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Comité d'Organization du Deuxième Symposium Franco-japonaise d'Aquaculture

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DISCOURS D'OUVERTURE DU PRESIDENT MATSUURA

F. MATSUURA
Président du Cometé d'Organisation

J'ai aujourd'hui le grand honneur de vous saluer a l'occasion de l'ouverture de la journée franco-japonaise. Je voudrais exprimer ici mes plus grands remerciements et souhaiter chaleureusement la bienvenue a vous tous et en particulier aux participants français qui ont bien voulu venir de si loin.

Comme vous le savez, le premier Symposium Franco-japonais sur l'Aquaculture s'est tenu avec succes au mois de décembre dernier a Montpellier. Son bilan s'est révélé hautement positif et il a été proposé par le Dr. Ceccaldi de tenir ce type de rencontre alternativement dans chaque pays. Malgré un certain nombre de problemes, il est a souhaiter qu'il y ait développement de la coopération scientifique et technique.

Ainsi, a l'issue de discussions entre chercheurs réunis, a-t-il été décidé de mettre sur pied un Comité chargé d'organiser le deuxieme Symposium Franco-japonais sur l'Aquaculture qui pourrait être l'amorce de cette coopération. C'est donc pour nous un grand plaisir que de voir aujourd'hui se réaliser cette rencontre sous le patronage de la Société Scientifique des Pêches Japonaise.

Il est évident que l'accroissement rapide de la population mondiale causera de graves problemes alimentaires dans un futur proche. Le domaine des pêches et des cultures marines offre certainement de tres grandes possibilités de développement a cet égard. Les techniques utilisées ne sont plus d'ordre purement empirique mais font désormais appel a la biologie, la physique, la chimie, l'ingéniérie, et l'agronomie. Il est donc de notre devoir, a nous spécialistes des pêches et de l'aquaculture, de contribuer progressivement a la solution de ce probléme alimentaire, non seulement au Japon mais aussi dans le monde entier.

Depuis longtemps le Japon et la France se sont intéressés au développement des pêches et des cultures marines et ont accumulé une somme considérable de connaissances scientifiques et techniques dans ce domaine. Les échanges d'information entre nos deux pays ont surtout lieu a travers publications et documents scientifiques, bien qu'il ne soit pas possible de prendre connaissance de tout ce qui existe, tant la litterature spécialisée est importante de nos jours. Par ailleurs, il est souvent difficile de pouvoir se comprendre uniquement par cette voie. La vraie communication doit passer par des rencontres et des discussions.

Tel est le but essentiel de ce Symposium.

La France et le Japon ont chacun leur culture propre, il est donc normal qu'il y ait divergence des modes de pensée. D'apres les expériences, nous savons combien la mise en commun d'approches différentes peut être propice au progres scientifique et technique. Tel est l'autre rôle du Symposium: permettre de découvrir un autre mode de pensée et contribuer également a une meilleure compréhension entre les deux pays.

Nous souhaitons que ce type de rencontre permette de mettre en place une coopération franco-japonaise aussi bien culturelle et scientifique que technique, et qu'il renforce les liens d'amitié entre le Japon et la France.

Bien que la durée de ce Symposium soit trop courte, je souhaite que les échanges soient les plus nombreux possibles et que vous puissiez en tirer le meilleur profit.

RESEARCH AND DEVELOPMENT OF SALMONID CULTURES IN FRANCE

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Abstract

Research in salmonid marine rearing induced in the early seventies provided the technical basis for the development of this activity on the littoral of North west France. Cage production increased rapidly between 1976 and 1981, then remained at the same level until 1984 when the overall marketed production was about 400 tons.

The present cycle of production is fitted to the environmental characteristics of the French coastline which presents a constantly high salinity (33-35‰), associated with warm summer temperatures (range 8 to 17 ^{o}C in the open sea). These environmental parameters create critical conditions during summer months and limit the rearing periods for several species.

Rainbow trout (Salmo gairdneri) ineluctably suffers consistent mortalities after a certain time of exposure to high salinity and high temperature seawater. The species develop anatomical lesions such as external hemorrhagic lesions, gill epithelial necrosis, modification of the fatty tissue surrounding the pancreas, and deep metabolic modifications: severe hydromineral disequilibrium, drastic drop in gill Na^+ K^+ ATPase activity, sharp decline in hepatic glycogen and blood cholesterol, modification of the plasma protein composition indicative of an inflammatory process; increase of blood pH associated with a respiratory alcalosis.

The production cycle is thus limited to cooler months with direct transfer of 150-200 g fish in November-December, and harvest of 1 to 1.8 kg fish between April and July.

The cycle of production of coho salmon follows a similar pattern, with adaptation of large 0 age fall smolts (120-250 g) and harvest through winter and spring of pan size (350-400 g) or larger fish (0.8 to 1.5 kg). Attempts to produce coho salmon in seawater with an early transfer of spring 0 age smolts (20 g in May) provided interesting results, but summer months may be critical in some years especially in some site locations.

Research carried out with other species are still on the preliminary phase:
(1) Brown trout (Salmo trutta) shows a high resistance to summer conditions in the sea and may be reared all year round with low mortalities. A development of the production may occur in the near future, providing that early maturation could be controlled.
(2) Atlantic salmon (Salmo salar) tests indicate a high sensibility to Aeromonas salmonicida, a moderate resistance to high temperatures and a high rate of early maturation after only one sea winter.

For all these species, the factors conditioning production development, as well as the major inputs to be expected from research progresses are discussed.

The first trials in salmonid marine rearing in France were initiated in the early seventies, simultaneously by a small private company and research organizations. These included preliminary tests of growth and survival in seawater with rainbow trout (Salmo gairdneri) and in the freshwater rearing phase of anadromous species like coho salmon (Oncorhynchus kisutch) and Atlantic salmon (Salmo salar) respectively in 1972 and 1973.

The following years allowed to define marine rearing criteria with production cycles adapted to the local coastal environment, both with rainbow trout and coho salmon (Harache and Novotny, 1976). The number of operating farms increased rapidly during the 1976 to 1980 period in North west France (north of the Loire estuary). Most of them were of small scale with limited investment and no freshwater facilities.

The production increased noticeably in the mean time, mostly with rainbow trout of which the juveniles could be purchased from freshwater growers, and reached a plateau in 1981 due to growing production costs and a relative stagnation of market prices.

We propose to analyze the characteristics of the production and discuss possible further developments.

Marine environment

The environmental characteristics of the coastal areas where cage rearing is practiced have been documented in Harache and Novotny (1976), Harache (1979), and Boeuf and Harache (1980).

The main points to be stressed are:

(1) mild winter temperature (7-12 °C) allowing a fast growth,

(2) high summer temperature (16-20 °C) with strong and unpredictable annual variations. A wide variety of local conditions are observed on the different sites,

(3) constantly high salinities in oceanic sites (34-36%) except in estuaries where lower values are observed during winter months.

The combination of both high salinity and temperature has been identified as the major cause of difficulties during summer months. This has led to several trials in a brackish water estuarine environment which did not bring obvious improvements. It is considered to date that the beneficial effect of decreased salinities is largely inhibited by estuarine characteristics which include both turbidity, frequent hypoxic conditions and possible pollution discharges. The best results are finally obtained in purely oceanic clear water presenting the smallest thermal fluctuations.

Juvenile availability

Rainbow trout

The French freshwater environment can be considered as excellent for salmonid rearing. This fact is clearly demonstrated by the rapid increase of rainbow trout production (26,000 t per year of which 8,500 t are produced in Brittany). The existence of this dynamic activity constitutes a favorable support for the emerging marine fish farming. In fact, the development of domestic rainbow trout rearing into seawater was facilitated by the existence of juvenile in appropriate numbers and size at a period where salt water transfer could be practiced. The almost totality of marine plants do not operate a freshwater hatchery and purchase the fish (120 to 200 g) in the fall (late October to end of December). These animals are generally 10 to 12 months old (from hatching) and are included in the faster growing part of the population, which is the first one arriving on the market. However, the available quantity during this period is presently probably limited to 500 t in Brittany; the prices are high and the competition between marine farms may contribute to a sure estimation. Further developments of the activity in seawater would necessarily implicate a better organization of the growers to produce themselves their own juveniles and/or modification of the freshwater activity oriented towards the rearing of a specific product for seawater transfer. This may provide a larger availability of high quality trout during the periods of high demand but would most probably induce a further increase in the prices of the juveniles.

One must consider that a modification of the production cycle in freshwater has to fit with the seasonal flow variations of the rivers. In Brittany, the minimum flows are observed in September and October at a time where the biomass in the hatcheries is highest and fish growth very active. These conditions are not always compatible with the production of high quality fish to be transferred directly into seawater. Transfers of trout from other regions may be considered but serious risks of VHS (viral disease) contamination is a dissuasive factor, as Brittany is so far still free of this disease.

Coho salmon

This species proved to be relatively easy to rear in freshwater in trout facilities, with high survival and excellent growth. However, the research carried out to test the adaptation to seawater of high salinity revealed reactions of the species to the local environment which are different than within the natural range of the species. Coho salmon exhibits a precocious smoltification in the first spring of its life but the "window" during which successful direct transfer to seawater could be practiced is very narrow and must be fitted both with smoltification pattern and seawater temperatures. However, summer temperatures on a warm year may be critical, especially on poorly situated sites and most growers prefer transferring smolts in the fall. Optimum dates and minimum sizes required both for spring and fall transfer have been determined experimentally by Harache et al. (1980) and Boeuf et Harache (1982). The demand of coho smolts by marine growers remained limited until 1982 as all the farms except one were choosing rainbow trout for their production. The limits of this activity appearing more clearly, a new interest towards coho led to an increasing demand of smolts which might raise rapidly. In 1984, coho salmon were reared in nine marine farms and in the mean time more freshwater growers tried coho salmon as a possible substitute for freshwater reared rainbow trout, due to the new fish farm effluent regulation requiring a decrease of rearing densities to match new pollution standards.

Availability of coho salmon smolts for seawater transfer remains low but could be organized by trout growers if the demand increases.

Other species

The production of juveniles of Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) is still almost inexistent in the areas developing marine farming.

In the hypothesis of the emergence of a demand of juveniles, several years would be necessary to organize smolt production.

Production cycles and market acceptability

The particular environmental conditions existing on the French sea shore, expressed above, led to define production cycles fitting with the physiological aptitude of the species and its biological rhythms. These have been described in Boeuf and Harache (1980).

It has to be noted that besides the summer mortalities problem, early maturation, a general phenomenon in France, would seriously affect trout and coho salmon. Moreover, it seems obvious that relations between maturation and summer vulnerability may be established.

