

The French Mussel Industry: Present Status and Perspectives

Jean Prou and Philippe Gouletquer

The French mussel industry produces around 60,000 metric tons on a yearly basis using two common species: *Mytilus edulis*, which is widely distributed along the Atlantic coastline, and *Mytilus galloprovincialis*, distributed mainly on Mediterranean shores. This production represents only half of the yearly consumption of mussels in France, leading to large imports from Spain and the Netherlands. Most imports occur between September and March, when the Atlantic production is reduced because of low meat quality due to spawning events. Although a public mussel fishery still exists, most production is based upon 3 culture techniques: on-bottom culture, longline and suspended culture, and bouchot-type culture, with the latter being developed in the 13th century. Annual landings from the public fishery are highly variable because of irregular spat recruitment. Presently, more than 1600 km of bouchots are distributed along the coastline, yielding around 55,000 t of mussels. On-bottom culture, a traditional activity, is limited and yields around 3000 t. Harvests from longline culture have significantly increased in the last 10 years, showing various degrees of success depending on the geographic location. This technique allows development offshore, far away from any pollutant source. Suspended culture has been successfully used to compensate for the irregular spat settlement within the intertidal area, as well as to expand marketing activity and increase growth rates. In the near future, the mussel industry will likely face several challenges, including increased sanitary regulations at the French and EU levels. This could result in further off-shore development, but might lead to space conflicts with other users (e.g., tourism, fisheries). To address that matter, Integrated Coastal Zone Management plans (ICZM) are currently under development in several Atlantic traditional rearing areas. The issues of product quality and labelling, such as geographic identification for marketing purposes, are among the top priorities for the mussel industry.

History of the French Mussel Industry

Mussel production in France involves two common species: *Mytilus edulis* is widely distributed along the English Channel to the southwest coastline of France, and *Mytilus galloprovincialis* is mainly distributed on Mediterranean shores. This wide distribution of mussels favored extensive fishing activity until the 19th century.

Mussel culture methods have been used in France since the 13th century, but only in one location in the southwest of France. According to legend, the origin of "bouchot" is attributed to an Irishman who was shipwrecked on the Charente coast in 1235. Sole survivor of this disaster, Patrick Walton stretched out nets at low tide to catch fish. He noticed that mussels attached themselves to the wooden stakes on which the nets were stretched. He then had the idea to plant

stakes in a line to harvest mussels and the first "bouchot" was born. This technique, well adapted to large intertidal mud flats, strengthened the development of the blue mussel industry in France. After the Second World War, the "bouchot" technique expanded to other intertidal sites, particularly along the Brittany and Normandy shores. Recently, off-shore cultivation of *Mytilus edulis* has developed in protected areas such as the Charentais Sounds on the Atlantic coastline.

Mytilus galloprovincialis has been cultivated since 1925 in Mediterranean lagoons, mainly in the Bouzigues area located in Thau lagoon. Suspended culture on ropes is currently used. More recently, leases in the open ocean have permitted further development of the industry. However, predation of mussels by fish has recently impacted the longline production of mussels in this area.

The French mussel industry produces around 60,000 metric tons on a yearly basis. Normandy (44%) is now the main producing area, followed by Brittany (25%), Vendée-Charente (18%) and the Mediterranean (13%). Around 1600 km of "bouchots" represent 95% of the production. On-bottom culture (2000–3000 t) is mainly located in the Bay of Brest, Pas-de Calais and South Brittany shorelines. Longlines are located along the Mediterranean coastline as well as in Vendée-Charente. Landings from the public fishery are highly variable because of irregular spat recruitment and range between 10,000 and 50,000 t. The overall production represents an exchange value reaching 100 million (US\$105 million).



