جامعة أبو بكر بلقايد

UNIVERSITY OF TLEMCEN

FACULTY OF NATURAL AND LIFE SCIENCES, EARTH AND UNIVERSAL SCIENCES

DEPARTMENT OF ECOLOGY AND ENVIRONMENT

SEGMENT: MARINE AND CONTINENTAL HYDROBIOLOGY

MASTER II: MARINE SCIENCES

MODULE: ELEMENTARY BIVALVE BIOLOGY, HATCHERY OPERATION, ALGAE CULTURE

HOMEWORK - DESIGN OF A HATCHERY

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Preamble

There are around 30000 species of freshwater and marine fish. However, less than 200 of them have started aquaculture production. Today, most of the world's fish development is ensured by fewer than 30 species.

The availability of young fish is a key element for initiating and then sustaining these productions. Fishing for juveniles in the natural environment is random and is not part of a sustainable approach to fish farming. Hatcheries were therefore developed to produce them.

They are managed by staff with a high technical level, capable of applying sophisticated breeding methods. The main difficulties of this rearing phase lie in the small size of the larvae at hatching (3 to 4 mm) and the constraint of sometimes exclusive feeding with live plankton during the first weeks of life. FAO (2008).

Today, hatcheries provide grow-out operations with:

- ✓ Morpho-anatomical and zoo-sanitary quality of juveniles.
- ✓ Availability for a large part of the year.
- ✓ An ability to produce calibrated individuals of animals.
- ✓ Potential added value through genetic selection.
- ✓ A relative diversity of species in breeding.

In aquaculture, a hatchery is a facility intended to produce eggs and larvae or fry, including fish, crustaceans and molluscs.

There are two hatchery models:

Somewhere only one species of fish is processed (specialized hatcheries) and those dedicated to several.

The current trend leans more towards multi-purpose hatcheries, in line with the modern orientation towards mixed breeding, or polyculture, of species with different eating habits, which makes it possible to use all the nutrient resources of the basin to obtain the best yield.

The establishment of a fish hatchery is subject to a certain number of prerequisites:

- Water availability adequate in quantity and quality;
- Area of land suitable for the construction of ponds, hatching tanks, buildings, etc.;
- Electrical force available, if possible;
- Communication and transportation facilities;
- Labor.

The water

The hatchery uses fresh water or sea water. It can come from dams, reservoirs, ponds, rivers, canals and wells of varying depths. These must always be in perfect working order because a breakdown of one or the other can lead to the temporary shutdown of the hatchery and the loss of current breeding.

Freshwater

The water that supplies the hatchery is intended for storage basins, incubation devices and larvae rearing.

Water temperature is another important factor. Warm water fish need water between 20 and 30°C for their reproduction.

This fact must be taken into account when establishing plans for the hatchery: if possible, it will be necessary to provide a simultaneous supply of cold water and hot water, so that one can be mixed with the other to obtain the optimal temperature.

It is also used for cleaning equipment, it must therefore be clean and if possible of drinking quality.

Fresh water used for cleaning equipment and rinsing all small equipment. In each room of the hatchery will be placed in a barrel or a 1/2 barrel of 200 liters which will be filled every day and chlorinated at 40 g/m^3. This water will be used to kill all the germs on the equipment that has been in contact with the farms. At the end of the day the barrel will be emptied onto the floor to be used for general cleaning of the room.

Water supply brings together the techniques for bringing water from its source through a network of pipes or architectural structures to places of consumption.

Seawater

Seawater comes into the hatchery by pumping. Pumping follows the rhythm of the tides. It is generally done at the start of the rising tide and is used to fill a 30 m3 storage tank in order to meet water needs for 12 hours (duration between two tides).

The degree of filtration varies depending on the unit to be powered. After the first pumping, the water passes through a 50 micron sand filter and arrives directly either in the nursery or in the storage tank. FAO (2008).

Sea water is rigorously controlled.

©Ifremer Argenton

Seawater treatment plant

It is therefore mechanically filtered in order to eliminate organic and mineral particles (1-10 µm), before undergoing treatment with ultraviolet radiation.

The objective is to avoid the introduction of pests, mainly of bacterial and viral origin, but also parasitic, into the breeding tanks.

Thermal regulation of breeding environments is sometimes necessary for the proper development of animals.

The air

The air supply is done by a battery of 3 suppressors activated according to demand. Each device has a flow rate which allows it to supply the larval breeding. But when the nursery is in production, two devices must be connected.

