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Development of culture techniques for new bivalve species

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Introduction (A. Bodoy and J.P. Mercer)

There are two main reasons for the development of cultivation techniques of new bivalve species.

First, the risk exists that traditionally reared species may be eradicated or severely depleted by pathogenic agents. For example, the Portuguese oyster, *Crassostrea angulata*, disappeared from the French coasts in the early 1970's and worldwide production of the flat oyster, *Ostrea edulis*, has been dramatically reduced by the effects of *Bonamia*.

Secondly, in some countries production may be self-limiting by the size and availability of national and international markets and a wider species range could offer some promising new economic opportunities for aquaculturists. In particular this applies to species where there are identifiable market shortfalls.

In selecting new candidates for cultivation a number of criteria should be considered:

- Marketability is extremely important and detailed market studies should be undertaken. Experience has shown that market prices prevailing prior to increased production from cultivation is an unreliable guide for making long-term predictions.
- Site availability and suitability for the proposed species should be considered from several aspects. Competition for food with existing species and overstocking of sites should be avoided if satisfactory growth rates are to be obtained. Water quality has to be of sufficiently high standards to satisfy consumer acceptance and to meet national and EC regulations. Thus water quality coupled with sanitary effects, depuration and their effects on the end product, whether fresh or processed, are major considerations.
- The possible occurrence of pathogenic agents and their effects requires special attention to avoid compromising future developments in cultivation.

Any technology has to comply with two main requirements. The most obvious is that profitability has to be achieved within a reasonable time frame, an example of this is given in one of the panel contributions.

Secondly, the ecological requirements of the species must be satisfied and particular attention should be paid to tolerance to temperature, salinity, tidal exposure, and current velocity. Also, e.g. sessile species perform better when allowed to fix on suitable substrates and motile species, such as clams, require particular sediments, at least during the final ongrowing period.

Following on from these remarks it should be re-emphasized that the dramatic advances in molluscan cultivation in the last two decades resulted directly from a better understanding of the fundamental biology and ecology of the organisms and their environment; clearly such work has a major role to play in any new developments.

In parallel further impetus to aquaculture has derived from more sophisticated economic analyses and market studies, presentation of product etc. as well as rational development of ancillary and support services.

Reliable supplies of raw material, i.e. "seed security" is the foundation on which the success of any developments depend. In addition to earlier comments consideration might be given to some recent developments and their challenging implications for the future, e.g.:

- Cryogenics and related technologies, in regard to storage and/or transport of genital products, embryos, eyed larvae, or indeed food organisms.
- Genetics, selection for favourable characteristics such as growth, disease resistance etc., evaluation of triploidy, transgenic manipulation and related areas.
- Photobiology, effects of light on all aspects of the reproductive and growing cycle of mollusca and their food organisms is improperly understood. Precise determination of these parameters may have considerable implications for future developments.
- Nutrition rations, recent developments in "off the shell" preserved foods as a spin off from

biotechnology studies and low-cost bulk production techniques as described in the panel contribution of J.P. Baud may be of significant importance for aquaculture.

- Diseases/pathogenic organisms etc., examination of natural resistance within populations e.g. for *Bonamia* resistance in *Ostrea edulis*, prevention by strict adherence to international codes, practices, and protocols such as ICES for introductions.

Finally, attention is drawn to the very considerable benefits from investment in research and development as exampled by an economic analysis of the US Sea Grant Programme. Where in 1987 it was shown that an expenditure of US$39 million stimulated an US$842 million impact to the US economy, i.e. over a twenty time return on investment!

Experimental culture of the Manila clam (*Venerupis semidecussata = Tapes philippinarum*) in Galicia (Spain) (J. Fernandez)

In June 1987 the Autonomous Government of Galicia (North Spain) authorized the culture of *Venerupis semidecussata*, commonly known as the Japanese clam, in Galician waters. An experimental study was then undertaken to assess the potential of this species for cultivation in these coastal waters.