Spat collecting on coconut fiber ropes

Growing and Processing Technology

Bouchot culture

Within intertidal areas, a typical spat collecting unit is made of one or two rows of 40 wooden poles (spat collecting "bouchot") on which 3000 meters of coconut fiber ropes are deployed. The density of rope is increased up to 5000 meters when the culture time is concomitantly reduced. On off-shore longlines, 500-m long ropes are wound on wrought iron rectangular frames. Spat collection occurs between March and June on the Atlantic coast and all year long in the Mediterranean Sea with peaks occurring in the spring and fall. Spat collection on off-shore platforms pro-

vides a better and more uniform yield compared to intertidal areas. Exposure of spat to air during ebb tide reduces growth and could be responsible for mortalities if extreme conditions are encountered (dry wind, thermal stress, etc). On the Brittany and Normandy shorelines, natural spat collection is insufficient to ensure a viable industry, so ropes with spat attached are therefore imported from the Vendée-Charente site.

Two months after spat fall, ropes and the attached spat are wound around large vertical poles (bouchots) in the intertidal zone. A mesh netting is used to cover the mussels to prevent them from being detached and lost, or preyed upon. In order to optimize spat densities during early development, mussel farmers thin the spat and prepare tubes of seed called "boudins". These cotton nets are wound around poles or suspended longlines.

Each pole is 4 to 7 m long, 15 to 25 cm in diameter, and protrudes 2 to 3 m above the bed. Several wood types are currently being used, including pine, oak and, more recently, squared Brazilian hardwood. Recycled plastic tubes are currently under evaluation. Bouchot structures vary between rearing areas. Generally, one or two rows of poles are spaced 25 m apart. The length of the rows and the numbers of poles used de-

depends on the regulations in each area. The rearing density is adjusted to suit the carrying capacity of the area.

Harvesting begins as soon as the mussels reach the 40-mm marketable length, usually after a 12- to 15-month rearing period. One pole produces between 25 and 60 kg live weight of mussels per rearing cycle.⁽¹⁾ Mussels grown on bouchot poles are harvested by hand or, more often, using hydraulic fishing equipment that removes the entire population of mussels at one time. A cylinder is lowered to the bottom of the pole, closed and pulled up, and the mussels are dumped on the boat to be washed, graded, weighed, and packaged in 15- to 25-kg bags. Undersized mussels are transferred to mesh tubes that are reattached in the field around the growing poles. Amphibious vehicles currently are used in intertidal areas to maximize working time.

On-bottom culture

The on-bottom culture technique is based on transferring mussels from natural beds with high densities to culture plots where the density is reduced to improve growth and fattening, and to control predation. One-year-old mussels are dredged on wild mussel beds, then taken to the culture plots where they are deployed at a density ranging from 25 to 30 t per hectare. This process is carried out in spring and early summer. The rearing cycle lasts 14 to 24 months.

Longline culture and suspended culture

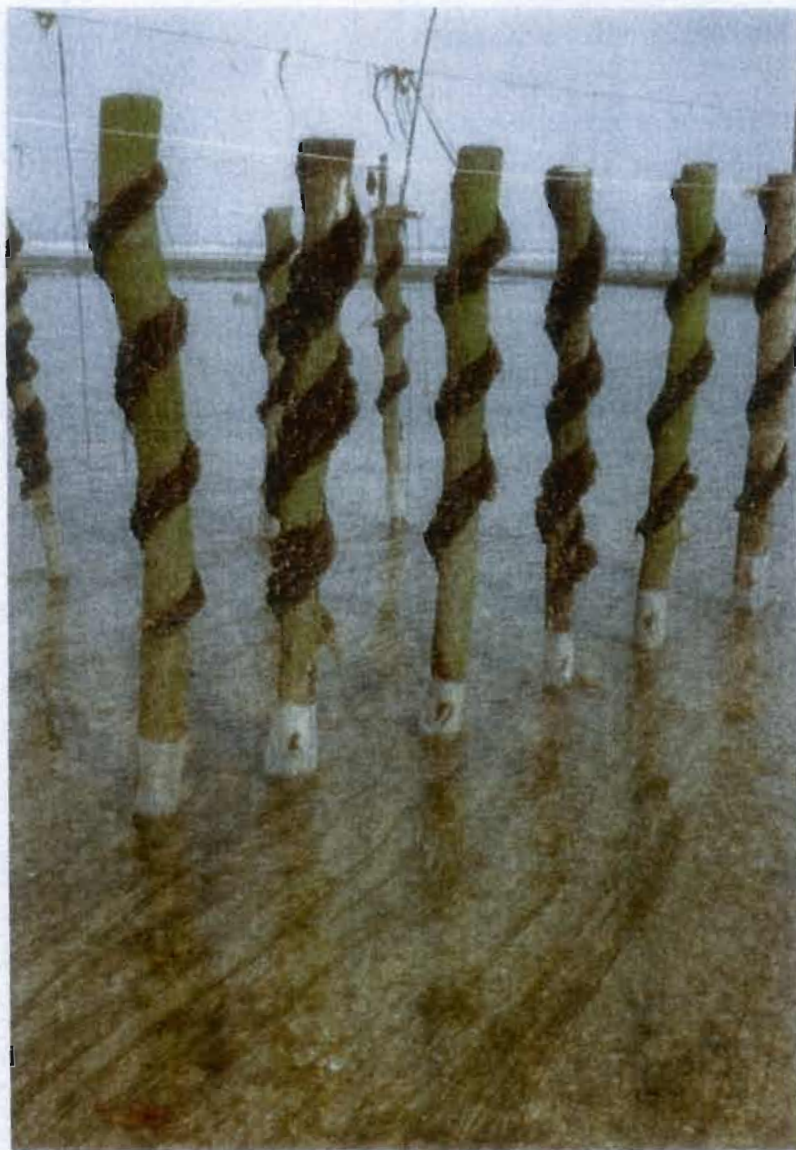
In the Thau lagoon, off-bottom culture is based upon fixed suspended structures (rafts) similar to those used for oyster culture. Seed is transplanted into plastic mesh tubes and hung vertically from the fixed tables.