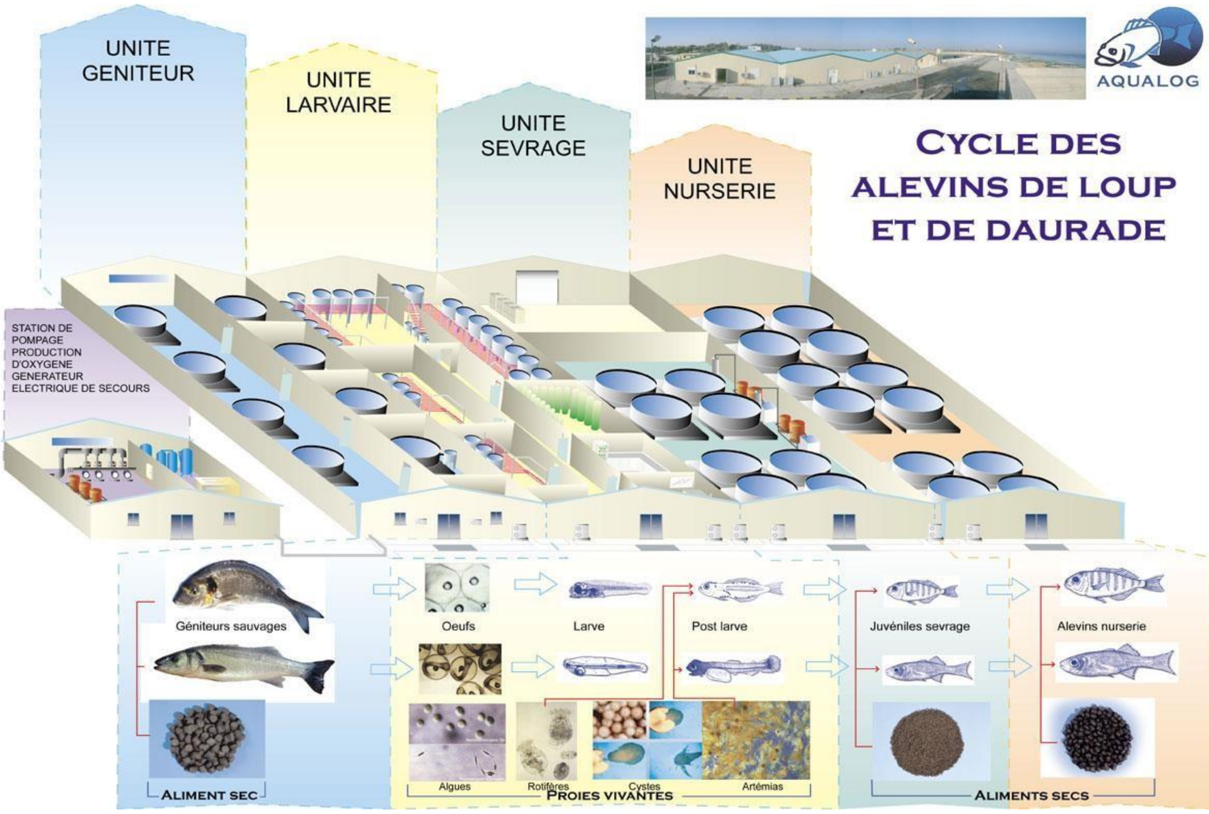
The air intake must be clear. The fragility of these devices requires careful maintenance.

Description of facilities

A hatchery complex consists of four elements:

1) Breeding ponds, acclimatization of breeding animals;
2) The hatchery itself (egg incubations, larval phase).
3) First-rearing systems;
4) Fry rearing ponds combined with production.

They are generally supplemented by areas of primary productions (phytoplankton and zooplankton).



Production process Breeding ponds

The reproduction

The purpose of storing brood stock is to provide them with favorable conditions for the development of the gonads with a view to obtaining better reproduction and well-fertilized eggs.

Placing in a maturation tank makes it possible to obtain the simultaneous maturation of females, therefore grouped clutches, and also to ensure stock management and biological monitoring of the spawners.

Breed species are mainly gonochoric (separate sexes). However, there are exceptions such as the sea bream which is a protandrous hermaphrodite (first male then female). The development of the gonads (testes and ovaries) before reproduction can reach 20 to 25% of body weight.

It is possible to hold between 20 and 50 breeders, weighing a total of approximately 150 to 250 kg, in 1000 m^2 of pond surface area. Where good propagation technique is practiced, about 50 to 150 broodstock of a single species (40 percent females and 60 percent males) will be enough to produce between 2 and 3 million fry of 20 to 30 days old.