To implement this research programme two batches of spat were obtained from a hatchery in Ria de Arosa and were distributed in representative selected areas of the rias. After 2 years of successful cultivation results were evaluated. Good growth was obtained in spat held on suspended trays and buried in substrata until they reached approximately 1g (12-15mm). At this stage those buried in sediment displayed rapid growth whereas those in suspension had a much reduced growth rate. Also in this latter case their valves showed noticeable swellings and/or a number of protruberances and in some cases, other serious deformations.

The mortality rate from all areas under both culture systems was low (about 20%). The main predator responsible for these mortalities was the common shore crab (*Carcinus maenas*).

Individuals showing higher growth rates in substrata reached commercial size (>30mm) in 20 to 24 months. It is important to note that particular characteristics of specific substrata had no significant effect on final production.

Although parallel studies could have yielded more data, at the moment there is no evidence of any natural settlement of the species, meaning that conditions in Galicia may not be optimal for natural reproduction of the Japanese clam.

Data analyses suggest that cultivation of spat in suspended trays, either in intertidal areas or on rafts (as a possible alternative to mussel cultivation) is profitable up to 1 year. After this it is necessary to plant them out in bottom sediments. This would permit cultivation in muddy areas that have until now been unproductive for shellfish cultivation.

Culture techniques of bivalve species in southern Mediterranean waters of Spain (A. Campos)

In recent years five species of molluscs have been cultured in Cadiz (Spain): *Ruditapes decussatus*, *Ruditapes philippinarum*, *Ostrea edulis*, *Crassostrea gigas*, and *Crassostrea angulata*. *O. edulis* is hardly cultured because of high mortality rates. Satisfactory results were obtained with *C. gigas* and *C. angulata*, but their commercial value is very low. The carpet-shell clam *R. decussatus* has been currently replaced by the Manila clam *R. philippinarum*. At present the Manila clam is the most important commercial clam in Cadiz. Growth was monitored for this species from March to October, when the water temperature was above 16°C.

At the nursery stage, two different upflow systems were used in the Bay of Cadiz; a floating nursery irrigated by an air-lift pump and an onshore nursery by gravity flow. In the floating nursery (2.5-4.5$m^3.h^{-1}$ per cylinder, at 0-44cm) Manila clams reached a stocking density of 130-160$kg.m^{-2}$. In the onshore nursery, however, final stocking densities only ranged from 13 to 26$kg.m^{-2}$. These figures are the double of those obtained for the carpet-shell clam. Mortality is very low for the Manila clam, but it may be a significant factor in summer for carpet-shell clams and the other species.

Various cultivation techniques were used for ongrowing Manila clams leading to the following results. Intertidal trays: placed on oyster trestles yielded stocking densities of 4-6$kg.m^{-2}$ (tide coefficient 0.80-0.90) after 3 months of cultivation. Intertidal bottom layings: substrates were firmed up by addition of sand and gravel to mud. Clam seed was planted at densities ranging from 200.m^{-2} to 400.m^{-2}. These were harvestable (at approximately 35mm) from 12 months (tide coefficient 0.70) to 16 months (tide coefficient 0.60) after a spring time planting. Mortality rates ranged from 30% to 50% and final densities were 1-2$kg.m^{-2}$ for upper zone plantings (tide coefficient 0.60) and 2$kg.m^{-2}$ for lower zone plantings (tide coefficient 0.70). It should be noted that carpet-shell clams all reach harvestable size by the end of the second growing season. However, the average mortality rates are 60-80% and the final stocking densities are always less than 1$kg.m^{-2}$.

Pond cultivation: Manila clams sown at initial stocking densities of 100-200 $seed.m^{-2}$ were harvestable after 12-16 months with final stocking densities of 0.5kg-1$kg.m^{-2}$.

Suspended culture: a trial with Manila clams in oyster trays resulted in a very fast growth to 27-30mm in length, while *C. gigas* in similar trays reached harvestable size in 6 months, growing from 2 to 60g in average live weight.