As a consequence, the rearing cycle, both for coho and rainbow trout remains confined almost exclusively to the October-July period, allowing thus to produce fish of 0.3 to 1.5 kg with an average weight of 0.8 kg when trout are kept in sea cages for harvest in June an average weight of 1.6 to 1.8 kg is reached. The period of harvesting is confined to a limited period March-July, creating specific commercial difficulties. Fish are sold round and fresh with good whole sale market prices (rainbow trout-28 to 32 F/kg, coho salmon-35 to 41 F/kg, or processed in the form of smoked small fillets which seem to have a good acceptance on the market.

The product, recognized of high quality is thus in competition with similar or comparable products either imported (rainbow trout, or salmon from Northern Europe) or produced in freshwater in France, and which remain for a longer period on the market. One may note a tendency of evolution in a part of the freshwater trout farming industry towards the production of large fish (superior to 1kg) destinated to the smoking processing.

Summer mortalities in seawater

Rainbow trout

Since the first trials, it has been apparent that rainbow trout was suffering serious mortalities during summer months, with strong variations following sites (15 to 90 %). This particular point has generated a research effort to explain this fact and possibly improve the resistance of the species. It appears today that the strains presently tested show ineluctably after a certain time of exposure to high salinity seawater of high temperature, physiological disturbances and severe mortalities affecting a part of the population. Surveys conducted since 1980 on different sites allowed to observe that sensible mortalities (over 1 % per day) appeared systematically after about 350 degrees day of exposure to temperature higher or equal to 17°C (Anonym, 1983). The symptoms observed on the trout during this period include:

(1) slow growth or even weight loss in certain fish; external hemorrhagic lesions, not or rarely associated with typical vibriosis outbreak,

(2) gill epithelial necrosis, intestinal desquamation and lesions of the fatty tissue surrounding the pancreas,

(3) severe hydromineral disbalance with pronounced increase of the osmotic pressure and electrolyte concentration in the plasma, and drastic decrease of the gill Na^+ K^+ ATPase activity in July,

(4) deep metabolic modifications including a decrease in hepatic glycogen and blood cholesterol and an increase of two plasma protein fraction, as sociated to a decrease of the albumin fraction - these protein modification are indicative of an inflammatory process.

It has also been shown that rainbow trout during this period shows a respiratory alcalosis, pH of the blood increasing to values higher than 8.0 (Thomas, 1980). In these conditions, fish would be able to use anaerobic metabolism ways.

All these facts show clearly the intensity of the physiological distress for this species kept into seawater or high temperature and make very hazardous to continue the rearing period after July even on the sites where the mortality is not too high, due to the impossibility to predict the evolution of weather in summer.

Coho salmon

This species may present similar responses on some sites, but is undoubtfully more resistant to these extreme conditions. This has allowed on several occasions farmers to adapt coho salmon in the spring of their first year or to keep large yearlings during summer with very low mortalities. However, for the same reasons developed earlier with rainbow trout, this practice cannot be considered as free of risks and cannot be applied to sites where water quality is poor.

Other species

The different preliminary trials conducted with atlantic salmon are not sufficient to conclude to a high resistance of this species to summer conditions: sensible mortalities (associated or not with bacterial infection) and moderate growth have been repetitively observed, in addition to a high rate of early maturation. However, major progresses have been made over the last years in the production of atlantic salmon one year smolts. Growth characteristics as well as development of the smoltification pattern have been described in recent papers such as Boeuf et al. and Boeuf and Harache (in press).

Trials conducted with some strains (migratory or sedentary) of brown trout (Salmo trutta) have clearly shown a good resistance and a growth superior to all other species tested during summer. This fact is opening new ways of investigations with possible application to the development (Boeuf and Harache, 1984).

Prospects for development

The specific environmental conditions of the French coastline makes it necessary to adapt techniques and find original patterns of exploitation fitted to environmental and economical constraints.

Potential improvements may be reasonably expected from specialized research within a delay of five to ten years. An experimental tool, constituted of two hatcheries and a cage rearing facility is progressively put in operation by CNEXO and INRA (Institut National de la Recherche Agronomique) in 1984 and 1985. Approaches in nutrition, genetic and zootechnic will be undertaken in these stations.

In nutrition, a research of feed well adapted to the specific needs of the animals in the French environment is presently initiated, more specially for the marine rearing phase. Improvement of performances may be expected in growth rates, food conversion, reproduction and possibly summer survival.

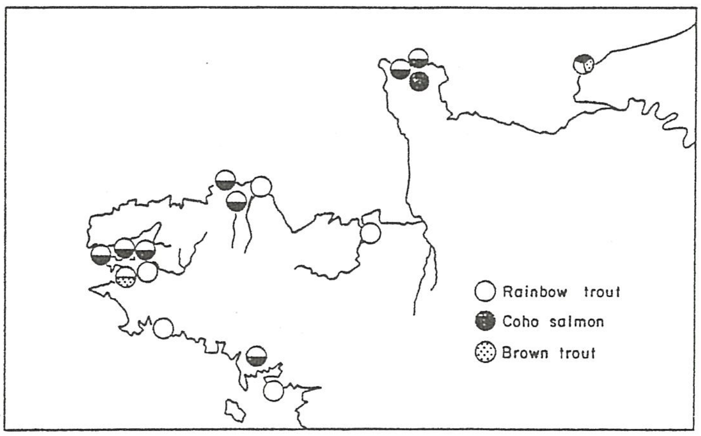
Genetics may provide answers to the problem of early maturation, either by the selection of appropriate strains for this purpose, or by the development of hybridization and cytogenetics (Chevassus et al., 1984).

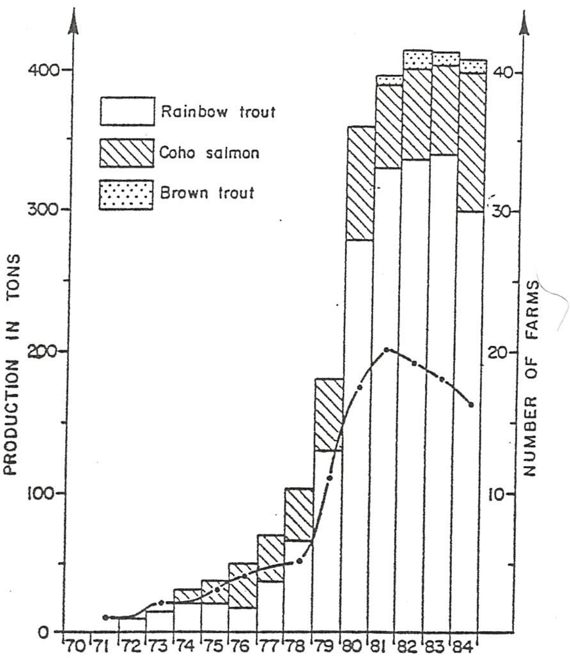
From a general point of view, the prospects for the development of the activity may be summarized as follows:

Considering the magnitude of the physiological disturbance affecting rainbow trout in seawater during summer months, it seems unlikely that a definite solution could be found and applied on a short term basis. This means that the activity will have to adapt to the particular situation of winter production, improve performances and reduce the production costs to remain competitive with comparable products. One may assess that a substantial cost reduction could be obtained in fairly large production units, assuring juvenile production, seawater fattening and possibly processing of the final product. In the other hand, it seems obvious that rainbow trout farming at sea can perfectly stands as a secondary occupation in complement of other marine activities. From a general point of view, an improvement of growth performances as well as a general decrease of production costs may be expected from optimization of rearing techniques.

Coho salmon of which technical and economical aspects were detailed by Harache (1979b and c) is susceptible of a substantial and rapid development providing that smolt production grows in regards to the demand of marine growers. The problems of reproduction in captivity of the species will have to be solved in order to constitute the basis of a real brood-stock adapted to the French environment. The scale and characteristics of the market for this type of fish remains to specify.

The possibilities offered by other species are still speculative as few informations are available yet, especially for atlantic salmon. Migratory sea trout or brown trout might well provide an interesting alternative to rainbow trout for the production of large size animals. More results are to be obtained concerning fish aspect (silvery color) and age at maturity. For both species, if the demand is raising, specific production in freshwater will have to develop, more probably by evolution of the existing rainbow trout farming industry.





For all these species, a major input is to be expected from genetics techniques susceptible of controlling early maturation in the next tears. Due to the excellent winter growth conditions, such an improvement would have important economic implications for the French salmonid aquaculture.

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MARINE FISH AQUACULTURE IN FRANCE

- Seabass (Dicentrarchus labrax), Seabream (Sparus aurata), Turbot (Scophthalmus maximus) -

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Introduction

Aquaculture production in France stems mainly from two traditional but performing activities: mussel and oyster cultures (87 % in tonnage) and salmonid rearing in fresh water (12 %). During the last decade, substantial efforts, considering the status of aquaculture in France, have been made in the field of biological and technical research, in order to promote the production of marine fishes, especially seabass (Scophthalmus maximus) as well salmonids in seawater (trout and salmon). For seabass, seabream, and turbot, first priority has been given to the control of juvenile mass production in hatchery. Consequently, detailed investigations on gonadogenesis, reproduction, egg incubation and hatching, larvae and juvenile rearing were conducted at the DEVA experimental station (near Montpellier) for seabass and seabream, and at the Brest experimental aquaculture center of IFREMER for turbot and sole. The second priority, which implies the availability of juveniles on a commercial basis, was to satisfy the minimum conditions required for the development of production.

If the results obtained in mass production of juveniles are still to be improved, especially for seabream and turbot, it has been proved that it is much more difficult to master all the socio-economical factors which in fine control the development of production.

1. Seabass

1.1. Status of production

Research on seabass was initiated in the early seventies at the Sète Biological Station of Montpellier University, by Barnabé and René in 1972. CNEXO started its own research program in 1972 at Brest, and in 1975 at the DEVA station located near Montpellier on the Mediterranean coast where an experimental hatchery was established.

From 1970 to 1978, basic techniques of maturation, larval and juvenile rearing were gradually improved. By the end of 1980, these techniques were implemented by three private hatcheries.

Juvenile production reached 600,000-800,000 fry/year and production of pan-sized seabass started on commercial basis, using both cage culture and pond methods. Later on, the development of production has been rather slow since several limiting factors were simultaneously encountered: (1) supply of juveniles, (2) farm implementation.

1.2. Larval rearing

Up to 1983, the main characteristics of larval rearing of seabass (Fig.1), both in experimental and commercial hatcheries, were:

(1) a rather low survival rate from hatching to the end of the larval stage (< 30 %),

(2) a great variability in the production results,

(3) a high frequency of larvae and juveniles showing vertebral and swim bladder abnormalities (> 70 %).