In other words, two breeding tanks, each of 2000 m^2 capable of containing 50 to 75 normal-sized broodstock (3 to 6 kg), will be necessary for a single species. If the hatchery has to process 5 species of fish, 8 to 10 such tanks covering a total of 1.5 to 2 ha would be sufficient. Breeders with different eating habits can be put together in the same tank.

But it is not advisable to reduce the number of pools and increase their surface area beyond 2000 m^2, because it then becomes difficult to net the spawners when their segregation by sex begins to take hold.

Breeding basins or ponds must be sufficiently deep (1.50 m on average) and amply supplied with water.

The location of these ponds must be chosen so that it is guarded against the possible theft of breeding stock and preferably located near the hatchery. A more remote location would cause transportation problems and require special monitoring and guarding.

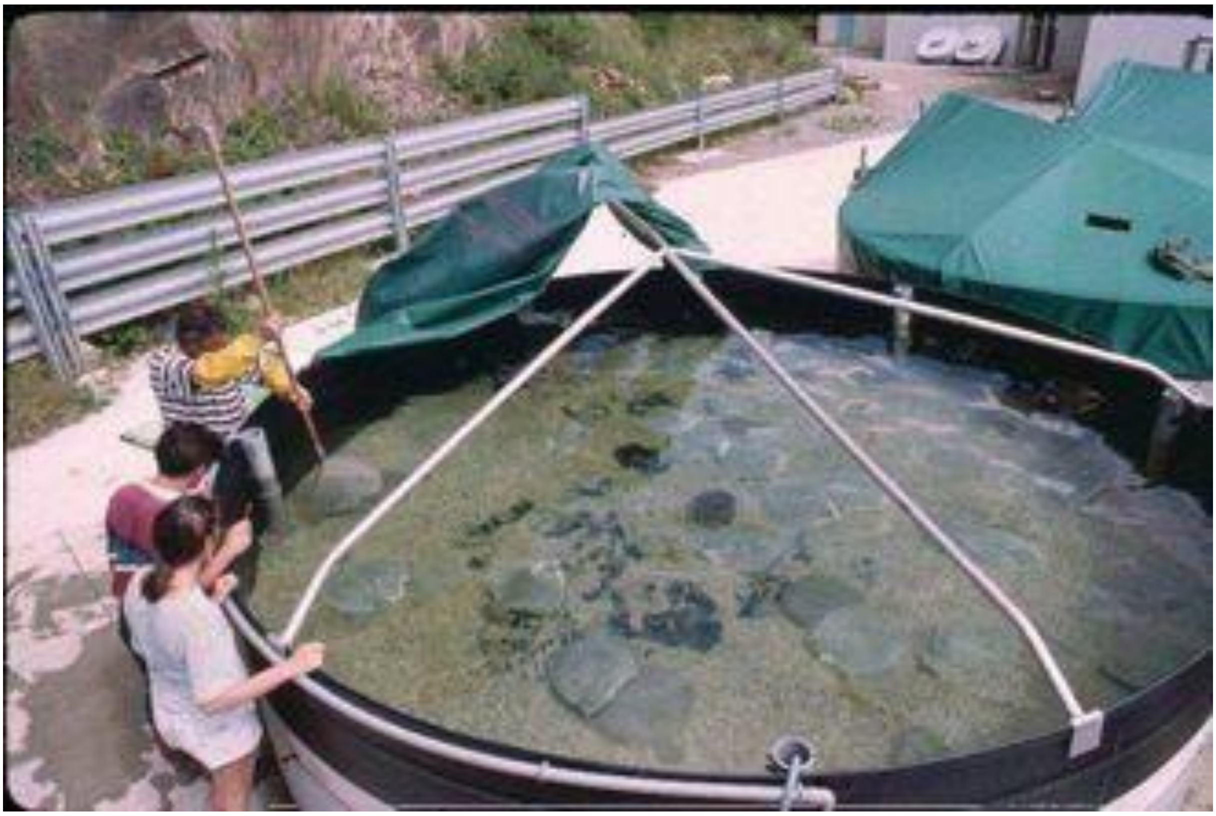
It is recommended to build these breeding tanks on a rectangular plan: for example, 75 m by 20, or 80 by 25, dimensions which will give the appropriate surface.

The sea water temperature and lighting duration are controlled, making it possible to constitute several breeding seasons staggered in time in order to ensure egg production at different times of the year.

Reproduction is characterized by the expulsion of gametes (spermatozoa and eggs) emitted simultaneously into the water; Fertilization is effective after a few seconds due to sperm mobility limited over time.

The emission of gametes is free or can be caused by hormonal or environmental induction. For turbot, artificial fertilization is necessary; the genital products are obtained separately by abdominal pressure, and then are brought together in a reduced volume of seawater for fertilization.

