The 1st International Oyster Symposium Proceedings

History, Status and Future of Oyster Culture in France

D. Buestel
Ifremer Pacific Center-Tahiti
B.P. 7004, 98719-Taravao-Tahiti-French Polynesia

SUMMARY

The history of oyster culture in France consists of a succession of development phases with different species, followed by collapses caused by diseases. The indigenous species *Ostrea edulis* was replaced first with *Crassostrea angulata*, then *Crassostrea gigas*. France is now the top producer and consumer of oysters in Europe, producing around 130,000 tonnes of the cupped oyster *C. gigas* annually and a remaining 1,500 tonnes of the flat oyster *O. edulis*. Cupped oysters are produced all along the French coast from natural (80%) and hatchery spat. Various structures are used to collect spat from the wild. After a growing-on period, oysters can be cultivated by three main methods: (i) on-bottom culture in the intertidal zone or in deep water; (ii) off-bottom culture in plastic mesh bags in the intertidal zone; or (iii) suspended culture on ropes in the open sea. The principal development that has taken place in culture techniques is the use of oysters produced in hatcheries, especially triploids. Almost all French oyster production is sold fresh and eaten raw straight from the shell. There is a strong seasonality in sales, with the most being made during the Christmas and New Year period. The abundant production and the lack of market organisation induce strong competition between the different production areas, causing prices to fall. In order to overcome this difficulty, oyster farmers have developed strategies of sales promotion and regional quality labelling. The hazards of production are numerous: environmental crises (microbiological pollution, toxic microalgae), unexplained mortality, overstocking etc. Recently, new problems with toxic algae have disrupted oyster sales. However, French oyster culture has many assets. These include a coastal environment offering favourable sites for mollusc growth and reproduction. Oysters have been consumed in France since ancient times and their culture is now well established with a concession system that favours small family firms. There is a young, well educated population of farmers, with technical expertise and "savoir faire". Careful monitoring of water quality assures good consumer protection, and research is making innovative contributions (selection, polyploids etc.). These points, and opportunities to expand the market, should ensure that this industry is well maintained in the future although the problem of toxic algae, probably linked to global warming, and the threat of new diseases are vital questions for future research.

Key words: Aquaculture, French oyster production, *Crassostrea gigas*, *Ostrea edulis*, flat oyster, cupped oyster.

INTRODUCTION

The French coastline, which is around 500 km long, provides favourable environments for mollusc development, particularly oysters which have always been much appreciated by the French. The north coast on the English Channel and west coast on the Atlantic Ocean are subject to tidal effects with mean tidal ranges varying from 10 m in the north to 4 m in the south. Water temperature fluctuates from 6°C to 17°C in the north but can reach over 20°C on the Atlantic and salinity fluctuates from 20 g/l in winter to 30-35 g/l in summer. These conditions, added to a great diversity of coast types with numerous highly rich estuaries, favoured the development of natural beds and later rearing areas. On the Mediterranean coast, although the conditions are quite different (lagoons with almost no tide, higher salinity (30 to 40 g/l) and warmer water in summer (up to 27°C)), the sites are suited to oyster farming owing to very high phytoplankton productivity. Oyster culture began in the middle of the 19th century and has remained very traditional in France, which remains the principal producer and consumer of oysters in Europe.

HISTORY OF OYSTER PRODUCTION IN FRANCE. THE EUROPIAN FLAT OYSTER *OSTREA EDULIS* AND THE CUPPED OYSTERS *CRASSOSTREA ANGULATA* AND *CRASSOSTREA GIGAS*

The history of mollusc culture in France is very informative. Fig. 1 shows the evolution of oyster production over the last century (Héral, 1989, Héral and Deslous-Paoli, 1991). Production recently stabilised at a high level, a situation not seen in the past as production was highly variable. Twice in the past, culture developed around a single species followed by a population collapse and reconstruction of the industry based on a different species.

The first species, which has been fished from time immemorial by dredging natural beds, is the native *Ostrea edulis*. The oyster beds were overexploited from the 18th century, especially along the Atlantic coast (Goulletquer & Héral, 1997), and in spite of a long series of restrictive regulations the landings became poor and irregular during the 19th century.

Culture of this species began in the 17th century with the use of former evaporation ponds for salt production in the Marennes region (Grelon, 1978). Juvenile oysters were fished and placed in these ponds and then left for 4 or 5 years before sale. These ponds became known as "*claires*", or salt water ponds. However this activity, which depended greatly on fishing, was only marginal. Oyster culture really took off following several large innovations, the first of which were technical. Between 1853 and 1859 Coste and De Bon started collecting spat from the wild (Coste, 1861). The technique of liming tiles was discovered in 1865, making it possible to obtain an abundant and regular spat supply without fishing. On-growing techniques for spat were then set up using special trays (Marteil, 1979). Another major innovation was administrative. In 1852, a law was passed in order to regulate the exploitation of public maritime areas so that land for oyster production was leased to farmers by the state. This law was modified in 1983 but is still in force. The precise criteria for allocating concessions favours those already on the "maritime register" (a register system of sailors from the navy, set up by Colbert). This system encourages small family businesses.