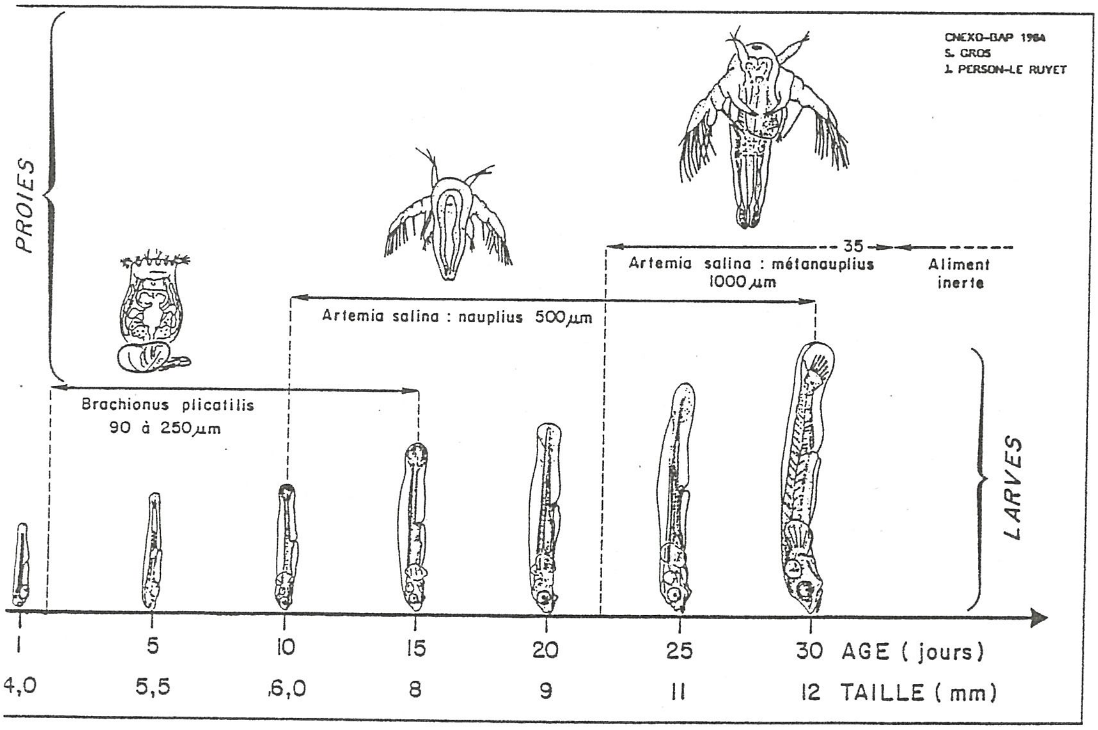


Fig. 1. Schéma du développement de la larve de bar de l'éclosion à un mois, et séquence alimentaire correspondante
Température d'élevage 19 ± 1°C (PERSON-LE RUYET et BEDIER, 1984).

The low efficiency of the hatchery techniques was a major obstacle to the development of seabass aquaculture. Among the various factors which could contribute to these rather poor results, attention was paid to major environmental conditions i.e. temperature, light, tank characteristics, stocking densities and feeding conditions.

Although the results obtained during the 1984 season need to be confirmed, it has been established that egg incubation and larval rearing temperatures and light are of major importance. The optimum temperature, based on subsequent larval rearing performances, during the incubation stage and the first period of larval rearing, is close to the temperature in natural conditions. Only later on, can higher temperatures (> 20 ^{o}C) be in order to shorten the juvenile production period. The intensity and wavelength must be considered together along with tank color. The best results were obtained with an extremely low light intensity and the use of rearing tanks with black walls.

Trials at the DEVA station in 1984 were realized using two larval rearing methods:

(1) semi-intensive in 10 to 15 m^3 circular ponds,

(2) intensive in 2 m^3 cylindro-conical tanks.

Water temperature was adjusted to 14-16 ^{o}C (instead of 18-20 ^{o}C the previous year), and light intensity was reduced from an artificial 2000 lux - 24 hours photoperiod pattern using fluorescent spots to a natural light and natural photoperiod (9 hours of daylight in January to 12 hours in April). Moreover, the color of cylindro-conical tanks modified from white-grey to black. Running water was used instead of green-water. Consequently, the water quality inside the tank was improved.

The results obtained (Table 1) show significant progress in seabass larval rearing: survival rate at 50 days increased from 15 % to 57 % in semi-intensive trials and to 43 % in intensive trials.

The rates of swim bladder and vertebral abnormalities still show a large variability despite a clear trend towards improvement.

Using semi-intensive rearing methods, the rate of well inflated swim bladder increased from 5-20 % to 15-72 % and from 5-15 % to 16-75 % using intensive methods.

During the 1984 larval rearing season, 720,000 juveniles were produced at the DEVA-Sud station. The same rearing methods were used in the commercial hatcheries located on the French mediterranean coast with similar results. All together, the production of seabass reached two millions juveniles, most of them exported to Spain and Italy.

TABLE 1. SEABASS LARVAE REARING RESULTS IN 1984 (DEVA EX. ST.)

METHOD	TANK N°	VOL (M³)	NUMBER INIT	LENGHT PERIOD (d)	SURVIVAL RATE (%)	% NORMAL SWIMBLAD.	No. JUVENILES PRODUCED
SEMI-INTENSIVE (10-25 I/L)	C1	15	200 000	50	73	72	105 550
	C2	15	330 000	50	49	32	51 180
	C3	10	192 000	50	53	41	42 020
INTENSIVE	X1	2	200 000	45	15	44	13 200
	X2	2	200 000	45	41	30	24 600
	X3	2	200 000	16	0	-	0 *
	X4	2	200 000	45	46	19	17 370
	X5	2	112 000	45	21	16	3 840 **
	X6	2	200 000	45	42	20	16 870
	X7	2	200 000	45	20	75	20 500
	X8	2	200 000	45	11	-	0 **
	X9	2	174 000	22	74	18	0 *

* heating system failure ** hydraulic failure.

1.3. Socio-economical requirements of sea bass aquaculture

Culture of seabass is mainly practiced in floating cages. It requires 28 to 36 months from hatching to commercial size under the French mediterranean conditions against 18 months only in South Mediterranean Sea (Tunisia).

Implementation of floating cages is related to the availability of protected coastal areas. Such suitable areas are already frequently occupied by other activities, especially oyster culture. The development of seabass production is in fact severely limited by space competition in France and, for the future five years, production prospects could be within a 1000-3000 t range.

2. Seabream

In France, seabream has been considered a less important species in aquaculture than seabass because of its lower price. This explains that, up to now, systematic research has not been conducted on the effects of environmental factors on reproduction and larval rearing. However, various trials on mass rearing have shown that the effects of light seem to follow an original pattern, rather different from what has been observed with seabass.

Up to 1984, juveniles were not available for seabream commercial fish farming. Nevertheless, various grow-out experiments from juveniles to commercial size fish have shown that the production cycle would be as long as for seabass (30 to 36 months in the French Mediterranean conditions) thus probably impairing its profitability compared to seabass.

3. Turbot

3.1. Status of production

Turbot aquaculture in 1984 in France remains an experimental activity despite the fact that some private farms are engaged in production. Research on turbot culture actually started in 1974-1975 at the Brest IFREMER Center, where the first priority was given to the establishment of larval rearing techniques.

3.2. Larval rearing

The figure has been established for a rearing temperature of 19 °C, at which larval stages last 30 days. The feeding pattern used is *Brachionus plicatilis* from opening of the month till day 11, then *Artemia nauplii* from day 18 to 40. From day 30, an artificial food is given and gradually substituted to *Artemia* (Fig.2).

Two critical periods with high mortalities are known during the larval rearing:

(1) from day 8 to 11, following the end of yolksack reserves,

(2) more or less around the 20th day, corresponding to the main organogenesis crisis of metamorphosis. However, after metamorphosis, turbot juveniles remain pelagic for approximately one month (Fig. 3).

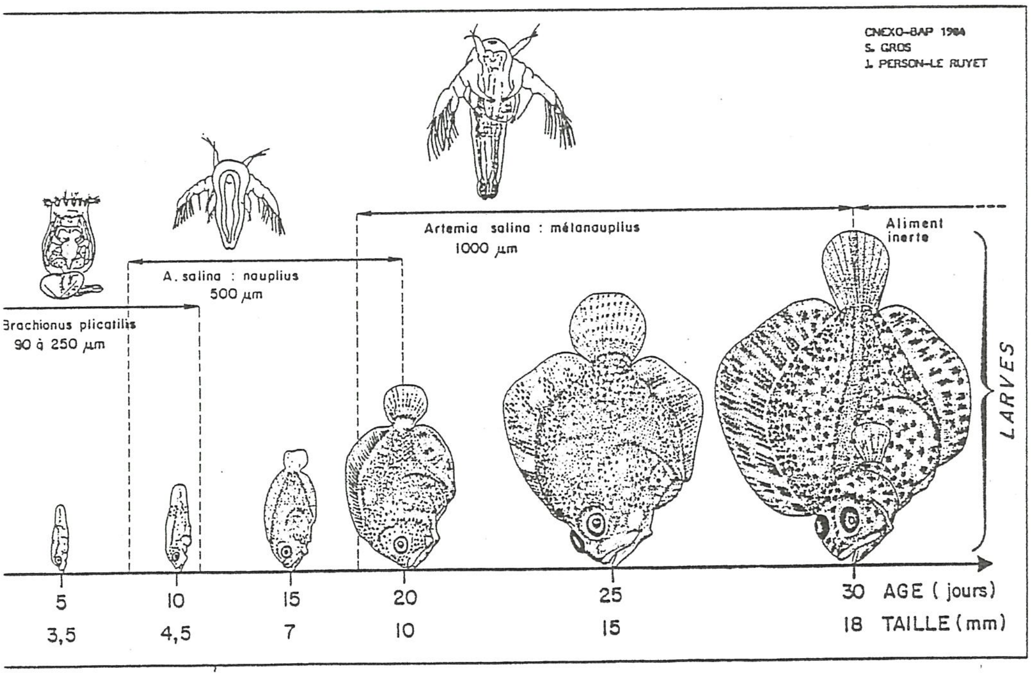


Fig. 2. Schéma du développement de la larve de turbot de l'éclosion à un mois, et séquence alimentaire correspondante
Température d'élevage 19 ± 1°C (PERSON-LE RUYET et BEDIER, 1984).

Fig. 3a is related to the survival rates observed in the last year experiments. Unfed larvae die before the 10th day. Curve II shows the results of 1982 rearing season which were the best ever obtained for turbot. Curves III and IV show more frequent results which are up to now unsteady.

Fig. 3b shows the prey/larvae pattern and gives the number of prey received per larvae and per day.

The main characteristics of experimental larval rearing are:

(1) 150 l cylindro-conical white-grey colored tanks,

(2) water temperature: 18 °C,

(3) light intensity 2000 Lux, continuously (24 h/24 h),

(4) initial feeding on Brachionus fed either on algae (Tetraselmis, Isochrysis, Nannochloris) and baker's yeast and algae (non enriched) or artificial diet (enrichment required then).