On the Atlantic coast, the reduced availability of intertidal areas for mussel culture led to the development of longline culture methods. The first trials were carried out in the Pertuis Breton during the 1960s using

raft techniques.⁽²⁾ New subsurface longlines have been recently developed to resist storms and wake effects along the Atlantic coastline and offshore in the Mediterranean Sea. Floats are connected together with horizontal lines that support a large number of vertical ropes where mussels are grown. Annual production rates reach 18 to 20 t per hectare.

The public fishery

Compared to landings in previous centuries, the mussel fishery in France is a declining activity. The Barfleur area natural bed, located in Normandy, is one



Tubes of seed (boudins) wound around "bouchot" poles

of the last but most exploited beds. Around 65 fishermen are licensed for a total annual catch of about 8000 t. Every year, a stock assessment gives estimates of the quantity of mussels that can be fished without damage to the juveniles. Dredging is authorized, but the activity is highly regulated with controls on the daily catch per fisherman, dredge size, and fishing time. In the Bay of Bourgneuf (Loire estuary), oyster culture predominates and mussel fishermen are viewed as competitors because access to mussel beds is free, without license or regulations. Dredged mussels are generally transferred to leasing grounds in Brittany or are reared locally on bouchot. In other traditional areas, such as the Charente Maritime (Atlantic southwest), the fishery is based upon regulated access. No reliable statistics exist.

Comparing growth performance

Mussels cultured using longlines and bouchot techniques show different growth patterns. Submersion time, current pattern and trophic resources such as phytoplankton and turbidity are responsible for the higher growth performance recorded for mussels grown on longlines. By using this technique, marketable size can be reached after 10 months, compared to 14 months for the bouchot culture type. In both cases, the growth rate is higher during spring when the phytoplankton blooms occur.

The market size of *Mytilus edulis* and *M. galloprovincialis* is different. In the Mediterranean, the mean market weight of *M. galloprovincialis* is about 26 g, lower than the market weight of Spanish mussels. For bouchot mussels, the mean weight is 10.4 g, less than mussels produced in the Netherlands.⁽³⁾

Market

Marketing of mussels is based upon species peculiarities. Since *M. edulis* spawns in the spring, the condition index and meat quality are low between March and May. Therefore, the national production is mainly marketed from June to January. To balance supply and demand, around 60,000 t of cultured mussels are imported each year. Mussels are imported from Spain throughout the year, imports from Northern Europe (Ireland, Great Britain) occur from January to April, and mussels are imported from the Netherlands from September to April.⁽⁴⁾

Mediterranean production is commercialized all year round since no major seasonal spawning event occurs. Importations from Italy occur from April to July. From a geographic point of view, the market is also well defined with each producing area having a well specified sphere of influence.