During the breeding season, the floating eggs are evacuated from the pond of breeding animals by overflow and collected in an egg collector. The spawning of a female can produce several hundred thousand eggs of small diameter (0.9 to 1.2 mm depending on the species). The laying period lasts 2 to 3 months.



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Staging tank for breeding animals

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Egg harvest by abdominal pressure in a female turbot

They press towards the genitals of males to collect milt.

Egg incubation

After collection, viable eggs are counted and then placed in an incubation tank. This phase corresponds to the period of development of the embryo (embryogenesis) inside the membranes of the egg; it ends with the hatching of a swimming vesiculated larva.

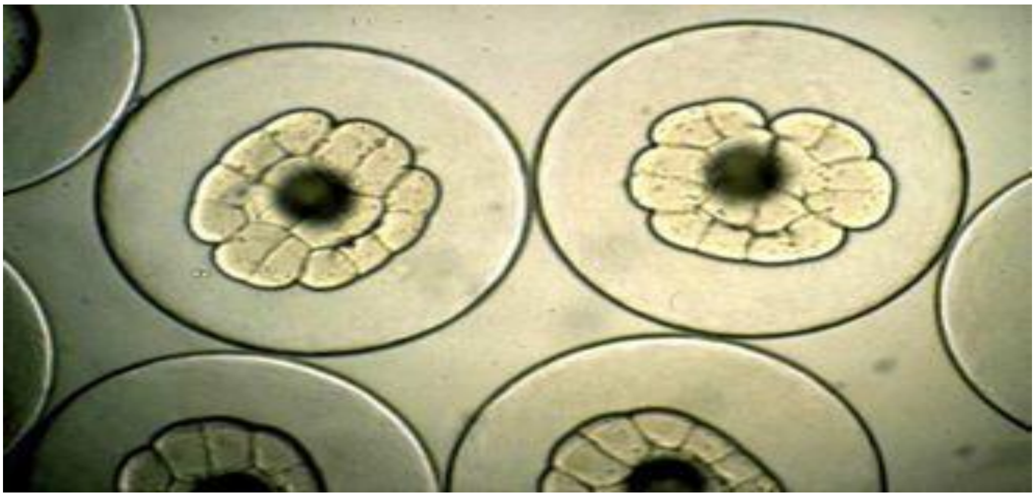
The duration of embryogenesis is specific to each species. It is also dependent on the temperature of the rearing environment within a range also specific to each species. Thus, the duration of incubation of the egg of the turbot, a temperate marine species, is 4 days at a temperature of 10°C and only 24 hours for the ombrine ocellé *Sciaenops ocellatus* and the paraha peue *Platax orbicularis* whose eggs develop in sea water between 25 and 30°C.