Four groups of factors could explain the high mortalities encountered during larval rearing:

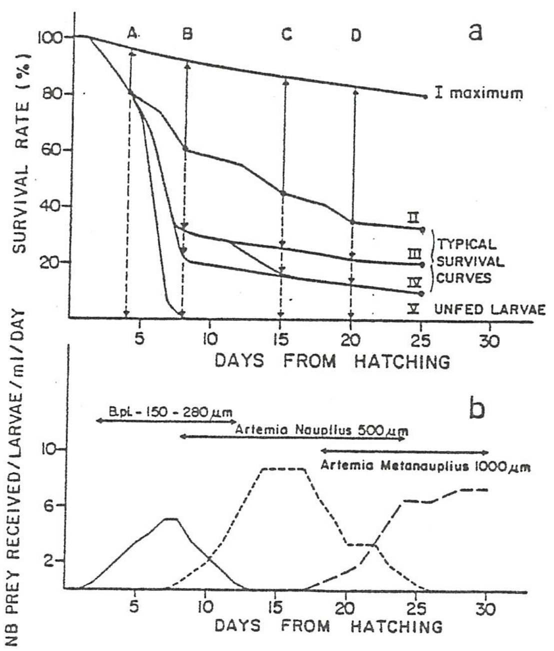
(1) initial quality of larvae related to the maturation process and incubation techniques,

(2) environmental factors during the rearing period,

(3) nutritional value of diets unfit to meet the requirements of larvae,

(4) pathological problems.

In order to improve these results, the Brest Center of IFREMER is planning to conduct research on the influence of water temperature (13-18 °C), light in-



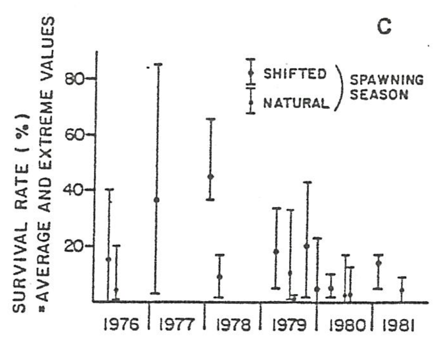


Fig. 3, First month larval rearing results at 18°C and continuous lighting: a--some typical survival curves; b--general feeding schedule: B.pl. = *Brachionus plicatilis* (Rotifer); c--average survival rates from 1976 to 1981.

tensity (50-2000 lux) and salinity (10-36‰). Moreover, since the nutritional hypothesis has gained in evidence in recent years, research will be resumed on the influence of Brachionus strains and their content in poly-unsaturated fatty acids according to the enrichment processes.

The following table summarizes the recent data on reproduction of seabass, seabream, turbot and sole held in tanks (Table 2).

The next Table 3 summarizes the data during larval rearing in hatchery.

Table 2. Quelques données sur la reproduction de poissons marins en captivité (PERSON-LE RUYET et BEDIER, 1984)

	TURBOT	SOLE	BAR	DAURADE	OBSERVATIONS
Taille moyenne de l'oeuf (mm)	1,0-1,1	1,2-1,4	0,9-1,3	0,8-1,0	
Taux d'éclosion : Larves écloses / total oeufs récoltés	≥ 50%	≥80	≥80	≥75	Pour les pontes spontanées mais le taux éclosion des oeufs viables est généralement 80-90%
Taille larve à l'éclosion (mm)	2,8-3,4	3,3-4,0	3,1-3,9	2,4-3,1	
Techniques de pontes					
- Spontanées	+	+	+	+	
- artificielles	+	0	+	+	
- induites	(+)	(+)	+	+	
Réponse du décalage de ponte	+	(+)	+	+	
Etalement de la saison de ponte (mois)	2	2	3	≥4	Sans intervention
Fécondité en captivité: nombre d'oeufs/kg de ♀ et par an	150-200 000	100-150 000	200-300 000	300-700 000	pour des adultes sauvages nourris sur aliment naturel frais
Age à la 1ère maturation sexuelle (années)	2 pour les ♂ 3 pour les ♀	3 ans	3 pour les ♂ 4 pour les ♀	3 pour les♂ 4 pour les♀	Pour les poissons nés en écloserie

Table 3. Quelques données indicatives sur la phase écloserie à 18-20°C (PERSON-LE RUYET et BEDIER, 1984)

	Turbot	Sole	Bar	Daurade	Observations
Poids à l'éclosion (mg)	0,2	0,6	0,4	0,3	
à 1 mois (mg)	50-75	50-75	10	20-30	
à 3 mois (g)	2	1-1,5	0,5-1	0,5	
Durée de la vie larvaire (jours)	30-40	15	40-50	40-50	
Age au sevrage (jours)	30-40	30-40	30-50	40-50	du laboratoire au pilote
Densité initiale (larve/litre)	20-30	60-80	*20-100	*40-80	* pour la méthode semi-extensive
Phases critiques : 1ère semaine	+++	-	++	+++	
: métamorphose	+	-	++	++	
Survie - à 1 mois (%)	≤5-40	60-80	* 30-50	≤10-30	* à l'échelle du pilote
- après sevrage (%)	≤ 5-30	30-60	15-25	5-20	
Consommation par larve produite :					
- Algues (cellule/l)	-	-	-	40 000	A titre indicatif Nombre de proies distribuées en filière intensive
- Brachionus	3 200	-	4 500	2 700	
- Nauplius d'A. salina	10 000	8 000	10 000	4 500	
- Métanauplius d'A. salina	7 000	11 000	2 000	17 000	
Les granulés sevrage - expérimentaux	+	+	(+)	(+)	
- commerciaux	(+)	-	+	+	
- secs	(+)	(+)	+	+	
- réhydratables	+	+	+	+	
- humides	+	+	-	-	
Taux de conversion*moyen sur granulés jusqu'à 3 mois	≥2	≥2-3	≥2	≥3	* poids sec de nourriture apporté sur le gain de poids vif

3.3. Juvenile and adult stages

The low numbers of turbot juveniles produced during the recent years allowed only limited experiments in two fields: determination of environmental requirements for temperature and salinity on one hand, and nutritional requirements on the other hand.

Optimum temperature, based on specific growth rate (%/day) ranges from 16 to 21 °C (Fig. 4).

Optimum salinity, based on the same criteria is around 24 ‰, but turbot shows a good ability to brackish-water adaptation despite its strictly marine distribution (Fig. 5).

In the field of nutrition, experiments were conducted on attractive substances and on the effect of protein and lipid content in artificial diets. Turbot shows very high protein requirements but the (CUP) protein efficiency ratio remains high even when the protein level in the diet decreases.

During the long term grow-out experiments on artificial diet, a new disease named "granulomatosis" syndrome, was observed. The main symptoms were:

(1) eye hardening and blindness,
(2) white subcutaneous deposits,
(3) renal granuloma.

Biochemical analysis of the deposits show an accumulation of tyrosine crystals and blood analysis give evidence of high tyrosine level. These phenomenon

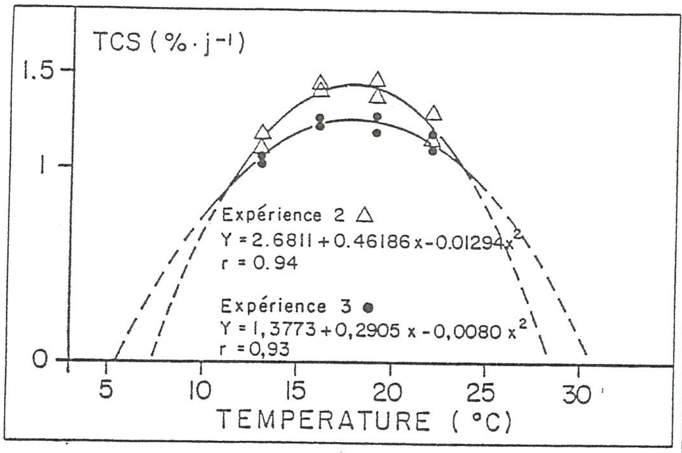


Fig. 4. Relation between temperature and growth in turbot (SCHERRER, 1984).

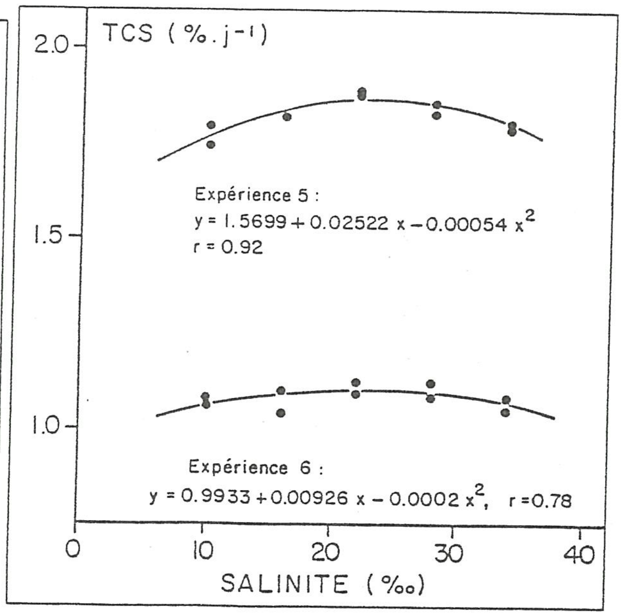


Fig. 5. Relation between salinity and growth in turbot (SCHERRER, 1984).

were induced by a depletion of vitamin C which stops the catabolic pathway of tyrosine (pHPP dioxygenase, no longer protected by vitamin C induces enzymatic inhibition). Injections of vitamin C give positive results on granulomatosis adding definitive evidence to the major role of vitamin C in the etiology.

Analysis of vitamin C in diet, ready to use, originally containing up to 600 mg/kg of vitamin C, show that the rate can be as low as 20 mg/kg after only a few minutes in pond water.

Considering these results and observations of tyrosine deposit in turbot seabream and seabass larvae, the hypothesis of a lack of vitamin C even in larval rearing can be formulated.

As a conclusion, it might be said that marine aquaculture in France is still an experimental activity except for seabass. Recent research have shown a large variety problems and problems and produced some original results.

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ACTUAL STATE OF PACIFIC SALMON CULTURE IN JAPAN

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Abstract

The outline of the present status of artificial recruitment of salmons and the intensive culture of salmon are presented, especially on the chum salmon, masu salmon and coho salmon.

In recent several years, the total catch in Japan maintain 10 million t level. Marine and freshwater aquacultural production are less than 10 % and 1 % respectively of the total catch in 1982. Their productions are almost stable: the total catch is 11,388,000 t, marine aquacultural production is 938,000 t and freshwater aquacultural production is 96,400 t in 1982.

