method to the French abalone *Haliotis tuberculata* and succeeded in producing its seedlings (a), Grown *H. tuberculata* (b), release of grown *H. tuberculata* into the sea (c, d) and measurement of shell length of grown abalone in the field (e) in 1975 when he has conducted research at COB from 1973 to 1976. Photos are provided by YK.

historical pictures. They thank *Maison franco-japonaise de Tokyo* and *Fondation Sasakawa franco-japonaise* for providing funds to invite French researchers in Japan in 2012.

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