Ombrine *Sciaenops ocellatus*

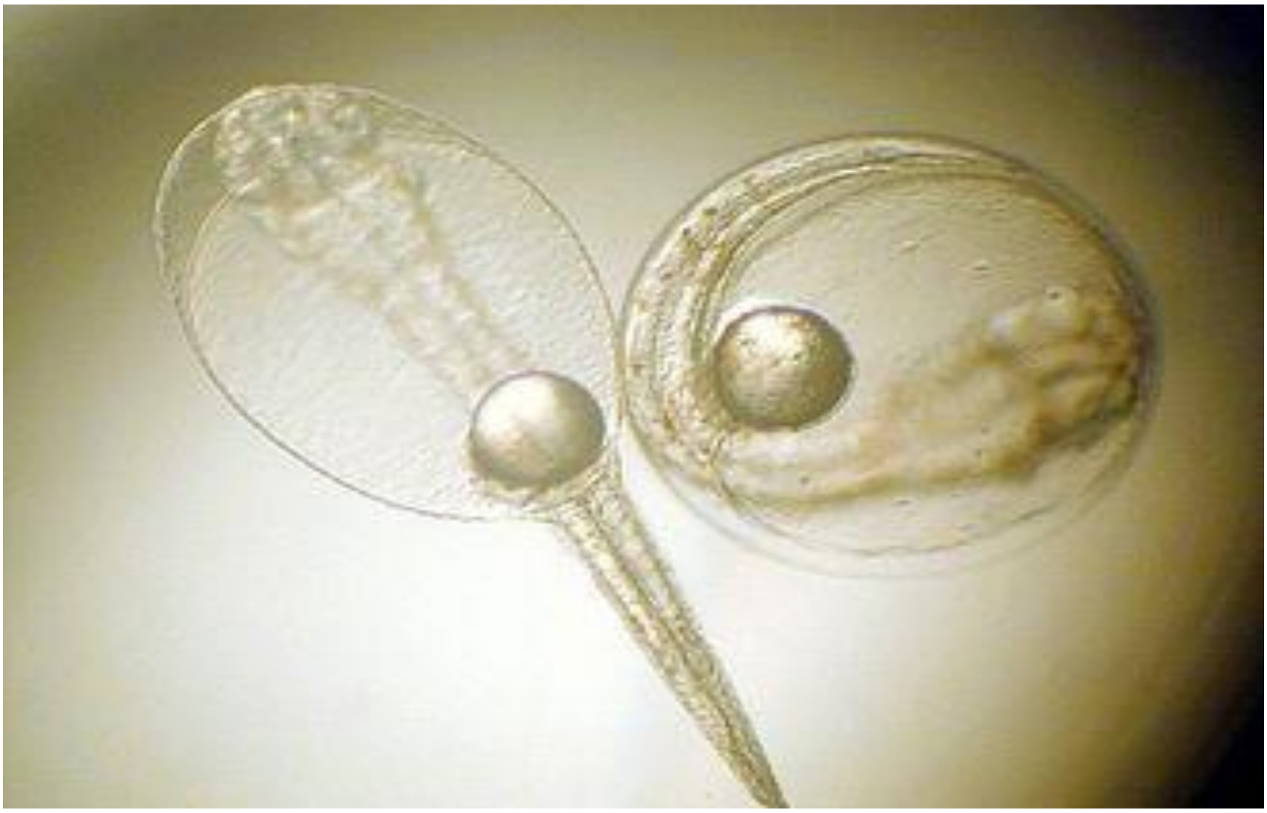
paraha peue *Platax orbicularis*

An incubator that can accommodate 50,000 salmon eggs

A structure adapted to this breeding phase as well as a density optimal number of eggs per unit of volume (1000 to 5000 per liter) combined with impeccable seawater quality in the living environment ensures high hatching survival.



©Ifremer Embryos of sea bass larvae



©Ifremer Egg and larva of umbrine

Larval development

The trophic life of the larva is characterized by two important stages closely linked to the evolution of its physiological functions.

The first corresponds to endogenous nutrition from the yolk reserves of the egg. At this stage, the mouth is not functional; the growth recorded during this phase is therefore correlated to the quantity and quality of yolk, mainly composed of proteins and lipids.

After a few days, the eyes, mouth, and part of the digestive system are functional. The yolk reserves are being resorbed, the larva must quickly evolve towards an exclusively exogenous diet.

She has, in fact, a few days to acquire behavior of effective hunting which will allow it to capture live prey.

In breeding, the difficulty consists of creating optimal living conditions so that this dietary transition is effective before the yolk reserves are exhausted.

If the success of this critical stage is not assured, the larva becomes exhausted and dies quickly.

First nursery ponds (or nurseries)

The rearing of juveniles, in other words the young spawn which begin to feed until they reach a size of 25 mm, constitutes the most delicate and critical phase of fish farming. This is what we call first stock management, or "nursery".

A modern hatchery complex requires special containers and small earthen ponds if best results are to be achieved.

- Special containers.

These are enclosures 20 to 40 m long and 5 to 6 m wide, with a surface area of 100 to 240 m^2, usually built of bricks or cement. Their payload averages 200000 to 400000 juveniles just starting to feed.

A female weighing 4 to 6 kg which breeds in good conditions can yield 0.5 to 0.7 kg of dry eggs, capable of producing the desired number of juveniles for stocking a special first nursery container. If ten of these females are bred per week, you will need 30 to 40 of these containers to raise the juveniles to 21 to 28 days of age.

- Earthen basins.

A good first nursery pond should not exceed 500 to 1000 m^2, being rectangular in shape and 10 to 12 m wide. The bottom of the pool must remain flat up to a distance of 2 m to 2.50 m from the longitudinal walls, then, from there, form an embankment at approximately 45° on each side which delimits a sort of pit 2 to 3 m wide and 50 cm deeper than the flat part of the middle of the basin. This pit serves as a refuge for juveniles.

Marine fish larvae grow extremely rapid, dependent on the nutritional regime and abiotic factors, mainly temperature and photoperiod.

The average weight of the larva at hatching will thus be multiplied by several thousand in a few months of life. The duration of the hatchery rearing period is conditioned by growth (tab. 1).

In fact, young fish only leave their nursery when they have reached a weight of a few grams. They are, at this stage, robust and resistant.

Table 1: Evolution of the average weight of some species in hatcheries: from larva to juvenile FAO (2008).