Recent annual production of salmon in Japan varies 110,000 to 150,000 t. For 1982, the catch of salmon is 136,309 t (salmons:112,826 t, trouts:223,483 t).

Among seven species of the Pacific salmons in Japan, chum salmon is dominant and most important (more than 90 % of the total), and secondly pink salmon, thirdly masu salmon.

The artificial hatching, incubation and release of juveniles project has been promoted under the patronage of the Fishery Agency since 1979 especially, and the technical innovation of the salmon propagation bring the successful results in Japan. Drastic increase of homing migrators and about doubled increase of returning rate (river and coastal regions) are thought to be due to the recent advantages of techniques in artificial incubation and releasing procedures, etc., as follows:

(1) Prolongation of feeding period for juvenile.

(2) Release at optimal time.

(3) Augmentation of number of juveniles released.

(4) Amelioration of condition of researches; expansion of the accommodation, continuous recruitment of young workers, good leadership and organization in the coworking between the various laboratories.

It is also memorable that an accumulation of fundamental biological data gave the lateral supports for the project of the Fishery Agency, in the domains of physiology and endocrinology for migration and osmosis, biochemistry, fish nutrition, disease and pathology etc. Moreover, several trials which contributed to the recent propagation of salmonids were cited in this report.

For the success of salmon enhancement project in Japan, the author wakes a memory of the past on the first discovery of the artificial insemination by Dom Pinchon in France in the 14th Century.

It is generally accepted that masu salmon is most delicious among the Japanese salmons. Recently, the stock status has been declining. Hence, the Fishery Agency has commenced to promote "Marine ranching project of masu salmon" since 1980. This project involves several technical difficulties: different ecological nature of masu salmon, long culturing period, acceleration of smoltification etc.

The coho salmon culture hold with commercial success in Miyagi Prefecture, which accounted for about 70 % of the total Japanese coho salmon production (2,900 t in 1983). The coho salmon culture has several characteristics:

a) This is not culture-based fisheries.

b) The culture techniques were exploited by a private food company and fishermen's cooperative association in Shizugawa.

c) Total culturing period is short.

d) Time of marketing do not compete to the cases of the other salmons.

For 1984, the total production of coho salmon in Japan is estimated to 3,500 to 4,000 t and 200 million yen.

Another sea ranching project is also in progress on amago salmon in the western Japan. A trial of enhancement of sockeye by utilization of Japanese kokanee (hime-masu) in the northern part of Japan has started.

Chum salmon culture

Culture-based fisheries, Saibai-gyogyo in Japanese, Pêcheries basées sur l'élevage in French (Hanamure, 1979) is now in progress in Japan, and a kind of saibai-gyogyo, the stock enhancement of salmonids has become more extensive in recent years.

Although Japan have about one hundred years' history on the artificial breeding of the chum salmon, the artificial hatching, incubation and release of juveniles of salmon has been especially promoted under the auspices of the

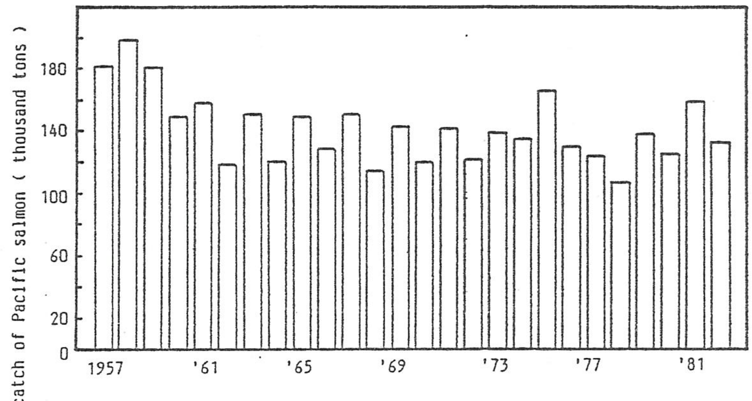

Fig.1 Total catch of Pacific salmon in Japan.
(Shirahata, Fishery Agency, 1983, Modified)

Fishery Agency since 1979. The technical innovation of the salmon propagation brought the successful results in recent several years in Japan (Shirahata, 1982). The evolution in total catch of the Pacific salmon in Japan for the past 25 years are shown in Fig. 1. The recent catches fluctuate at a level of 110-150 thousand tons even under the 200 miles regime (Kawasaki et al., 1981), for example, in 1982, the total catch of salmon is 136,000 t composed of 113 thousand t of salmon and 24 thousand t of trouts. In 1981, the returns of the chum salmon have reached 30 million fishes, accounting for 70 % of the total catch of Pacific salmon in Japan. The annual numbers of chum salmon migrator (coastal catch plus escapement) in Honshu Island has 30 % of the total returns of the chum salmon in Japan.

Table 1 shows the Pacific salmons in Japan composed of seven species. Among these salmons the chum salmon is the most abundant and important salmon in Japan, and is more than 90 % of the total, secondly the pink salmon, the third masu salmon is less than 3 %. The annual evolution of the returning rate is shown in Fig. 2. The drastic increase in returns of chum salmon might have resulted from the recent advances in artificial hatching, incubation and release techniques,

Table.1 Pacific Salmon in Japan

Shirozake	Chum (=Keta, =Dog) salmon	Oncorhynchus keta
Karahutomasu	Pink (Humpback) salmon	O. gorbuscha
Sakuramasu	Masu (Cherry) salmon	O. masou
(Yamame	Land-locked masu salmon	O. masou)
Benizake	Sockeye (=Red) salmon	O. nerka
Masunosuke	Chinook (=Spring, =King) salmon	O. tshawytscha
Amago	Amago salmon	O. rhodurus

etc., as follows:

1) Prolongation of feeding period for juvenile (previously fry-weight at release: 0.3-0.5 g, at present: about 1.0 g),

2) Release at optimal time,

3) Augmentation of number of juvenile released,

4) Amelioration of condition of research: improvement of hatching facilities, continuous recruitment of young workers, and good leadership and organization of the cooperations.

Their practical techniques are not here detailed. The highest returning rate obtained for chum salmon was 11.5 %, and was attributable to fin-clipped fry released at 8.3 g body weight from a sea-pen in Iwate Prefecture (Iioka, 1982).

There are 262 salmon migrating rivers in Japan (149 rivers in Hokkaido, 113 in Honshu Island). The number of the river of increased 1.6 times during past ten years by salmon enhancement. Although number of homing migrators is a few, the distribution of river of salmon migration expanded even to barren rivers at the coast of Japan Sea.

It was thought that the survival rate in the ocean is 30 to 50 % and the coastal survival rate is estimated to be only 2-3 %. In recent years, for example, in Hokkaido, the coastal survival rate of juveniles released after prolonged feeding can be expected to be at a much higher level of as high as 6-10 %.

Twenty four years had already gone since our colaborative work on <u>Salmo salar</u> of the river of Adour (Cédard et al., 1961). Behind the scenes of recent salmon propagation, it is noticeable that an accumulation of fundamental biological data gave a lateral support for the projects of the Fishery Agency, in the

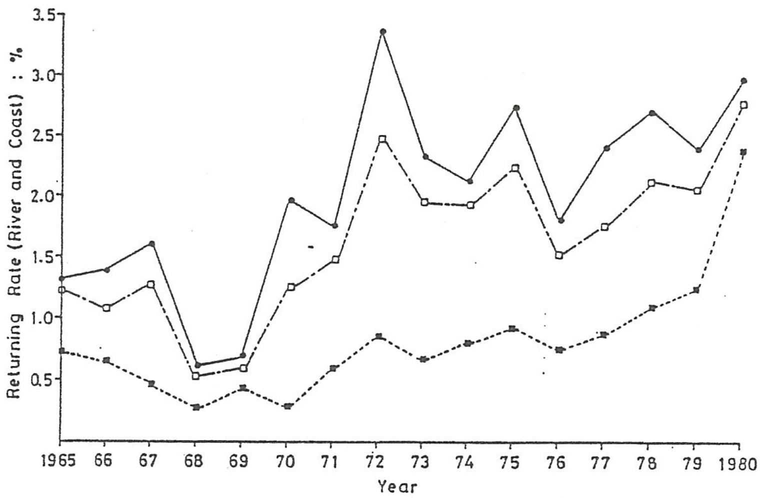

Fig.2 Evolution of Returning Rates of the Salmons. (Source : Fishery Agency)
Total —·-o-·— Hokkaido ——•—— Honshu ----*----

domains of physiology, endocrinology, and biochemistry as well as pathology and nutrition (Fontaine, 1975, Ueda, 1982, Kawauchi et at., 1983, Ogata et al., 1983).

Recent salmon enhancement project also bring back a memory on the first discovery of the artificial insemination by Dom Pinchon in France at the 14th Century. Claude Louchet (1957) has written in his book as follows: On attribue la dècouverte de la fêcondation artificielle des oeufs de truite à un moine francais du XIV eme siecle, Dom Pinchon de l'Abbaye de Reome.

In Japan, the experimental through culture of chum salmon in tanks, from egg to 3 yr-old adult, has been established by Sato and Kashiwagi before 1968, though the experimental trial of chum salmon culture had conducted in Hokkaido (Awakura and Tamura, 1962). The intensive commercial culture of rainbow trout in the sea floating net cage had been carried out in the Ogatsu Bay, Miyagi Prefecture (Koganezawa et al., 1967). Although this industry had disappeared in Japan, it is thought that these techniques had contributed for improvement of successive salmon cultures (Koganezawa and Sasaki, 1982).

Masu salmon culture

New marine ranching project of masu salmon is conducted under the direction of the Fishery Agency (Marine Ranching Program Progress Reports on Masu Salmon Production (4), 1984). Masu salmon is one of the most delicious salmon among Pacific salmons in Japan. Japanese salmon enhancement enter an epoque of quality more than quantity. This salmon is so-called Asian or Japan Sea-salmon, and ecological behavior resembles rather to <u>Salmo</u> <u>salar</u> (Kubo, 1976).

Their smoltification rate varies depending on the regions: high in the northern Japan, low in the southern. The physiological mechanism of smoltification is now investigated (Bern and Mahnken, 1982).

There are several difficulties in the masu salmon enhancement as follows:

1) Survival rate is low,

2) Culture period to marketing is long, so feeding cost is high and there is a risk to disease,

3) Sexual difference of smoltification.

The majority of seaward migrator is female. Therefore, monosex culture is now paid attention at the view point of biotechnology (Onozato, 1983, Yamazaki, 1983).

High value products are desired and the demand for foodstuff of low value has gradually diminished. In this contex, there is a problem of white-fleshed chum salmon (Bunake in Japanese). Recently, the cost of Bunake is one third of the silvering chum salmon. Utilization of Bunake and high value salmon enhancement such as masu salmon should be exploited.