A strong demand for national products and especially for the "bouchot" mussels exists. The demand is reflected in the difference in the retail price of around 2.5 euros/kg for domestically-produced mussels compared to 1.7 to 2.1 euros/kg for imported mussels.

In France, households represent 65% of the total consumption of shellfish, principally oysters and mussels. There is demand for fresh mussels in about 40% of French households, which are characterized by a 2-person lower or middle class family in the 50- to 64-year-old age class. About 33% of the retail household purchases are made at specialized outlets. "Hypermarkets" (55% of the purchases) are leading and tend to take the place of wholesalers for mussel commercialization.

In 2002, 32,879 t of mussels were consumed outside of households and in non-collective restaurants: 82% of the mussels were consumed fresh and only 18% had been frozen; 87% were consumed in the shell, compared to 13% prepared without the shell.⁽⁵⁾

Mussel Farmers Organizations

The French mussel industry includes more than 1000 farms which usually produce and also market their products. Most of the farms (70%) are family-size companies with a mean production of about 52 metric tons.⁽⁶⁾

The National Shellfish Committee (CNC) is the national industry body of French shellfish farmers. It is the compulsory stakeholder for all decisions and regulations related to shellfish management. French rearing areas are spatially divided into 7 Regional Shellfish Committees (SRC's). Under the supervision of the Ministry of Agriculture and Fishery, these committees are authorized to collect professional taxes. More recently, Organizations of Producers (OP's), recognized at the EU level, have been established and are responsible for marketing initiatives, as well as advertising campaigns. SRC's are in charge of quality issues, certification processes, and industry development.

Sanitary Control

Since the French shellfish market is based mainly on raw and fresh products, it is particularly important to protect the public from eating polluted or unhealthy products.

Microbiological aspects

Shellfish producing areas are divided into 4 classes according to seawater sanitary conditions. Class A zones permit cultivation or fishing and marketing without depuration. In Class B zones, mussels must



Hydraulic fishing equipment

be depurated either in a depuration plant or farm installation under agreement before marketing. Cleaning of mussels in specialized depuration plants is necessary for class C zones. Shellfish fishing and exploitation are forbidden in Class D areas.

Classification of areas is done after a zoning study based on shellfish analysis for fecal contamination. For example, A zones must satisfy 2 conditions. The first concerns fecal coliform concentrations: more than 90% of counts on a 100-g flesh sample must show MPN (most probable number) values lower than 300; one value larger than 1000 is sufficient to reject the A classification. The second concerns mean concentration of heavy metals per kilogram of wet flesh (0.5 mg for mercury; 2 mg for cadmium; 2 mg for lead).⁽⁷⁾ Sanitary agreements of farm installations are given by both the Veterinary Office (sanitary) and Maritime Affairs (State legislation). Finally, products are controlled by the Veterinary Office at each step of the marketing process (packaging, transport, dealers). There are regulations concerning fecal coliform concentrations (300/100g wet flesh) and the presence of

salmonella per 25 g wet flesh.⁽⁸⁾ Furthermore, the shellfish industry organizes its sanitary controls on their own products to demonstrate and guarantee sanitary quality.

"REMI", conducted by IFREMER, is a Microbiological Monitoring Network.⁽⁹⁾ Three hundred and eighty-five sites are sampled on a monthly or quarterly basis depending on the sanitary conditions. This national network has two objectives: providing data for the zone classifications and detecting abnormal concentrations. Micropollutants are also of concern in establishing the zoning. Regulations focusing on heavy metals, for example, have drastically changed recently and the legal threshold is now half of the previous level.