A crisis hit flat oyster culture throughout Europe after 1920 when massive unexplained mortalities were reported and the flat oyster then disappeared from the Arcachon and Marennes regions. However, spat capture picked up again some time later in southern Brittany where flat oyster production has continued, reaching a maximum of 28,000 t (metric tons) in 1960. The Mediterranean also produced flat oysters until 1950 when high mortalities occurred there also, inexplicably putting an end to production in the area (Fauvel, 1985). In Brittany, a disease caused by *Marteilia refringens* broke out in 1968 followed by another disease in 1979 caused by the parasite *Bonamia ostreae*. Production dropped from 20,000 to 2,000 t. Despite numerous efforts to relaunch flat oyster production, it remains very low to this day.

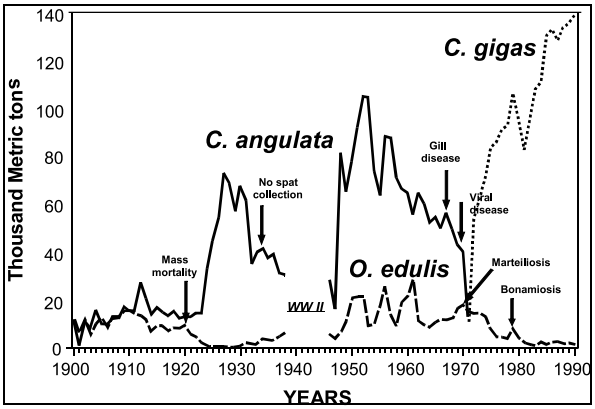

Fig.1. Historical trends of French oyster production (from Héral, 1989)

Flat oyster culture was developed at the turn of the 19th century, especially in the bay of Arcachon where a yield of around 15 to 20,000 t per year was reached between 1908 and 1912 (Bouchet *et al*, 1997).

The first imports of the Portuguese cupped oyster *Crassostrea angulata* into Arcachon date from 1860 and were made to compensate for the scarcity of the flat oyster. The species then spread along the Atlantic coast and both species, *O. edulis* and *C. angulata*, were produced at the same time. Following the large-scale flat oyster mortalities in 1920, the Portuguese cupped oyster replaced the flat oyster in the main culture sites of Marennes-Oléron and Arcachon. Production increased rapidly and extended widely after World War II, reaching 90,000 t after 1950. From then onwards, oyster growth began to decrease and mortalities began to increase, indicating overstocking of production units (Héral & Deslous Paoli, 1991). Production gradually decreased until the outbreak of the "gill disease" in 1966 (Comps and Duthoit, 1976), later

identified as a viral disease caused by an iridovirus (Comps *et al*., 1976). This disease spread throughout all culture zones causing massive mortalities between 1970 and 1973 and leading to the total extinction of *C. angulata* in France.

The oyster industry reacted quickly to this alarming situation with the "Resur" plan which consisted of introducing a new species, *Crassostrea gigas*, from the Pacific. Following some small-scale trials conducted between 1966 and 1970, several hundred tons of *C. gigas* cupped oysters were imported from Canada between 1971 and 1973 (Grizel and Héral, 1991) to form broodstock. This operation was successful and from the first year in Marennes-Oléron abundant capture of spat allowed healthy, fast-growing oysters to be produced. At the same time, 10,000 t of spat were imported from Japan and distributed to all the other production sites. The result was a great commercial success and production increased quickly. Spat capture developed rapidly in Arcachon and Marennes, producing enough spat to supply all the production sites, so that further spat imports became unnecessary.

Hence, in spite of several crises, France has always produced large quantities of oysters, unlike other countries such as England, where production plummeted after World War II (Neild, 1995). The demand for oysters on the French market has always been large with a long-standing tradition of high consumption at Christmas and New Year.

PRESENT STATE OF CULTURE OF OYSTER *CRASSOSTREA GIGAS*

Production techniques

The high diversity of the rearing areas gave rise to several techniques which can be classified into three main types: on-bottom culture, off bottom culture and suspended culture. On-bottom culture consists of sowing the oysters directly onto the intertidal sea-bed (about 25% of the total production), or in deep water, 5 to 10 m depth (10%). Off-bottom culture is done by using plastic mesh bags set on trestles (tables) in the intertidal zone. This is now the principal technique used, accounting for 60% of the total production. Suspended culture (5%), is done by hanging oysters fixed on ropes or in baskets from special frames (tables) in the Mediterranean lagoons or on lines in the open sea. Although there are not many different types of techniques, there are an infinite variety of cultural practices due to a diversity of factors: size of the business, situation of the culture site, number of employees, plurality of activity etc. Moreover, as French oyster farmers are very individualistic it can be said that each one has his particular manner of working.