Coho salmon culture

Coho salmon culture has achieved a commercial success in Miyagi Prefecture. At present, Miyagi Prefecture accounts for about 70 % of the total Japanese coho salmon production. The production in Miyagi is 1,900 t in 1982, 2,900 t in 1983. The recent evolution of coho salmon production in Miyagi Prefecture is shown as Fig. 3. The diminution in 1981 was due to the winter typhoon, and the many netpens were destroyed in Shizugawa Bay. Coho salmon culture has some characteristics as follows:

1) The culture techniques were exploited by a private food and Shizugawa Fishermen's Cooperative Association,

2) This is an intensive culture and not culture-based fisheries,

3) Total rearing period is of short duration as shown in Fig. 4,

4) Landing time is different from those of other salmons.

Coho salmon mariculture started from 1975 at Shizugawa Bay and extended to another area such as Onagawa Bay, etc. (Fig. 5). For 1984, the total production of coho salmon in Japan is estimated to about 4,000 t and production value is

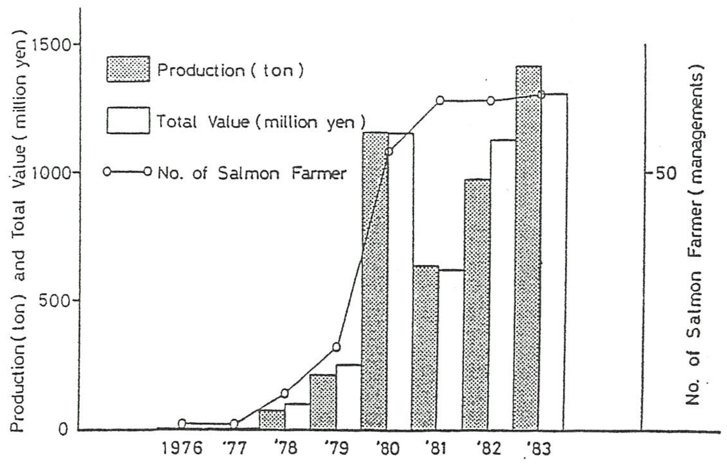

Fig.3 Evolutions of production of coho salmon in Shizugawa, Miyagi Prefecture. (Yoshida, 1984).

over 250 million yen (Yoshida, 1984; data from Kesennuma Fisheries Experimental Station).

The eggs of coho salmon are imported from U.S.A. and Canada to the hatcheries in Tochigi Prefecture. However, very recently, Yoshida's group (Daiwacho and Kesennuma) has obtained the eggs from the adult coho salmon cultured in Japan (Yoshida, 1984).

In the end of October, portable plastic tanks are settled near fishmarket of Shizugawa. The juveniles of coho salmon arrived from Tochigi are acclimatized for seawater:

(1st day) 0 to 40 % seawater
(2nd day) 40 to 60 % "
(3rd day) 60 to 80 % seawater
(4th day) 80 to 100 % "

During the acclimatization, the juveniles are starved and begin to feed after transportation to the net-cage in the sea. Three types of net-pens are utilized in Shizugawa Bay: viz. 4 m hexagonal type for 5 m depth, 10 m square type for 7-10 m depth, and 14 m square type for 10 m over depth. The latter can rear about 7,000 juveniles. The moist pellets composed of congealed sardine or mackerel are mainly utilized as foods, and the moist pellets are supplemented with vitamins, carotenoids etc.. Euphausia pacifica and squid viscera are also very effective as food additives.

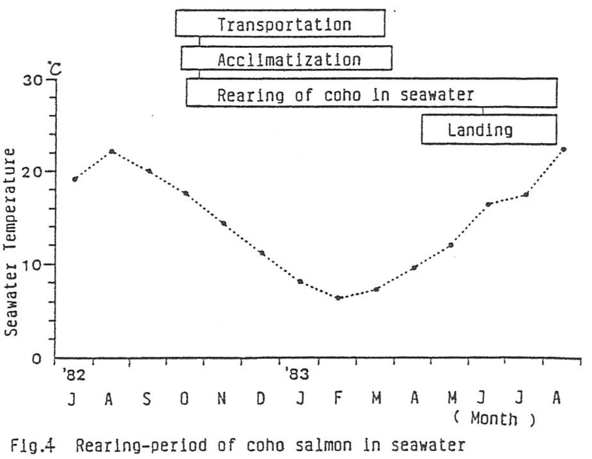

Fig.4 Rearing-period of coho salmon in seawater
(Yoshida, 1984).

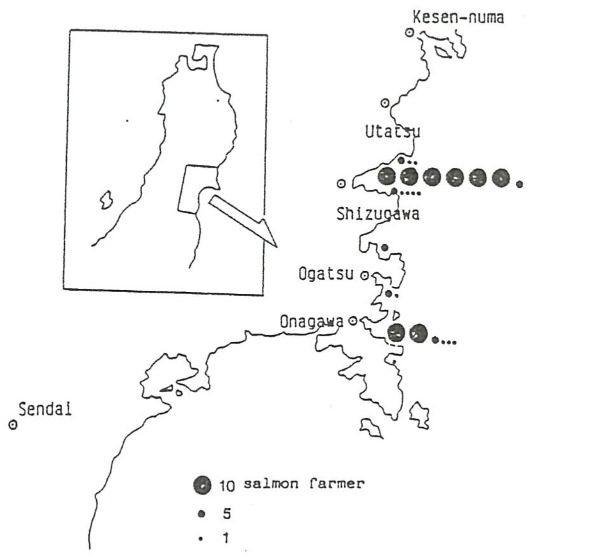

Fig.5 Distribution of coho salmon farmer in Miyagi Prefecture
(Yoshida, 1984)

Another sea-ranching project is also in progress on amago salmon in the south western Japan. Moreover, a trial of enhancement of sockeye has started in the northern part of Japan by using Japanese kokanee (Himemasu in Japanese). Very recently, sockeye culture has commenced in Shizugawa Bay. One yr-old Japanese kokanee weighing 70 g, are reared in the net-pen from November 1983 and the sockeye weighing 500-1,300 g are obtained in the fall of 1984 (Endo, 1984). Hence, further challenge to sockeye farming is greatly anticipated.

Acknowledgment

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CRUSTACEAN CULTURE IN CONTINENTAL FRANCE AND OVERSEAS

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Abstract

In France, lobster hatcheries produce post larvae for purposes of restocking, for studies related to restocking and to provide specimens for fundamental research.

Penaeus japonicus is used for restocking studies in several coastal lagoons, both on the Atlantic and Mediterranean coasts. The results thus far obtained are promising, demonstrating high growth and survival rates.

Several hatcheries are in operation in the Pacific (Tahiti, New Caledonia) and in the Caribbean (French Guyana, Martinique, Guadeloupe) producing various penaeid species as well as Macrobrachium. The cultured products are used mainly for local consumption.

1. Introductory remarks

The world demand for sea food is increasing on an annual basis and the prices for fresh products are universally high, especially so in the more developed countries. This is particularly true for the larger crustaceans, including shrimp, a product which is much appreciated by almost all sea food consumers.

France, along with Japan, is one of the major countries where sea food is very much in demand: the consumption of mollusks for instance is approximately 5 kg/year/capita. In contrast with the Japanese, however, the French eat their oysters raw and the shrimp cooked (DOUMENGE, 1984).

In France, the fishing industry takes advantage of various natural populations, even though overexploitation prevails. Such is the case for example for lobster Homarus gammarus and Nephrops norvegicus (or "langoustine"). Other crustacean species which are fished and sold on the market include:

shrimps: Palaemon serratus, sold under the French name of "crevette rose" (pink shrimp) and Crangon crangon, sold under the name of "crevette grise" (gray shrimp),

crabs: Cancer pagurus (or "tourteau"), Maia squinado (or "araignée") and Carcinus maenas (or "crabe enragé" or "crabe vert"),

rock lobsters: Palinurus vulgaris (or "langouste").

The above represent the main species which are sold and consumed.

In order to satisfy the increasing demands made by the market, France imports crustacean products from Great Britain, Groenland, Thailand, Senegal, the Ivory Coast, Tunisia, Canada, Denmark, Cuba, Ireland, USSR, Gabon, Turkey, etc..

These imports represent 27,100 t for an amount of 696 million F (¥ 18 billion) i.e. 14.2 percent of the total seafood importation to France. For crustaceans, in 1983, total French importations reach 55,000 t and exportation are 9,500 t roughly. Net imports of crabs are 7,000 t, of rock lobsters 1,500 t, of blue lobsters 1,900 t, of Nephrops 3,500 t, of crayfish 1,500 t and of other crustaceans 4,000 t.

The demand for seafood is likewise high in the Pacific and Caribbean islands and is generously consumed by about 1,600,000 people, who generally appreciate very much sea food.

In an effort to reduce the cost of imports, and in order to eventually transform France from a net importing country to an exporting country, several aquaculture operations have been developed. They have occasionally been financed though private funds, but more often with ?money accorded by various ministries, including the Ministry of Research and Technology, and the State Secretary of the Sea, as well as by various Regional offices. The lat??ter have recently become more autonomous and are in better position to help finance research and development in various related fields, including sea shore management and, of course, aquaculture. A good example of their activity will be provided during this meeting with the presentation of the Office Regional de la mer, created recently by the Région Provence-Alpes-Côte d'Azur.

2. Crustacean culture in France

2.1. Recent history

Since the early seventies, several attempts have been made to initiate shrimp culture in France. Penaeus japonicus was first introduced on the Mediterranean coast near Hyeres by a private company, then in Britanny, in Plouharnel, near Quiberon, where a hatchery was established for the rearing of a variety of marine species.

Another experiment have been developed in Gironde department, near bassin d'Arcachon (LEDOUX, 1973).

Since then, an aquaculture plant, has been built by the Centre National pour l'Exploitation des Océans (1) near Palavas-les-Flots, and has gradually been developed to this day. They have developed, in connection with a private association, the Centre d'Aide pour le Travail (CAT), Compagnons de Maguelone, a production of Penaeus japonicus fed with marine food from trawlers. The activity of this association is still in production.

2.2. Actual stade: station DEVA-Sud

At the same time, the station DEVA-Sud succeeded in controlling and rendering routine the process of reproduction in P. japonicus. This was in large part based on the successful research conducted in certain laboratories, especially at the Centre Océanologique de Bretagne (LAUBIER-BONICHON, 1975, 1978).

At the present time, the station DEVA-Sud of IFREMER is involved with the production of larvae and post larvae of P. japonicus in controlled conditions. Applied, as well as fundamental research, is being conducted at different sites on the larvae and post larvae obtained from the station DEVA-Sud hatchery.

Researches are actually in the process of enhancing the quality of compound diets for crustaceans and of studying the artificial food chain in intensive culture.