Species	Larvae at hatching (mg)	Juvenile at end of hatchery cycle (mg)	Number of days in breeding	Breeding temperature (°C)
Sea bass fish	0.40	2000	120	20 to 25
Sea bream	0.30	2000	120	20 to 25
Paraha peue	0.20	1000	32	26 to 29
Turbo fish	0.15	5000	120	18 to 20
Ombrine	0.20	1500	35	25 to 30

Rearing the larvae

Marine fish larvae are plankto-phagous in the natural environment. The need to control this specific diet has long been a blocking point for significant production of juveniles. Zooplankton from the marine environment, a natural source of their food, seemed appropriate.

Attempts to collect or cultivate different species have been carried out without convincing success. In 1960, Ito succeeded in mass rearing the rotifer *Brachionus plicatilis* (50-150 µm) in seawater; the use of this prey as live food for the larvae will allow for the first time the production of thousands of juveniles. Moehl *et al*, (2005)

Juveniles of Ombrine on the 40th day of breeding

The food chain, unicellular algae, rotifers and branchiopod crustaceans *Artemia salina*, still corresponds today to a typical diet in livestock farming, although these prey are not present in the diet of marine fish larvae in the natural environment.

They are distributed alive into the breeding tank, manually or using an automatic machine, in a continuous and controlled manner over time in order to effectively meet the exponential food needs of the larvae. After 10 to 20 days of rearing depending on the species, the small size of the plankton becomes a limiting parameter to calm the insatiable appetite of the developing larvae. Moehl *et al*, (2005)

©Ifremer - Cultured unicellular algae

©Ifremer - Rotifer

©Ifremer – Artemia

The seaweed room

The algae room allows you to cultivate different types of algae belonging to phytoplankton.

It is cultivated, among others, the following algae: *Isochrysis* aff *galbana*, *Skeletonema costatum*, *Pavlova lutheri*, *Chaetoceros calcitrans*.

Food weaning is then a nutritional necessity and economic. It corresponds to the gradual transition to an exclusive supply of inert particles of compound feed.

These have the advantages of a controlled nutritional formulation and fragmentation adapted to the size of the mouth of young fish. The classic weaning sequence in a hatchery takes place over a period of 8 to 15 days depending on the species being reared.

During the first days, live prey and inert particles are simultaneously continuously distributed to the larvae; then, very gradually, the supply of live prey decreases and finally stops at the end of this pivotal period of breeding. Moehl *et al,* (2005)

<u>Controlled and controlled production</u>

Recent progress in research in nutritional physiology has made it possible to develop microparticles covering the specific nutritional needs of very young larvae.

The size range of this inert food is between 50 and 200 µm, i.e. those of rotifers and artemia. This new formulation makes it possible to bring forward the age of food weaning; we then speak of early weaning.

Thus, for the Ombrine, the work carried out between 2002 and 2007 at the Ifremer laboratory made it possible to bring forward the date of food weaning from the 25th to the 7th day of rearing, without any drop in performance. For sea bass larvae, the progress is even more significant since live prey can be advantageously replaced by microparticles of compound food from the first food intake.

Today, the greater precocity of food weaning of larvae ensures a significant reduction in the need for living plankton. The partial or total elimination of these live prey workshops will have a strong influence on the reduction in the cost price of juveniles.

These advances in larval nutrition have therefore been and remain essential to the sustainability of the production of juvenile marine fish.

The quality of the larvae’s living environment must be optimized and then managed throughout the rearing cycle. Thus the temperature, the availability of dissolved oxygen, the photoperiod and the intensity of illumination are essential factors for the survival, growth and morpho-anatomical conformity of the animals produced.

Particular care must also be given to the installation optimal hydrodynamics of the breeding environment. The mechanical energy generated by the movement of the seawater mass must be adapted to the low swimming capacity of young larvae. It must guarantee the homogeneous distribution of live prey and compound food particles throughout the breeding structure.

Likewise, hydrodynamics must imperatively ensure the evacuation of organic matter (feces, uneaten food) which is a potential source of degradation in the quality of the larvae's living environment. Indeed, these organic supports constitute an ideal substrate for pathogenic bacterial colonization.

There is a zoosanitary charter which governs the control of production and ensures their traceability: international trade, classified diseases, veterinary certificates and list of authorized medicinal products. Today, juvenile production tools implement a rigorous prophylactic approach from the selection of breeding fish to the sale of juveniles, the purpose of production.

This preventive approach corresponds to a rigorous health policy which should make it possible to minimize the introduction and dissemination of pathogens within the production tool. It is characterized by control of the health quality of hatchery inputs (sea water, air, biological material), by the segmentation of production workshops and by raising awareness and training of staff.