Total production

Oyster production statistics, which are often imprecise, come from various sources: Ministry of Fisheries (DPMA), producer's organisations (CNC: National Mollusc Production Committee), Ifremer Maritime Economics Service (SEM), Ofimer (National inter-profession bureau for sea and aquaculture produce). These statistics are summarised annually by Ifremer (Kalaydjan, 2004).

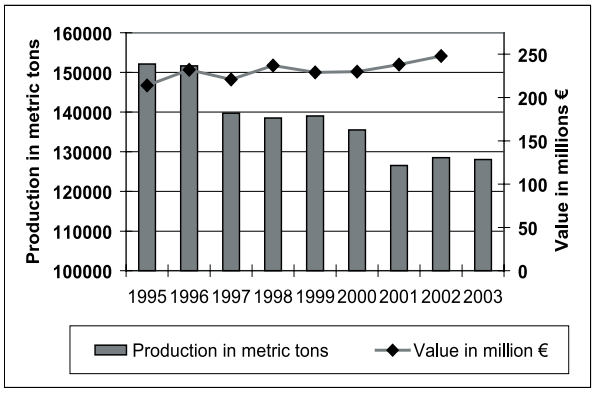

Fig.2. French annual production of the Pacific cupped oyster *Crassostrea gigas* (Kalaydjan, 2004)

Shellfish culture as a whole (oysters, mussels and other species) produces 187,000 t in France providing around 10,000 jobs in 3,750 companies operating on concessions of a total area of 20,000 ha. France has an annual production of about 130, 000 t of *C. gigas* cupped oysters (Fig. 2). Cupped oysters are therefore the principal shellfish production activity with 2,650 companies operating over an area of 14,000 ha.

A general census of oyster culture made by the ministry of agriculture in 2001 (Girard *et al*, 2005) gave a total of 107,400 t for oysters commercialised. This decrease in 2001, also visible on Fig. 2, can be explained by a number of events. There was a bad year for spat collection in 1998, a destructive storm in 1999 in the Marennes-Oléron region and high mortalities in Normandy. However the data from the 2001 census are lower than those shown in Fig. 2 (Kalaydjan, 2004). The census total, based on statements of production, was prob-

ably under estimated. On the other hand it is possible that the data in Fig. 2 combine both production and commercialisation. The true production value could be between the two data sets.

Present production totals make France the biggest producer and consumer of oysters in Europe. Their value has stabilised at about 230 million euros per annum, irrespective of the magnitude of production, implying a certain trend towards market saturation. A maximum of 152,000 t was reached in 1995 and 1996 together with the first sales difficulties. Thus, a tonnage of 150,000 t appears to be the market saturation threshold. Since 2001, production has remained stable at close to 130,000 t.

Main characteristics of different production zones

Seven oyster production regions with different characteristics can be distinguished (Fig. 3).

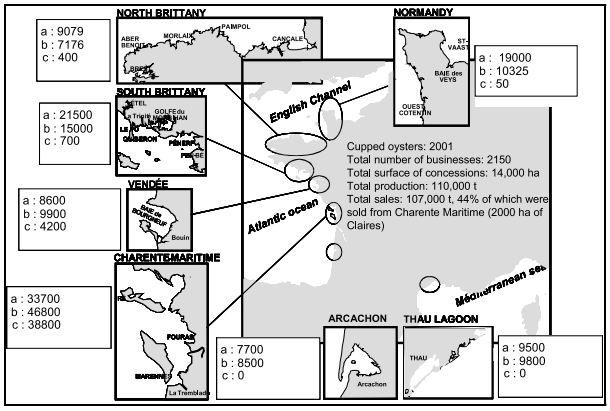

Fig.3. Main characteristics of the different areas of oyster production in France in 2001 (data from a ministry of agriculture census, Girard, 2004) All figures are in metric tons; a: annual production. b: commercialised production. c: oysters refined in claires.

Normandy

Normandy is a recent production zone that has been exploited since the 1960s thanks to the availability of the mesh bag production technique which allows the vast intertidal zones to be exploited where bottom culture is not possible due to wave movement. This zone produces about 20,000 t of cupped oysters over 1,025 ha (168 businesses). Good growth is achieved and half of the oysters from Normandy are later transferred to Marennes-Oléron to be refined in salt water ponds. Normandy is more a region of production than of trade. Recently, large mortalities affected the baie de Veys (loss of 2,000 t in the year 2000). The causes, as yet undetermined, are thought to be due to environmental anomalies (Ropert and Kopp, 2000).