Since 1974, heavy metals, pesticides and hydrocarbons levels have been monitored by the Coastal Environment Monitoring Network (RNO). Forty-three sites are surveyed four times a year.⁽¹⁰⁾

The presence of phytotoxins in mussels is also of concern for sanitary control. In 1984, a Phytoplanktonic Monitoring Network (REPHY) was imple-

mented in French coastal waters.⁽¹¹⁾ Every two weeks, 62 sites are sampled for estimation of phytoplanktonic cell counts. In high-risk areas or seasons, weekly samples on up to 133 sites are collected and analyzed. If a bloom occurs, shellfish are also collected for analysis of phycotoxins. Regulations give the following values :

PSP: less than 80 µg /100 g wet flesh

DSP: negative results with 24-h mouse bioassay

ASP: less than 20 µg domoic acid/g wet flesh (HPLC method).

Although so far not detected in French waters, AZP is part of the regular monitoring according to EU regulations. When a bloom occurs and tests are positive, the area is closed by state officials. Shellfish sales are stopped until two negative tests (i.e., two consecutive weeks) are reported.

The French mussel industry is systematically striving to maintain an A classification for the mussel rearing areas. Since no inland facilities for mussel depuration have been developed due to resulting summer mortalities, a B classification leads to a halt in production and marketing. By way of example, several events in 2000 in the Bay of l'Aiguillon due to floodings resulted in a temporary closure. This resulted in the development of an extensive management plan to restore freshwater quality at the watershed level to sustain appropriate seawater quality in mussel rearing areas.

Product Quality

The Shellfish National Committee decided in 1999 to develop a label to protect the product called "Moules de Bouchots". Specifications include aspects of cultivation (French origin of spat, growth on bouchot, growing area, packaging), product characterization (6 months minimum growth, 20% of flesh) and traceability of the product from spat to market.

In Normandy, a 5-producer organization (OP) also defined specifications for the mussels fished on Barfleur wild natural beds. These specifications concern origin, minimum length (40 mm), product quality (28% of flesh) and sand removal in a specialized treatment plant. Traceability of the product is also certified.⁽¹²⁾

Issues Affecting Future Development of the Mussel Industry

Pests and predators

Mussel culture on longlines has developed rapidly in the open Mediterranean Sea. For the past few years, large sea bream shoals have significantly damaged more than 70% of the mussel stocks cultured on

longlines. Predation is rapid and no solution has been found in spite of fishing attempts.

Toxic phytoplankton blooms

Mussels are the most sensitive species to phycotoxins. Sales prohibitions usually occur during the marketing season, leading to significant losses for the local mussel industry. Moreover, inaccurate or dramatized information presented by the media have a negative impact on the brand image of mussels, even in surrounding safe areas. Moreover, several large rearing areas are located near international harbors where deballasting occurs. Introduced species that produce phycotoxins might have an effect on the mussel industry in the future.

Silting up

During the spring of 2001, a large mud deposit that caused mass mortalities was observed in the Somme Bay area, in the north of France. The large amount of mud was linked to high concentrations (500,000 individuals/m²) of the spionid annelid *Polydora*. No obvious solutions to prevent this phenomenon have been found. Cleaning of the area by farmers, a labor intensive practice, is still the only efficient way to address the problem.

On intertidal flats, mussel culture could increase silting up, leading farmers to leave the concerned area. In Aiguillon bay, a historical site for bouchot culture in France, higher levels of intertidal flats are now abandoned because of silting up.

Space for expansion and potential space conflicts

Spatial expansion of mussel cultivation from intertidal areas to off-shore zones leads to conflicts with traditional users of these zones such as fishermen or tourists (sailing activity). Advantages of off-shore mussel cultivation include improved growth and access to enhanced seawater quality. For fishermen, mussel farmers are considered to be foreigners who are unable to manage their traditional place in the coastal zone. Fishermen also point out a decrease of their fishing rights. However, in the case of overfishing, off-shore longlines can be viewed as a protected area for fish reproduction and survival of the early stages.

Off-shore longlines are often used in zones that are protected from storms. Islands or bays which offer these characteristics are also convenient for sailing activity. Surface decrease of the stretch and landscape deterioration (buoys, rafts, etc.) could be the main conflicts encountered.

New restrictions in terms of pollutant thresholds

New regulations reducing the allowable thresholds of pollutants, mainly based upon the precautionary approach without a scientific basis for public health concerns might over the long term affect the mussel production industry.