Thus, Manila clam seems to be a promising species, especially for subtidal cultivation, in the temperate-warm waters of southern Europe.

Intensive culture of bivalves in ponds from saline ground waters (J.P. Baud)

The French production of cultured Manila clams was estimated at 600t in 1988. Initial cultivation trials started in 1980 in intertidal areas and saline ponds. Available space for expansion of these semi-extensive cultivation systems is, however, limited. Furthermore relative food shortages during the winter months cause slow growth.

Intensive cultivation can provide a solution to space requirements but only if large quantities of low-cost food are available all year round.

Two main techniques are currently in use for bulk production of microalgae, i.e. monospecific production (by successive inoculations of cultures into increasing volumes of seawater) and plurispecific production in natural seawater, enriched with fertilizers.

Saline ground waters are abundant at shallow depths in some parts of the French Atlantic coast. These are low in particulate matter and have a nutrient composition suitable for algal production. *Skeletonema costatum* has been easily produced with such water in $50m^3$ concrete tanks. The cost of 1kg dry weight of algae is estimated at FF17.4.

Hatcheries have produced 80 million Manila clam spat from larvae fed exclusively on this diatom grown in the saline ground water. The nursery stages used the same food diluted with natural seawater.

The main parameters affecting spat growth performance were identified as follows.

- water temperature;
- shellfish density per production unit;
- phytoplankton flow;
- seawater flow;
- timing of phytoplankton production.

After statistical treatment the most important parameters were identified and ranked as: temperature, food flows, stocking density of shellfish, and seawater flow.

Economic analysis showed that the nursery should be used throughout the seasons to be profitable. Equipment for holding and growing spat was 48% of annual costs, while other costs amounted to about 2%. The annual return on investment was estimated at 38.5%.

Intensive ongrowing was then carried out in ponds fed by waters from the nursery system with a volume turnover of 500% (five times) per day. Stocking density was $100 clams.m^{-2}$ and the clams were protected from crab predation by nets. After 6 months the density was $5.9kg.m^{-2}$, with a survival rate of 86%, with an average individual weight of 6.9g, and an average size of 31.2mm.

Final ongrowing is carried out from March to October without predator protection. Best results were obtained at densities of 300 $ind.m^{-2}$ per pond with a once daily (100%) turnover of water and a food concentration of 200 $cells.\mu l^{-1}$, equivalent to $63\mu g.l^{-1}$ of chlorophyll. Survival rate was 87% and the average size 42.1mm.

Semi-enclosed systems are being tested, in order to reduce inputs of natural seawater and food. Preliminary results indicate that a final biomass of $4.5kg.m^{-2}$ could be achieved, being ninefold higher than that normally achieved by traditional extensive techniques.

Intensive cultivation of bivalve molluscs should be profitable in these systems. This is due to the low-cost food produced in saline ground waters obtained from shallow depths and requiring no further treatments or additions. The possibility of bulk preservation of this low-cost food resource (e.g. as an algal paste or powder) could allow similar intensive molluscan production techniques to be transferred to less favoured environments at reasonable costs. This work could also be of importance in the cultivation of other species such as oysters and pectinids.

Within the scope of these intensive cultivation investigations no environmental constraints were identified.

Development of culture techniques for scallops and Manila clams in the United Kingdom (M. Gillespie)

HATCHERY SYSTEM

The very poor natural spatfall experienced by scallop growers in 1988 has prompted renewed interest in hatchery production of *Pecten maximus*. There are plans for at least two systems to be constructed; so some hatchery produced seed should be available in 1990. Production of Manila clam (*Tapes semidecussatus*) seed has been established for a number of years but the Ministry of Agriculture, Fisheries and Food (MAFF), Conwy, have been investigating the viability of triploid seed which would allay the fears of conversation organizations about the spread of the introduced species from cultivation beds. Early results look promising. MAFF have also evaluated the use of dried marine microalgae in mollusc hatchery systems. This would reduce dependence on the laborious and expensive production of live algae in continuous cultivation systems. The trials gave good results from the dried algae species currently available.