Brittany

There is a long-standing tradition of flat oyster culture in this region. The coast of Brittany is highly varied with numerous bays and estuaries that favour cupped oyster culture. Oysters are cultivated in mesh bags (70%) and in deep waters. The main sites are Cancale, Paimpol and Morlaix in the North, the gulf of Morbihan and the bay of Quiberon in the South, but there are a large number of secondary sites such as the Belon Riviera. There are many businesses, of all different sizes, a number of which are managed by farmers from Vendée or Charente-Maritime. As in Normandy, Brittany is a region good for oyster growth and part of the stock is raised in here and then transferred south for refining. Total production was estimated at 21,500 t over 4,500 ha (490 businesses) in 2001.

In the bay of Quiberon, there is large-scale development of cupped oyster cultivation on the bottom in deep water (Mazurié *et al*, 2002). A hundred farms produce about 10,000 t per year over 2,600 ha of concessions.

Vendée (Bourgneuf bay)

Cupped oyster culture started relatively recently in Bourgneuf bay (1947). The oysters are cultured directly on collector tubes and in mesh bags. The production in 2001 was around 8,600 t from about 1,070 ha (290 businesses). This zone is characterised by low yields, mostly due to bad culture practices such as overloading of mesh bags and culture on collector tubes. The oysters therefore tend to grow slowly and be of mediocre quality. Half of the oysters produced are refined in claires. Due to the presence of polders and good quality groundwater, several hatcheries have been set up in this region.

Charente-Maritime (Ile de Ré and Marennes-Oléron)

Marennes-Oléron bay is a renowned site for oyster culture, with a longstanding tradition reaching back to the transformation of ancient salt works in the 17th century (Grelon 1978). Marennes-Oléron is the main area of spat collection and sells spat to all the other regions. Production in this region is characterised by complexity of the farming practices, overstocking of cultivated beds and generally high production costs, but added value for the oysters

refined in the claires (salt water ponds), This area produces most of the spat collected in the wild: 3 billion spat out of the total 4.5 billion used annually. Spat is mostly collected on corrugated PVC tubes.

Production in 2001 was estimated at 33,700 t over 4,400 ha including 2,100 ha of claires (1,084 businesses). One of the handicaps to production in this region is the silting up of the "parcs", which means that a large distance has to be travelled by boat to reach the concessions and that working time is limited by the tide. The production costs are therefore higher than elsewhere. The numerous rotations of stock for the different culture phases increase costs still more. Many farmers have parcs in the other production zones elsewhere in France, where they transfer their oysters for certain phases of culture. Other farmers purchase oysters, particularly from areas that produce fleshy oysters such as Normandy and Brittany, and then refine them in the claires. This refining practice, which earns the well known Marennes-Oléron labels (*fines de claires, spéciales de claires*), adds value to oysters produced in the other zones. The Marennes-Oléron basin markets about 46,800 t of oysters per year, which is nearly half the national total.

Marennes-Oléron bay is characterised by chronic overcrowding however (Héral, 1989), resulting in reduced growth performances.

Arcachon

Oyster culture in the Arcachon basin has an ancient, rich and turbulent history. There have been many ups and downs from the beginning of the 1860s to the present day. Problems have occurred due to overproduction, environmental degradation and overstocking of farms (Bouchet *et al*, 1997). In 2001 Arcachon produced 7,800 t of cupped oysters and about 0.5 billion spat (374 enterprises).

The most recent crisis involved contamination of oysters with toxic algae which meant their sale was prohibited for several weeks during the summer of 2005. Economic destabilisation of oyster farming in Arcachon had already occurred due to a human factor: the effect of the antifouling paint tributyltin (TBT) used for leisure boats (Alzieu *et al*, 1989). These products lower the quality of oysters by deforming the shells (formation of muddy blisters) and by impeding growth. They also had a very detrimental influence on reproduction leading to a total absence of spat collection for five years, from 1977 to 1981. This crisis deeply affected oyster culture in Arcachon by drastically reducing the number of businesses. Production is now about 8,000 t, from off-bottom or mesh bag culture. Arcachon bay is also another area producing spat from collection in the wild.

Mediterranean: Thau, Leucate, Corsica

With an annual production of about 9,500 t of cupped oysters over 360 ha (248 businesses), the Thau lagoon is an essential site for Mediterranean production (600 t in Leucate and 200 t in Corsica). The farming technique used is specific to the Mediterranean where there is no tide. The oysters are cultured on ropes, hanging from structures known as "tables" that are driven into the sediment. The productivity of Thau lagoon is very high and growth is extremely fast (12 to 18 months to reach commercial size).