2.3. Restocking experiments in Mediterranean coast

Restocking experiments with P. japonicus larvae are in progress since 1981 in several coastal lagoons. These are located in the Languedoc-Roussillon region and are conducted in the Etang de Maugio, de Thau, de Gruissan, de Bages Sigean, and de Leucate, by a group lead by Conseil régional: the Centre d'Etudes et de Promotion des Activités Lagunaires et Maritimes en Languedoc Roussillon (CEPRALMAR). The results obtained using semi-intensive culture methods are very encouraging and show good growth rate (from 3 g to 35 g for males and to 60 g for females in 5 months). Several tons of shrimps have been recaptured.

New experiments are presently in progress in a coastal lagoon located near Marseille-Marignane Airport, at Etang de Berre, where 110,000 post larvae have been released in the middle of June.

2.4. Restocking experiments in Atlantic coast

Other experiments are in progress in Noirmoutier Island (Ile de Noirmoutier) in Bourgneuf Bay, near Nantes, where a company, Aqualive, supported by France Aquaculture, is conducting research both with mollusks short neck clam Ruditapes philippinarium and shrimps P. japonicus. The thrust of their work is to establish optimal densities coupled with the use of different kinds of food, including both natural and compounds diets. Generally speaking, the mean density seems to be about 60 g/m^2 (Keraron, 1983).

Other semi-intensive experiments have been conducted in Gironde, close to the Bassin d'Arcachon, in the area of Certes, where a rather good growth rate, up to 11 g in 4 months has been observed when mussels are employed as a supplementary source of food.

The actual selling price of P. japonicus (live) at the production level is 120 F (¥ 3,120)/kg for 15-16 g shrimps and 100 F (¥ 2,600)/kg for the 12-13 g.

2.5. Hatcheries

Several hatcheries are able to produce P. japonicus fry: these are located in Brest, Centre Océanologique de Bretagne (IFREMER); Palavas, DEVA-Sud (IFREMER) in Etang de Thau, Les Poissons du Soleil (private company) and in Martigues-Ponteau near Marseille, Company SEPIA Interanational.

2.6. Research

Fundamental research and studies on larval and juvenile physiology, on compound diets and on genetics are currently being undertaken in several laboratories, in Montpellier, in Palavas, in Centre Océanologique de Bretagne (Hew and Cuzon, 1982), in Paris (Cahu, 1979), in Marseille (Yagi, 1983). Several other studies are likewise on the way, mainly on the physiology and biochemistry of penaeids (Ceccaldi, 1982; Ceccakdi et al., 1984). These concern investigations of the digestive enzymes (Galgani, 1983; Galgani et al., 1984), free amino acids in blood and in tissues, blood proteins (Boucard et al., 1984) and lipid metabolism in relation to growth and survival rates under different environmental conditions (Yagi, 1983; Yagi and Uno, 1983; Yagi and Ceccaldi, 1984). Several other attempts to increase efficiency and the security of hatcheries are also in progress.

Fundamental research is however very much required to improve the prospects of production through aquaculture (Ceccaldi, 1982).

The characteristics of digestive enzymes such as proteases including trypsin, chymotrypsin, aminopeptidases and carboxypeptidases have been examined. Immunological techniques employed to measure the trypsin activity in P. japonicus larvae during their development revealed a maximum rate secretion during the zoea stage. Trypsic activity is maximal at stage D2, D3 of the moult cycle. Comparative studies of protease secretion levels have been conducted with reference to other penaeid species (Galgani, 1983; Galgani et al., 1984).

To improve the artificial selection process for *P. japonicus*, enzymatic polymorphism studies have been undertaken on populations cultured through several generations (Laubier-Bonichon et al., 1984).

With reference to controlled reproduction, artificial insemination is now employed routinely in several penaeid hatcheries. Spermatephores are extracted from the males, and the sperm is transferred and used for fertilizing females. This technique is successfully employed for both *P. japonicus* and *P. vannamei*.

Growth of the ovary depends on various environmental factors, and ecophysiology of reproduction, endocrinological mechanisms and blood proteins for instance represent important research areas for different groups of crustacea.

3. Crustacean Culture Overseas

Because penaeid shrimps are generally tropical species, culture of these crustaceans is particularly good in warm waters. This, of course, is one of the reasons why shrimp aquaculture is being developed and supported in overseas French Departments (Prefectures) and territories.

3.1. French Polynesia

At the Centre Oceanologique du Pacifique (COP) in Vairao, Tahiti, established by CNEXO, hatcheries produce fry of several crustacean species. While no all of these species spawn and develop with a relative rate of success, by controlling various environmental factors, including light and temperature and employing eyestalk ablation, spawning is greatly facilitated. In some species, artificial insemination is used successfully.

Culture ponds have been created in Tahiti and other islands, as Moorea for instance, where the total production is limited by the appropriate amount of land available for aquaculture.

Macrobrachium species, mainly *M. rosenbergii* is produced from post larvae at Vairao, Tahiti. These are reared in a highly specialized hatchery, using high density production. Ponds have been constructed on some of the wider parts of the island, and cultured animals are sold at the local market at a profitable rate. The feed pellets which have been used have a low protein content, with a conversion rate of 3. The local price is 110 F (¥ 2,850)/kg. The farms where M. rosenbergii are reared ranging from 3 to 10 hectares.

3.2. New-Caledonia

Since 1971-1972, a company located in Baie de Saint Vincent, New Caledonia, partially supported by national funds and technical support by COP,has been able to produce several tons of penaeid shrimps.

Two companies presently manage and produce shrimp on roughly 10 hectares of land. Japanese enterprises have also begun to develop aquaculture on the western coast. It is anticipated that local market will become be saturated in a few years, when 150 t will be produced.

3.3. French West Indies

In French West Indies, on the islands of Martinique and Guadeloupe, Macrobrachium culture dates back to 1978, with the establishment of several small farms, as set up by private companies, individuals and cooperatives, about 10 on each island. The entire production is sold locally and, curiously, in that region, Macrobrachium is called ècrevisse (crayfish).

Due to the limited availability of land, production cannot be extended much more; there will nevertheless be some increase. A large hatchery, leaded by CNEXO, have been created in 1980 on the side of other smaller hatcheries, for the regional needs. These hatcheries have produced 7 million post-larvae in 1983. The technique used is much more in clear water than in green water; thischnique is imported from Tahiti, where the production is fairly good (AQUACOP, 1977, 1983).

Two cooperatives currently operating on the island of Guadeloupe, are very much concerned with aquaculture. They undertake water quality surveys, and conduct studies on the composition of compound diets, animal densities and restocking matters. Two small hatcheries are presently in operation.

Research is needed to acquire a better knowledge of the physiological requirements of this species and its behavior in waters of different qualities (Yagi and Uno, 1983).

3.4. French Guyana

In French Guyana, a project for Macrobrachium production is being planned to help small size production around hectares, generally integrated in classical farms. Another type of organization in aquaculture exploitation of large size, more than 2 hectares. A company, Guyane-Aquaculture, has been funded to manage a hatchery.

Actually, 90 hectares have been managed, and 30 more hectares are on the way to be completed.

3.5. Island of La Rėunion

On the island of La Rėunion, in the Indian Ocean, there are preliminary attempts to develop Macrobrachium aquaculture. Operations are in their first stages.

4. Cooperation With Other Countries

Actually, IFREMER is in contact and working closely under contract with several countries including Brazil, Ecuador, Indonesia, Philippines and Malaysia, who have succeeded in building hatcheries and sustaining production levels for several species of penaeid shrimps.

5. Conclusion

Development of industrial crustacean aquaculture in France is less important than in Japan, where, generally speaking, aquaculture is profitable. In France, the prices of the sea food market are lower, and the dietary habits quite different (Doumenge, 1982). The state of French aquaculture requires more fundamental research and development studies to adapt the production of crustacea to national market needs, as well as to the international market pressures.

Development of crustacean aquaculture in France is essential, because the rate of import represents roughly 25,000 to 30,000 t per year; an upgraded aquaculture program will hopefully reduce these figures significantly.

TAGGING TECHNIQUES AND RELEASE OF LOBSTER <u>HOMARUS</u> <u>GAMMARUS</u> IN FRANCE

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Introduction

Release of lobsters in France started on 1972 from three hatcheries along the Atlantic French coast (islands of Yeu, Houat, and Sein). Each production was about 100,000 post larvae (Stage 5).

Till 1977, release of lobster was done only with stages 5. On 1977 we started rearing lobsters during one year to obtain juveniles for restocking; each hatchery had its own research program.

Since this year a national research program on lobster take place and the hatcheries are obliged to work inside this program.

This program has three principal axes:

(1) The stock management, with an effort on the collect of data on the catches; this is done by the I.F.R.E.M.E.R.

(2) The monitoring of the juveniles in the natural environment to estimate the real impact of restocking operation and indicate the best way for success.

(3) The production of 10,000 one year old juveniles by year for releasing.

During the spring and summer 1984, our research effort was done on: (1) tagging technique, and (2) release on artificial shelters to realize a close monitoring in order to consider the behavioral problems.

1. Tagging Technique

After several trials of tagging without success with an external tag (type "Floy-tag") adapted to the size of the juveniles, we look for the tagging technique fluently used on salmonids: the micromagnetic tags placed intermuscularly. The material used is the one manufactured by the Northwest Marine Technology Society in U.S.A. The tag is a magnetizable steel wire of 1 mm length. These tags have a binary code which permits to separate each year and site of release. During last summer, 10,000 juveniles have been tagged with this technique and released along the Britanny coast nearby the island of Houat.

For the 1984 campaign, we put the tag in the tail, at the level of the third abdominal ring. The mortality rate induced by the tagging operation was about 2%, whereas the loss rate of the tag through one molt was zero if the tag was well placed intermuscularly. The principal difficulty occurring during the tagging operation is to place exactly the tag. This is a very important problem, because the tag may be well magnetized and get so the best chance for detection later, only if it is placed nearby the longitudinal axis of the animal.

For tagging in abdominal ring, it is not easy to inject the tag at the same correct place because of the configuration of the tag injector and the flexibility of the tail (Fig. 1). So we must do a research effort on this problem and different places of the tag will be tested in regard to the survival range of the juveniles and the retention range through the successive molts.

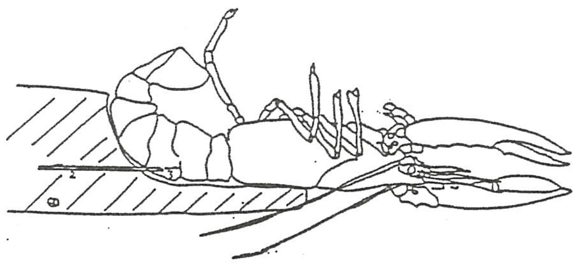


Fig. 1. Tagging position of the lobster.