This approach should make it possible to confine medicinal products to a strictly curative aspect in the event of a proven pathology. FAO (2008).

<u>After the hatchery</u>

After a few months in their breeding tanks in the hatchery, the young fish reached an average weight of a few grams. At this stage of development, they are able to continue their life cycle in floating cages at sea or in breeding structures on land positioned on the coastal strip. French hatcheries produce more than 60 million marine fish fry each year, around 60% of which are exported to Europe. Moretti *et al*, (2005)

As soon as laying has occurred in the breeding tanks, the eggs are transferred and stored in a room dedicated to this purpose: "the hatchery.

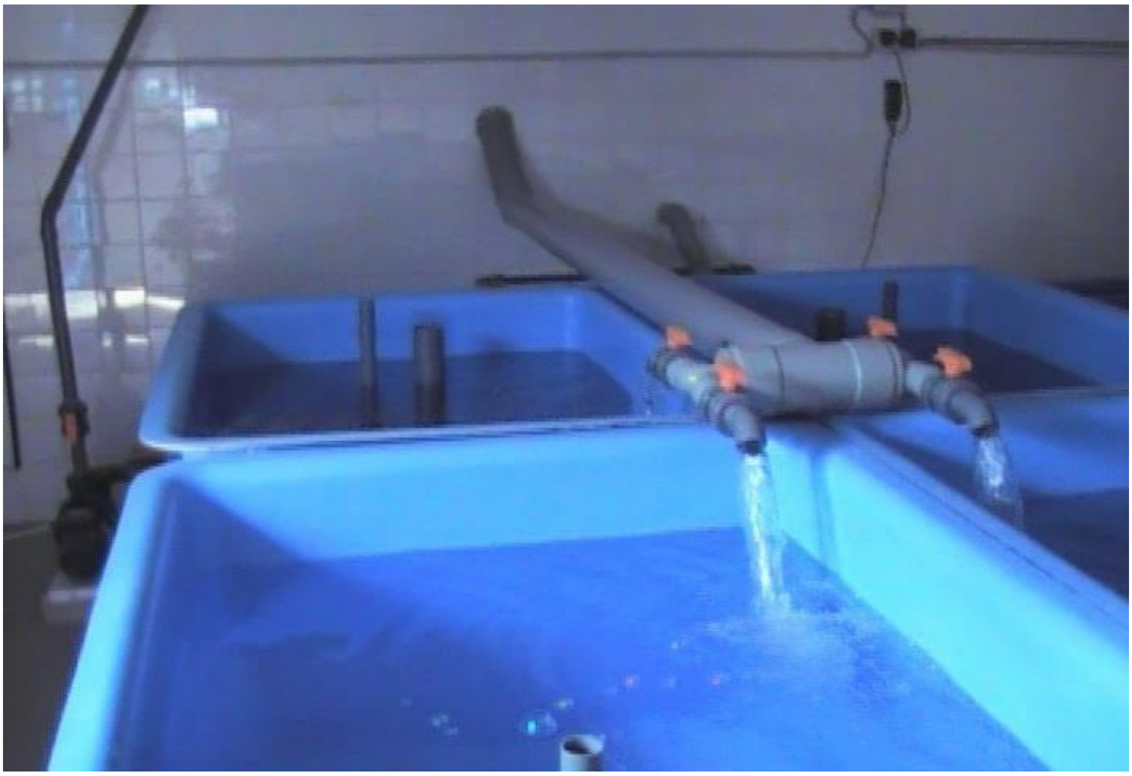
After a few days, small larvae gradually appear inside the egg, Little by little, the latter free themselves from their membrane which kept them prisoner inside the oocyte and start swimming in the breeding tanks, ready to welcome them.

After a week of hatching, it is then time to feed all these little fish larvae with a natural diet consisting mainly of small aquatic crustaceans; artemia nauplii

<u>Frying</u>

A few weeks after hatching, the small fish larvae are transferred from the hatchery to the rearing unit.

Pre-Magnification



These fry, which have become sufficiently large, are transferred from the hatchery to a new breeding enclosure where they can complete their development.

At this stage of development, these young fish can double in size within a fortnight. Once a sufficient size of around 30 to 40 g has been reached, they can then be transferred back to a new breeding enclosure called "grow-out"...

Magnification

These fry become strong and robust young fish; are transferred again to a new enclosure called "magnification".