This zone does not produce spat, these are brought from Atlantic coast or from hatcheries. Recently, a new technique ("pearl net") of on-growing of small hatchery spat was tested with very good results. As the quality of the products obtained from the hatchery spat is generally excellent, the use of this spat is increasing a great deal in the Thau zone. Furthermore, hatcheries can produce triploid oysters, whose quality is better in summer during the tourist season.

End product: efforts to improve the quality of cupped oysters

Market context

Practically all French oysters produced are sold fresh, and are mostly eaten raw straight from the shell. The annual production corresponds to the demand of the French market and there is very little trade with other countries. Oysters are considered as a traditional, affordable luxury product.

There is a strong seasonality of sales, with more than half of the consumption takes place over Christmas and the New Year. At this time of year there is strong competition between oysters and other products with a similar 'festive' image (salmon, foie gras, etc.). The producers are now finding it difficult to cover production costs, that are rising more quickly than sales prices. Sales to the wholesale market are decreasing in favour of direct sales (about 30 %), which are now more profitable. The market is not well organised and the different production zones compete with each other, thus bringing the price down. The wholesale prices are very variable (an average of 1.9 euros/kg in 2001,

Kalaydjan, 2004). Producers'organisations from the different basins are still not efficient enough in maintaining prices.

The oysters still have a very good image with consumers. However, apart from health concerns, there is also an increasing demand for information about the product (origin, culture site, quality etc.). It is therefore necessary to make the products known whilst improving quality. The efforts to promote oysters and improve their quality are carried out at two levels, through norms (sizes, conditioning, filling index) and through the identification of products (designations, certifications, labels).

Quality criteria for cupped oysters

From the point of view of the external appearance, the oysters must be well shaped. They should never be too long and narrow but should be well cupped ('*coffrée*'). The outside of the shell should be smooth without barnacles or worm tubes.

As for the internal appearance of the oyster, the flesh should fill out the shell. It should be firm, not milky (without gametes) and be ivory in colour. A black lace-like mantle is additional good feature. The flesh should have a slight, pleasant, iodine smell. The shell should be clean and the nacre hard, without blisters or chambers (caused by polydora parasites or due to the influence of anti-fouling TBT paints).

Because each site confers its own particular taste to the flesh, oysters can be regarded as local products. An oyster should not be too salty. The texture of its flesh should be firm and crunchy. Although the taste will be variable, smoothness and a slightly sweet flavour are generally appreciated. The oyster should "taste of the sea" (Neild, 1995).

The quality of the oysters in the main French basins is regularly tested within the framework of a network set up by Ifremer to monitor the oyster growth (Fleury *et al*., 2001).

Refining the oysters in Claires

Refining is an operation intended to improve the quality of products (meat content, better taste) and their commercial value. Claires are small shallow earth-bottomed ponds communicating with the sea. Abundant phytoplankton blooms fatten oysters cultured at low density in claires and give them a especially desirable taste. The occasional presence of a particular microalgae species *Haslea ostraria* gives the gills a green colour. These green-gilled oysters are in great demand. According to the duration of immersion, culture density and index of fattening (percentage flesh, see below), oysters are classified as "Fines de claires", "Spéciales de claires" (Grelon, 1978) or the top quality level "Pousse en claire".

Classification of oysters according to weight and soft tissue development (filling)

The most basic information for consumers consists of a system of classifying oysters according to their total individual weight. This system is compulsory for all oysters whether they are sold by the kilo (most frequent) or by the dozen. Oysters are graded from 0 (very large) to 5 (very small), according to their unopened weight. French consumers do not like oysters that are too big or too small and the most frequently consumed grade is N°3 (66 to 85 g).

A second criterion for classifying cupped oysters is according to the filling rate calculated as percentage soft tissue. The oysters are not classified if the value of this index is less than 6.5. They are called "*fines*" when the index is between 6.5 and 10.5. They are classed as "*spéciales*" when the index is above 10.5. The classes "*fines de claires*" and "*spéciales de claires*" refer only to oysters that have been refined in salt water ponds.

Efforts to promote and publicise products

each production region tries to get ahead by promoting and publicising its product. Many different criteria are used for labelling oysters with these objectives in mind.

Promotion of products: generic brands such as the Belon (*Ostrea edulis*) or geographical brands such as oysters from Marennes-Oléron, Bouzigues, Arcachon, Normandy, Brittany etc...

Product specificity: classification according to the filling rate and time refined in salt water ponds, local-level geographical origin: "Indication Géographique Protégée"-IGP and "Appellation d' Origine Controllée"-AOC (under preparation in Thau).