1. Head mold of the tag injector
2. Injection needle
3. The tag

In the future, the detection and collection of the tagged lobsters may be difficult because the tag is not perceptible by the fishermen. For this reason the release of tagged juveniles is concentrated only on one part of the coast. The fishing area which must be controlled is about 2,000 km^2 with about 150 fishing boats distributed in 9 harbors. The catches of lobsters on this area are about of 35 t.

All lobsters fished will be collected and checked individually. This collect of tagged lobsters will require important means because the market of lobsters escape at all sale by auction and the control will be realized directly when the fishing boats come back to the harbor.

2. Release of lobsters

Since the beginning of releasing operations with juveniles, we have two question marks:

(1) Is there an adaptation problem of the reared animals to the natural environment ? The rearing technique used is in individual containers; may be, this method bring some alterations on the behavior, injurious to the survival rate in the sea (defense against predators, search for feeding, temperature etc.).

(2)Where are the best places for releasing?

2.1. General technique for the release of juveniles

The release of juveniles lobsters is done by diving on place which seems good (between 8 to 16 m deep and on rocky substrate). Each juvenile is placed in a "submersion shelter". This shelter is made by a steel or plastic tube closed with a paper sheet. The paper is discomposed by the water and the lobster can go away from its shelter. This shelter is done only to protect the juvenile during its submersion, to give him a time of habituation to its new environment protected against predators (Fig. 2).

Often we have observed juveniles going out of this shelter, explore the area surrounding and come back. But this technique does not allow a real observation of the juveniles after their releases, because the lobsters go out from these shelters to the close rocky substrate where they are almost impossible to localize by divers.

2.2. Experimentation

2.2.1. Ecological and behavioral studies. We don't know the real ecology of the juveniles because it is not easy to find them in the natural environment. We studied the relation between the juveniles and the substrate. In this study we found a good attraction of juveniles for little stones laying on sand or mud. We

Fig. 2. The submersion shelter.

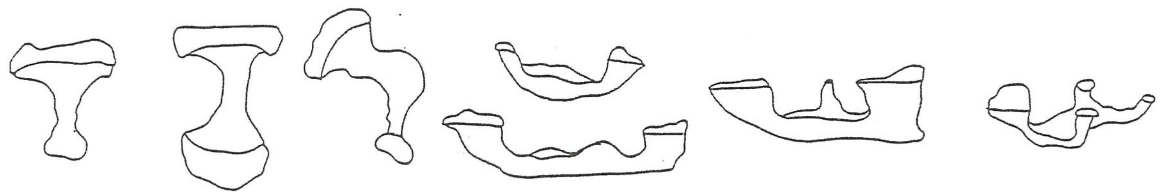
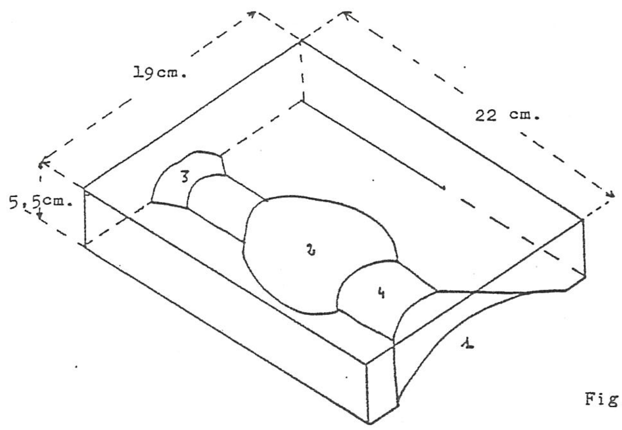


Fig. 3. Different kinds of burrow built by juveniles in the sediment.

have made polyester molding of the burrow, noting the size of the runs in regard to the size of the animal. The results obtained depend of the substrate and of the endurance of the observation. We can find burrow with one, two, three, four, and even five openings (Fig. 3).

Meanwhile the most current configuration is a burrow with two openings: one principal entrance and a smaller secondary opening. Between these two openings, the runs show a larger place called the chamber. From these observations we built a concrete artificial shelter well adapted to the mean size of the one year old juveniles where we can hope that the lobster will stay during a long time to allow good observations on the behavior (Fig. 4).

In a parallel direction with this research, we continue in the laboratory behavioral comparisons between wild and reared juveniles (digging behavior, defense, feeding, etc.) to get more and more informations to be able to judge if the juveniles released are well adapted for survival in the sea. A transition rearing period between the individual rearing in the hatchery and the release in the sea may be necessary: communal rearing, feeding with alive preys.



1- Entrance
2- Chamöer
3- Secondary opening
4- Run

Fig. 4. Concrete artificial shelter (weight 5 kg).

2.2.2. <u>Experimental release on artificial shelters</u>. During the summer 1984, we started the experimentation with this type of shelter placed on a sandy substrate covered with seaweed. The depth was about 6 m and the fauna was rich (Table 1). The shelters were placed in line of eight units with 5 m space between each shelter; eight lines at intervals of 5 m were placed. Each juveniles had a mean territory of 6.25 m^2 and the total number of shelters is 64 (Fig. 5).

Three successive releases have been done, the size range of the one year old animals was between 12 mm and 17 mm of thoracic length with a mean on 15 mm (Fig. 6). Monitoring by daily dives was done and also someone during the night. We inspect four lines by rising slowly the shelters, the other lines are raised only one week later.

Table 1. Tentative list of associated fauna

French name	Latin name	Abundance index	Predator index	Competitor index/shelter
	Cnidaires Phylum			
Anemones	Anemonia sulcata	++	+	−
	Annelides Phylum			
Vers	Sabella pavoneca	+++		
	Mollusc Phylum			
Nasses	Nassarius reticulata	+++		
Buccins	Buccinium undatum	++		
Glycymeris	Glycymeris glycymeris	+		
Bucarde epineuse	Acanthocardia aculeata	+		
Lutraire	Lutraria lutraria	+++		+
Vernis				
Seiche	Sepia officinalis	+	++	
	Arthropodes Phylum			
Bernard l'hermite	Eupagurus bernhardus	+++		
Crabe honteux	Calappa granulata	+++	+	+++
	Macropodia longirostris	+		
Crabe nageur	Macropipus depurator	+	+	+
Etrille	Macropipus puber	++	++	+++
	Echinodermes Phylum			
Etoile de mer	Asteria rubens	++		+
	Marthasterias glacialis	++		
Oursins	Echinus esculantus	++		
	Echinocardium cordatum	++		
	Vertebrate Phylum			
Tacaud	Trisopterus luscus	++	+	
Lieu jaune	Pollachius pollachius	++	++	
Motelle	Ciliata mustella	++	+	+
Syngnathe	Syngnathus acus	+		
Rouget	Mullus surmuletus	++		
Gourlazeau	Centrolabrus exoletus	+	+	
Dragonnet	Callionymus lyra	++		
Gobie noir	Gobius niger	+		
Gobie des sable	Gobius minutus	+++		
Sole	Solea solea	++		

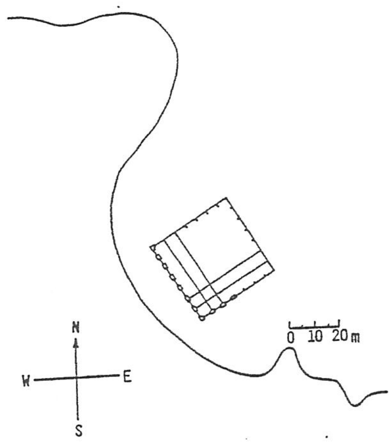


Fig. 5. Releasing site
with the shelters arrangement.

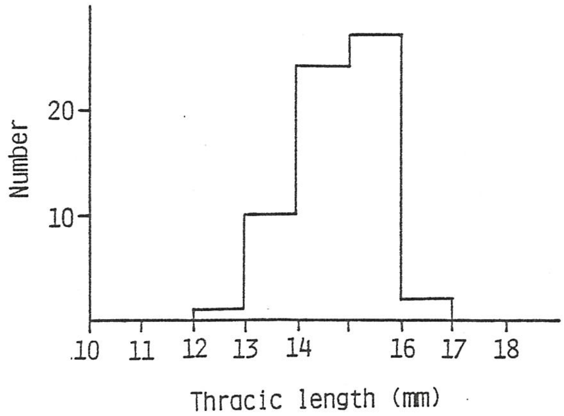


Fig. 6. Size distribution of juveniles
(sample including 64 animals).

Behavioral observations: The juveniles were placed one by one at the entrance of the artificial shelter; two principal type of behavior were observed.

(1) The juvenile go out quickly from the shelter and go to explore the surrounding area; the diver cannot follow it during a long time and the animal disappear.

(2) The juvenile stay in the shelter and it does not seem want to go out during the ten minutes after releasing; the lobster begin to explore the sediment with its claws and it start building its burrow.

For the burrowing behavior, the young lobster does not seem to have an adaptation problem in spite of the undifferentiated claws (individual rearing). This is not necessarily true for the defense and feeding behaviors.

Results: We note that only 24 hours after the release there is a high escape rate: 70-80% (Table 2); this fact is surely tied with the behavioral observations explained before. It seems that the lobsters which have built their burrows will stay under the shelters during a long time; this, in spite of decreasing percentage of recovered juveniles. We can explain this fact by the abundance of competitors for using the shelters: Portunus, Calappa ? etc. All the shelters where

Table 2. Percentage of juveniles found under the shelters

	Days after release				
No. of juveniles released	1	7	14	21	28
64	26.6	15.6	12.5	9.4	4.7
54	31.4	24.1	14.8	9.3	-
43	21.0	13.1	9.3	-	-

the lobster have gone out were occupied by these crabs; we can observed a Portunus of a big size and a juvenile under the same shelter. The presence of high number of competitors (sometimes 3 or 4 crabs around the same shelter) burrowing in the substrate and coming under the shelter have surely conduced to drive out the juvenile. Some shelters have been found completely covered with sand only by the burrowing action of the crabs.

One lobster with its molt have been observed under a shelter and 28 days after the first release a high percentage (80%) of the juveniles have grown up.

From this first experiment of release under artificial shelters we can consider some ways of research for next years:

(1) The preparation of the juveniles before the release, in order to reduce "the submersion stress".

(2) The choice of the releasing site to avoid too important competition on the shelter.

(3) Modifications of the shelter to can see the animals without damage for its burrow.

3. Conclusion

We have done a summary of the restocking technique in France. Now, the release of lobsters seems more like an extensive aquaculture than a real restocking. In fact we have natural lobsters stocks all around the French coast; so it seems easier to get an increase of the stock by taking some generals rules for stock management (increase of the marketable size, decrease of the fishing effort, etc.).

With the actual production capacity of the hatcheries (about 15,000 juveniles each one) we do not know what is its real impact compared to the natural recruitment.

But the number of shelters is often indicated like a limiting factor for the increase of a lobster population, so it is possible to think that the establishment of lobsters is realizable on particular sites using well adapted shelters.

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