At this stage, they will be able to perfect their growth which once reached a sufficient size can be sold

REFERENCES

Bendimerad M.A. & Román G. 2013. The salinity effects on the growth and the survival of the Pectinidé *Chlamys varia* larvae. *Canadian Journal of Fisheries & Aquatic Sciences*, Vol 19, N°.8, 193-197. 2013.

Bendimerad M.A., Boutiba Z. & Román G. 2008. Factors affecting settlement and postlarval growth of the black scallop, *Chlamys varia*. *Canadian Journal of Fisheries and Aquatic Sciences*, Vol 65, N°. 4, 261-263. 2008.

Bendimerad M.A., Boutiba Z. & Román G. 2010. Effect of diet on larval growth and settlement of *Chlamys varia*. *Canadian Journal of Fisheries & Aquatic* Sciences, Vol 70, N°. 3, 1-3. 2010.

FAO. (2008). Aquaculture development. 3. Genetic resource management. FAO Technical Guidelines for Responsible Fisheries (Vol. 5). Rome.

FAO. (n.d.). Inbreeding and Brood Stock Management. Fisheries Technical Paper. Rome.

Moehl, J., Halwart, M., & Brummett, R. (2005). Report of the FAO-WorldFish Center workshop on small-scale aquaculture in sub-Saharan Africa: Revisiting the aquaculture target group paradigm. Limbé, Cameroon, 23-26 March 2004. CIFA Occasional Paper. No. 25. Food and Agriculture Organization, Rome. 54 p. Rome: FAO.

Moretti, A., Fernandez-Criado, M. P., & Vetillart, R. (2005). Hatchery production of seabass and gilthead seabream. Rome: FAO

RECOMMENDED READING

Anon. 1979. Feasibility study for a commercial oyster hatchery in Tasmania. Tas. Fish. Devel. Authority: 115 pp.

Breese, W.P. et Malouf, R.E. 1975. Hatchery manual for the Pacific oyster. Sea Grant Program Pub. No. ORESU-H-002. Oregon State Univ. Corvallis, Oregon, USA: 22 pp.

Castagna, M. et Kraeuter, J.N. 1981. Manual for growing the hard clam Mercenaria. VIMS Spec. Rep. In Applied Mar. Sci. and Ocean Eng. 249: 110 pp.

Curtin, K. 1983. Oyster hatchery pilot scheme; setting up, operation and future role of hatcheries. N.Z. MAF: 16 pp.

Dupuy, J.L., Windsor, N.T. et Sutton, C.E. 1977. Manual for design and operation of an oyster seed hatchery for the American oyster, *Crassostrea virginica*. Spec. Rep. Applied Mar. Sci. Ocean. Eng. 142. VIMS, Gloucester Point, Virginia.

Helm, M.M. 1994. Towards reliable bivalve seed supply in Nova Scotia. Bull. Aquacul. Assoc. Canada 94 (4): 9–14

Holliday, J.E. 1984. International developments in oyster hatchery technology. Misc. Bull. 1. Div. Fish, Dept. Agriculture. New South Wales, Australia: 101 pp.

Huguenin, J.E. et Colt, J. (eds.). 1989. Design and operating guide for aquaculture seawater systems. Dev. Aquaculture Fish. Sci. Elsvier. 20: 264 pp.

Hurley, G., Henderson, K., Percy, M. et Roscoe, D. 1987. Design of a small scale shellfish hatchery. Nova Scotia Dept. Fish. Halifax, NS, Canada: 45 pp.

Im, K.H. et Langmo, R.D. 1977. Hatchery produced Pacific oyster seed: economic feasibility on cultch in the Pacific Northwest. Sea Grant, Oregon State Univ. Corvallis, Oregon, USA. Pub. No. ORSESU-T-77-010: 80 pp.

Neima, P.G. et Kenchington, E. 1997. Report on commercial scallop hatchery design. Can. Tech. Rep. Fish. Aquat. Sci., 2176: 55 pp.

Robert, R. et Gerard, A. 1999. Bivalve hatchery technology: the current situation for the Pacific oyster, *Crassostrea gigas*, and the scallop *Pecten maximus* in France. Aquat. Living Resour. 12 (2): 121–130

Spencer, B.E., Helm, M.M. et Dare, P.J. 1977. Recommended quarantine measures for marine molluscs. MAFF Fish. Res. Tech. Rep., Lowestoft, No. 32: 7 pp.

Utting, S.D. et Helm, M.M. 1985. Improvement of seawater quality by physical and chemical pre-treatment in a bivalve hatchery. Aquaculture, 44: 133–144

Wickins, J.F. et Helm, M.M. 1981. Sea water treatment. p 63–128. In: Hawkins, A. D. (ed.) Aquarium Systems. Academic Press, London: 452 pp.