Quality brands: Red label "Marennes-Oléron", "Pousse en Claires" (refined in salt water ponds with precise quality specifications), certificate of production conformity "Exquise de la Méditerranée" (defining a precise process), names of non-certified individuals e.g. special Cadoret, Papin,

Gillardeau, etc (referring to particular producers).

All these efforts have encountered a considerable number of difficulties. There is such a proliferation of regional and local designations competing with each other that this has become confusing for the consumer. There is also a large variability in the products depending on the environmental conditions and so consistent quality is very difficult to achieve. The consumer lacks knowledge on the quality of products when this is not represented through their sale price. Beyond measurable norms (size, index) the multiple quality criteria are not very conclusive and more than 50% of oysters are still sold simply under the designation Marennes-Oléron.

Product diversification: triploid oysters

A polyploid is an organism with more than two base genomes. At present it is possible to produce triploid oysters in hatcheries. These have three base genomes corresponding to 30 chromosomes per cell. Polyploid animals and plants also exist in nature and triploid oysters are not classed as genetically modified organisms (GMOs). Triploidy essentially induces two advantages in the cupped oyster, a quicker growth rate and near sterility endowing the animal with a more constant quality from the point of view of filling rate. In fact triploid oysters do not reproduce in summer and therefore have good soft tissue development but very limited gametogenesis in this period. At present, the use of these oysters is increasing progressively in France and about 80% of the 800 million spat sold by hatcheries in 2005 were triploids. Triploid oyster production makes up about 15 to 20% of total French production. Today demand for hatchery spat is widely superior to supply in spite of the higher price.

PRESENT PROBLEMS FOR FRENCH OYSTER PRODUCTION

French oyster production faces numerous constraints:

Biological constraints

- **Pathology:** inherent risks of monoculture
- **Basin management:** exceeding trophic capacity, summer mortality

Environmental constraints

- **Pollution:** bacteria, anti-fouling paint, chemical contaminants
- **Toxic algae:** Diarrhetic Shellfish Poisoning (DSP), Paralytic Shellfish Poisoning (PSP), Amnesic Shellfish Poisoning (ASP)
- **Competition for space**

Socio-economic constraints

- **Adaptation of enterprises** (European norms)
- **Market organisation**

Considering the history of oyster production in France, it is obvious that there are a large number of risks involved in monoculture of the cupped oyster. This situation is taken into account in research into mollusc pathology and genetics.

In pathology research, the primary effort is made to prevent disease. Preventive efforts consist of monitoring mollusc resources, testing imports, identifying pathogens and developing diagnostic tools. These are the objectives of the REPAMO network (Réseau de Pathologie des Mollusques), set up by Ifremer and co-ordinated by the laboratory at La Tremblade, which is also the reference laboratory for mollusc pathology for the European Union and for the International Animal Health Organisation (OIE) (Thébault *et al*., 2000).

These preventive measures are complemented by research into the main diseases. The objectives are to identify the pathogens and describe their developmental cycles, set up experimental reproduction techniques for disease causing organisms, develop diagnostic tools that can be used in research or in disease control and finally, to study the impact of these diseases as well as their evolution in space and time.

Current genetics research consists of the following research actions: (i) characterising the domestic and wild populations to be farmed; (ii) evaluating new species, broodstock from new populations and hybrids so as to counter the risks inherent to monoculture; (iii) selecting strains that are resistant or tolerant to disease in order to find responses to the animal diseases that reduce production; (iv) breeding lines that have better growth performance, flesh quality or survival in order to improve productivity.

Several studies on basin management have modelled how ecosystems function in mollusc production zones, particularly in Marennes-Oléron where there is chronic overstocking. Efforts are currently underway to decrease biomass on the farms in the intertidal zone of this region. This decrease would be compensated by offshore farming in the bay of Marennes-Oléron using deep-water culture on the bottom or on ropes attached to long lines. These

projects have led to conflict, mainly with fishermen but also with other sea users (tourism, navigation etc.).

Besides the overstocking problem, cupped oyster culture has been facing problems of summer mortality for several years, sometimes reaching catastrophic proportions. In order to determine the cause of this mortality and propose solutions, a vast four year pluridisciplinary research program (MOREST) was undertaken and is now in its terminal phase. Research into physiology, ecophysiology, pathology and genetics was conducted and the first results show that the risk of summer mortality is linked to multiple factors. Temperature over 19°C appears to be a trigger, but many other influences are then involved. Genetic origin, reproduction in relation to available food level, pathogens including *vibrio* spp., water inflow from rivers and their catchments and nature of the sediment all have an influence. An important result of MOREST is the possibility of reducing summer mortality by using selected resistant strains of *C. gigas* (Samain, personal communication).