Perspectives

The French mussel industry shows a net deficit of production. The main reason is the lack of space for expansion. Current rearing areas are fully exploited and new development requires additional space. However, new development will not significantly improve the supply and demand balance since most of the production in France is seasonal (summer). Urbanization and industrialization is leading to a reduction in water quality, therefore limiting new mussel culture development. Areas dedicated to tourism or protected by environmental regulations are generally not practical for new development, even for extensive aquaculture. Historically in France, shellfish culture has been located on intertidal areas, while fishermen occupy the open sea. That could explain the lack of mussel aquaculture development using the Dutch approach which links fishery and aquaculture methods.

Longlines are the most advanced technology that has developed over the past 10 years. The rearing area (400 long lines, each 100 m long) located in the Pertuis Breton produces between 2000 and 3000 metric tons of mussels each year and numerous spat for several French rearing areas. It offers a good alternative for "bouchot" mussel reared on intertidal flats. However, new surface leases are bound to coastal zone plans integrating other activities and also environmental constraints. There will be conflicts between users are not only for space but also over water quality. In the Pertuis Charentais, conflicts between agriculture and shellfish farming occur over the question of managing freshwater fluxes from the watershed. The estuarine specificities necessary for mussel culture (larval survival, phytoplankton blooms, etc.) could be seen as being damaged by the increased need in agriculture for freshwater for irrigation.

The supply of the French market by both domestic and foreign origins of mussels involves a multi-product market. This segmentation is revealed by the different retail prices for bouchot mussels, *M. galloprovincialis*, and imported products. Recently, this differentiation was increased by certification and

the development of trademarks that cover both the origin of the product (Mont St Michel bay, Barfleur) and the cultural practices (bouchot). But these processes need a strong professional commitment to be successful and the individualistic nature of the shellfish sector is now confronted by "hypermarket" strategies characterized by a strong demand for freshness, hygienic quality, traceability, certification and convenience products. One of the keys for the future is which group, the shellfish industry or the organized supermarkets, will drive the product specificities with regard to consumer requirements and needs.

Notes and References

1. Boromthanasart S, Deslous-Paoli JM. 1988. *Aquaculture* 72:255-263.
2. Dardignac-Corbeil MJ. 1990. In, *Aquaculture* (G Barnabé, ed.), p. 285-341, 429-442. Ellis Harwood Ltd, Chichester.
3. IFREMER. 1998. Rapport 13. In, *Projet Qualité des mollusques. Synthèse des résultats : Propositions et applications. Rapport interne de la direction des Ressources Vivantes de l'IFREMER*. DRV/RA/RST/98-07 b -- SETE.
4. www.eastfish.org/Trieste/Presentations/SophieGirard.ppt (retrieved 5 September 2002).
5. www.cnc-france.com/actualite/rhf.htm (retrieved 5 September 2002).
6. Dubuisson-Quellier, 2001. Problèmes de qualité sanitaire des eaux du littoral et réorganisation des relations productives et marchandes : Le cas du bassin mytilicole de la baie de l'Aiguillon. In, *Impacts des informations produites par l'IFREMER sur la qualité des eaux littorales dans la production et la commercialisation des coquillages*. p. 143-258. Ecole des Mines de Nantes.
7. www.cnc-france.com/reglement/classement.htm (retrieved 5 September 2000).
8. www.cnc-france.com/reglement/criteres.htm (retrieved 5 September 2000).
9. www.ifremer.fr/envlit/surveillance/remi.htm (retrieved 5 September 2000).
10. www.ifremer.fr/envlit/surveillance/rephy.htm (retrieved 5 September 2000).
11. www.ifremer.fr/envlit/surveillance/rno.htm (retrieved 5 September 2000).
12. www.nfm.fr/html/MouleBarfleur.htm (retrieved 5 September 2002).

Jean Prou is the Department of Aquaculture – Shellfish Coordinator, IFREMER, B.P. 133, 17390 La Tremblade, France (e-mail jean.prou@ifremer.fr). Philippe Gouletquer is the Head of the Genetic-Aquaculture & Pathology Research Laboratory, IFREMER, B.P. 133, 17390 La Tremblade, France