INTENSIVE MARINE FISH FARMING IN EUROPE: 
A STATE OF THE ART

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The confidence in aquaculture gained with salmon in Norway in the early eighties, as well as the prospect of support through national and European community grants, stimulated European investors to evaluate the commercial farming potential of the European seabream, Sparus aurata, and the European seabass, Dicentrarchus labrax, in the Mediterranean. The effort has been a great success. Current production of these high value species is more than 15 thousand metric tons annually.

The production bottleneck with most marine fish species is the larval stage. It is very difficult to achieve cost-effective mass-production of high quality fingerlings because their larvae are much more difficult to rear and feed than the robust salmon larvae, which have a large yolk sac to sustain them for weeks before exogenous feeding is required. In most marine fish the yolk reserves are exhausted in a matter of days, and the much smaller larvae have such a primitive digestive system that they must be fed live zooplankton.

The mass-culture techniques for Japanese seabream, Pagrus major, which were already successfully applied in Japanese prefectural hatcheries, were not adopted for the first commercial operations in Europe. Instead the pioneering farms that were set-up in the early 1980s in France, Italy and Yugoslavia developed more controlled, highly intensive units. Today, European marine fish hatcheries operate at stocking densities of 100 or more fish larvae per litre, and obtain survival rates at weaning onto formulated feeds of 30 to 40 percent for seabass and 10 to 20 percent for seabream.

The successful transition from pilot scale culture to commercial farms producing several million bass and bream fry per year was made possible by improvements in the techniques for producing and utilizing live food. As a starter food, small and super-small strains of the rotifer Brachionus are mass-cultured on algae as well as on off-the-shelf algal substitution diets, and eventually enriched with particulate or emulsified products to boost their level of essential nutrients, especially the highly unsaturated fatty acids EPA 20:5n-3 and DHA 22:6n-3. After a few days of feeding on Brachionus, the mouth of the larvae has grown sufficiently to allow ingestion of larger prey, namely the nauplii of the brine shrimp Artemia. This zooplankton substitute can be conveniently produced from commercially available cysts after 24 hours of incubation in seawater.

Concerted efforts in Artemia research in the 1980s identified the nutritional limitations of Artemia and led to the selection of strains and batches of cysts that would produce predictable output from bass and bream hatcheries.

The use of Artemia enrichment through bioencapsulation of selected components in a particulate or emulsified form is a must in marine fish hatcheries in order to meet the nutritional requirements of the very sensitive larvae. The technology for manipulating the dietary value of Artemia came at a most appropriate time as it enabled the improvement of nutritionally deficient Artemia from the Great Salt Lake in Utah, where vast quantities of cysts could be collected in a period when demand increased exponentially.
Several other zootchnical developments contributed to more predictable output in the Mediterranean fish hatcheries. For example, the disinfection of *Artemia* cysts with hypochlorite and sodium hydroxide, by application of the cyst decapsulation technique, a process which allows the removal of the cyst shell without affecting the viability of the cysts.

There were also improvements in the methods for cyst hatching and nauplius separation and cleaning, especially following the enrichment bath. Floating surface cleaners in the fish culture tanks concentrated and allowed the removal of all traces of floating oil that might have been introduced with the live food, oil which could prevent the young fish larvae from gulping air to inflate their swim bladder. Fish without a functional swim bladder must expend much more energy simply to stay in the water column, and this eventually leads to spinal cord deformities and reduced food conversion efficiencies.

Today fewer than 50 bass and bream hatcheries in the Mediterranean produce more than 65 million fry annually. These are marketed for growout at about US$ 0.80 per 2 gram fry in the case of European seabass and up to US$ 1.00 for each *Sparus* fry.

In the pioneering years the facilities were large and all culture tanks were under one roof. Today modular hatchery systems are preferred because they allow one unit to be shut down for cleaning, disinfection and dryout while the other units continue to operate. Seasonal dryouts have proved to be critical for ensuring the elimination of any harmful bacteria that have built up in the system.

Much of the equipment and machinery that was originally developed for the salmon farming industry in Norway is finding its way into the Mediterranean seabass and seabream farms. Container systems are used for fry transport from the hatchery to the growout units, often over considerable distance, and for stocking the fry into cages. The cages themselves have evolved from simple wooden structures to the Wavemaster steel cages which can be installed in open seas away from coastal areas where there may be conflicts between aquaculture and tourism. The modern cage technology, especially the steel structures and the flexible polar circle type of cage, allow the exploitation of semi-exposed sites. However, no totally open sea cage has yet proven effective for bass and bream. This probably has less to do with structural considerations than the zootchnical and managerial difficulties in farming these species.

As in salmon farming, sophisticated harvester systems are now in use for seabream and seabass. For example, the Brailig fish net is used in a bream farm in Greece. There have also been significant improvements in the quality of feeds, especially since extrusion techniques have been adopted. Local feed mills are gradually entering the fish feed manufacturing business as local markets for bass and bream feeds expand (currently more than 8000 tonnes in Greece), justifying the investment.

Automatic feeders are also widely used, and as reported at the EAS Bordeaux Conference, there is great potential for the use of self-feeders (operated by the fish themselves), because the individual differences in fish behavior can result in significant improvements in FCRs, especially in seabass.

The more than US$ 100 million of marine fish farming industry in the Mediterranean is not restricted to cage farming. Several land based farms are in operation, in Italy, Tunisia, and in other Mediterranean and more northern countries in Europe where heated effluent from power stations may be used to shorten the growout periods from 18 to about 12 months, compensating for the higher investment and operational costs of such a facility.

The successes with bream and bass have provided the incentive to evaluate other high priced marine fish species such as the other bream species *Puntazzo*, *Dentex*, *P啷rus* and *Diplodus*, the dolphinfish *Coryphaena* and the sole *Solea* in the Mediterranean and turbot *Scophthalmus*, halibut *Hippoglossus*, cod *Gadus* and wolfish *Anarichus* in the cooler waters in Europe.