As concerns sanitary constraints, a huge effort has been made in the last 10 last years to respect precise requirements of European sanitary rules in France. Culture areas are classified according to the density of faecal bacteria in the water. Research is underway to complete regulations which also take viral concentrations into account to ensure better consumer protection.

Seventy percent of companies have the authorisation to sell on the wholesale network or as retailers. They are registered as “expéditeurs”. French oyster farmers proved their dynamism to adapt their shipping units to European rules and much has been done to modernise businesses in the last ten years.

Environmental constraints stemming from the quality of farmed waters is also closely monitored by Ifremer through its different networks: (i) REMI network, monitoring the microbiological quality of oysters in the environment; (ii) REPHY network, monitoring toxic phytoplanktonic blooms (DSP, PSP, ASP); (iii) RNO network, monitoring the main chemical contaminants.

Wherever there is a strong increase in toxic algal blooms, special attention is being paid to improving the monitoring and understanding of such phenomena. Shellfish detoxification trials are also underway in an attempt to restrict the economic impact of these blooms (Lassus 2002).

CONCLUSION

French mollusc production has many strong points. There are numerous natural sites which are favourable for this industry. Shellfish collection is an ancient activity, and now shellfish farming is well established along the coast with a concession system that favours small family firms. Technical expertise and practical know-how are well developed. Oyster consumption is traditional and festive, but could undoubtedly be increased by offering more and better information to the consumer about the products and by improving year-round quality (e.g. for tourism in summer). Present efforts being made by the profession on quality aspects should lead to considerable progress. Mollusc production also benefits from support from research. Even though progress is slow, recent practical innovations are growing in importance (triploid oysters, long line rope culture, deep water culture). In France, farms are monitored through microbiological and phytoplankton toxin testing, thus guaranteeing a healthy product for the consumer. An important new development has come from the increase in the use of hatchery spat (about 15% of the total production in 2001). Hatchery spat production, which started with diploid spat about ten years ago, had initially irregular quality but has now begun to be much more reliable (faster growth, greater growth homogeneity, good oyster shape). This improvement came with experience and by selecting the best genitors for breeding in the hatcheries. A notable increase in hatchery spat use after genetic improvement concerned triploid spat (now produced by crossing tetraploids and diploids without using chemical treatment). Although the first reactions of the producers were negative towards triploids, due to the possible consumer acceptability problems, there is now a real boom for triploid spat because of its excellent performances. Growth is faster with sometimes the gain of a year out of a three year production cycle. Mortality is reduced and the look and taste are often better, particularly in summer.

There are also numerous drawbacks: oyster farming is a traditional, artisanal and individualistic profession with strong competition between producers. Furthermore businesses are often below critical size to incorporate modern developments. The market is very complex and there is a lack of organisation, meaning that competition between production zones is very strong. The producers’ organisations have not managed to regulate the

situation and the prices fetched are still low. As a consequence, the small producers tend to sell their product directly so as to increase its added value. However this is very time consuming, in detriment to production. Consumption of oysters is very seasonal but consumers do not necessarily recognise the differences in quality of products on offer. Overstocking of farms, which is often chronic, and numerous natural hazards (climate, bacterial contamination, toxic algae, mortalities) increase production costs. Monoculture entails serious risks especially as the historical background implies that the risk of a new disease is very real.

The main challenges for French oyster culture in the near future are:

Within the profession

Control the quantity and quality of production.

Lower production costs: by using new techniques and production zones (deep water, long line rope culture), mechanisation, selection.

Organise the market: through price support, promotion, recognition of quality brands, extension of the sale period (triploids in summer).

Environmental management

Monitor for major hazards: by detecting microbial and chemical pollution and toxic algae

Improve health quality: by maintenance of water quality in mollusc producing basins, improvement of treatment procedures (purification and detoxification)

Reduce risks of animal diseases: by prophylaxis.

Integrate management of the coastal zone: reduce competition for space (tourism, fisheries, environmental protection) though co-operation and regulation.

Although a "revolution" has been achieved in the treatment of shellfish according to the European rules, there has been comparatively little innovation in techniques of production which remains very traditional. In the present context of strong market competition, efforts to improve oyster quality will be essential for the future. Quality certifications will require better zootechnological management and testing. Many small companies are not large enough in terms of manpower to carry out this quality control process. As was the case for agriculture, amalgamation of some enterprises will certainly be necessary in future. Costs could be reduced by mechanising operations but this is not possible with the traditional techniques used at present. The use of hatchery spat in association with long lines in the open sea should permit some mechanisation. Reduction in costs should also be possible as the domestication of oysters begins, triploids offering increased growth and quality and selected oysters for lessening summer mortality.

Apart from the risk of disease affecting the cupped oyster *Crassostrea gigas*, the main problem now is the increasing occurrence of toxic algae which is probably related to global warming.

Nevertheless, the dynamism of the profession and increasingly greater efforts in organisation and environmental management should allow the maintenance of French oyster production in the future.

REFERENCES

Alzieu, C., Héral, M., Dreno, J.P., 1989. Les peintures marines antisalissures et leur impact sur l' ostréiculture. Equinoxe, N° 24, pp. 22-31.

Bouchet, J.M., Deltreil, J.P., Manaud, F., Maurer, D., Trut, G., 1997. Etude intégrée du bassin d' Arcachon. Tome 5. Pêche et Ostréiculture. Rapport IFREMER, DEL 97.09/ Arcachon.

Comps, M. et Duthoit, J.L., 1976. Infection virale associée à la "maladie des branchies" de l'huître portugaise *Crassostrea angulata*. C. R. Acad. SCI., Paris, 283 série D, pp. 1595-1597.

Comps M., Bomami J.R., Vago C., Campillo A., 1976. Une virose de l'huître portugaise *Crassostrea angulata*. C. R. Acad. SCI., Paris, 282 série D, pp. 1991-1993

Coste, M. (1861). Voyage d'exploration sur le littoral de la France et de l'Italie. Imprimerie Impériale, Paris, 292 p.

Fauvel Y., 1985. L'étang de Thau : compétition dans l'exploitation, une redite. Rapport IFREMER/ DRV/SDA, 48 p.

Fleury, P.G., Cornette, F., Claude, S., Palvadeau, H., Robert, S., d'Amico, F., Le Gal, P., Vercelli, C., 2001. Réseau de suivi de la croissance de l' huître creuse sur les côtes françaises (REMORA), résultats des stations nationales, année 2000. Rapport IFREMER, DRV/RA/RST/01-02, 48 p.

Girard, S., Pérez Agundez J.A., Miossec L., Czerwinski N. 2005. Recensement de la conchyliculture. Agreste. Cahiers N°1. 87p.

Goulletquer P. and Héral M., (1997). Marine molluscan production trends in France: from fisheries to aquaculture. U.S. Dep. Commer., NOAA Tech. Rep. NMSF, 129, pp. 137-164.

Grelon, M. (1978). Saintonge. Pays des huîtres vertes. La Rochelle Ed. Rupella, 364 p.

Grizel, H. and Héral, M., (1991). Introduction into France of the Japanese oyster (*Crassotrea gigas*). J. Cons. Explor. Mer, 47: 399-403.

Héral, M., 1989. L'ostréiculture française traditionnelle. In «Aquaculture» (G. Barnabé, ed.), Lavoisier, pp. 347-397.

Héral M. and Deslous-Paoli J.M., 1991. Oyster culture in European countries, in "Estuarine and marine bivalve mollusc culture" (W. Menzel, ed.), CRC Press Inc., Boston, pp. 153-189.

Kalaydjan, R., Bihet, G.,., Daurès, F., Dehez, J., Girard, S., Guyader, O., Pérez Agundez, J.A., Thébaud, O., 2004. Données économiques et maritimes françaises 2003. Bilans et prospectives Ifremer. 95 p.

Lassus, P., 2002. Coquillages contaminés par des phycotoxines paralysantes. Vers une procédure de détoxification. Série comportement des polluants. IFREMER Brest. 48 p.

Marteil, L., (1979). La conchyliculture Française. Troisième partie. L'ostréiculture et la mytiliculture. Rev. Trav. Inst. Pêches marit., 43, (1): pp. 5-130.

Mazurié, J., Foucart, M., Langlade A., Bouget, J. F., Fleury P.G., Joly J.P., Martin A. G., 2002. Analyse des pratiques, contraintes et performances d'élevage de l'huître creuse *Crassostrea gigas*, en 2001, sur différentes concessions en eau profonde de la Baie de Quiberon. Rapport IFREMER, DRV/RA/RST, 2002- 08, 61 p.

Neild R., 1995. The English, The French and THE OYSTER. Quiller Press, London, 212 p.

Ropert, M., Kopp J., 2000. Etude des mortalités ostréicoles de l'hiver 1998/1999 en Baie des Veys. Rapport IFREMER, DRV/RA/RST/2000-10, 52 p.

Thébault, A., Dobert, M., Chollet, B., Dumais, M., Joly, J.P., Garcia, C., Comtet, T., Le Coguic, M.J., Martin, A.G., Pichot, Y., 2000. Bilan 2000 du réseau REPAMO. Réseau National de surveillance zoosanitaire des mollusques marins. Rapport IFREMER, DRV/RA/LPG, 79 p.