ONGROWING SYSTEMS

The culture of queen scallops (*Chlamys opercularis*) is now established using lantern nets and pocket nets fabricated in the United Kingdom. The longer growth cycle of king or great scallops (*Pecten maximus*) has prompted research into less capital intensive systems. Suspended culture by ear hanging has given good results on a small scale and efforts are now being made to mechanize the drilling and attachment of the small shells.

Seabed cultivation experiments are being conducted by the Sea Fish Industry Authority (SFIA) and the Department of Agriculture and Fisheries for Scotland (DAFS) to investigate the viability for large-scale production/stock enhancement. SFIA are also testing the culture of Manila clams in raised trestle systems which have given improved growth rates, but winter susceptibility to frost has still to be evaluated. The effectiveness of different predator netting systems has been investigated by MAFF with worthwhile results for the grower.

Profitability of giant scallop culture in Quebec, Canada (C. Cantin)

Over the past few years, a great deal of biological and technological research on giant scallop (*Placopecten magellanicus*) culture has been conducted by Canadian scientists. At present, no commercial enterprise is in operation in Quebec. Though the reputation of this seafood indicates strong economic potential, there is very little proof that scallop culture in Quebec is profitable. This study, which is the first in a series covering various species, is designed to fill this gap.

METHODOLOGY

In cooperation with biologists working on this species, we established the profile of several model enterprises and defined a typical production cycle. The most recent results of biological studies on spat collection, growth, mortality, etc., were applied to these enterprises. Certain economic parameters such as labour costs, material, and other costs were added to the biological assumptions. Financial results were then estimated on a 10-year period with an electronic simulator normally used in agriculture.

Table 1 Basic coordinates of a model enterprise

Level of production	8375kg of meat	Gross revenue	CAN$139862
Sale price	CAN$16.70.kg^{-1}	Cycle	4 years
Producer's salary	CAN$20000.yr^{-1}	Investment	CAN$365434
Jobs created	5 jobs (25 weeks)	Interest rate	12% & 14%
Financing	50% by grants 50% by loans		

RESULTS

A first simulation of giant scallop culture using the classic suspension method with Japanese lanterns has proven unprofitable. It has proven that the average enterprise would face a deficit of CAN$573000 following a 10-year period of operation, the main problems being the high cost of equipment and the length of the production cycle.

Following this first simulation, another study has been made of a culture in suspension,

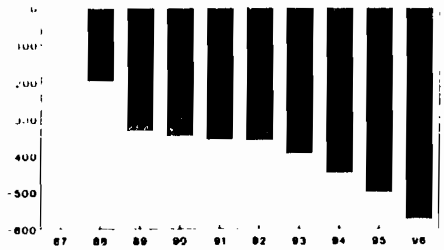

Fig.1. Cash flow income (in 1000 CAN$). Scallop culture enterprise. Collecting spat and Japanese lantern method.

using the ear-hanging method, which was thought to be less costly in terms of capital expenditure. Eventhough cash flow improved, there was still a deficit, the main problems being labour costs and length of the production cycle.

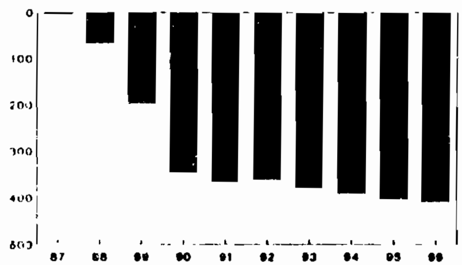

Fig.2. Cash flow income (in 1000 CAN$). Scallop culture enterprise. Collecting spat and ear-hanging method.

To solve the problem of the production cycle, another study of a culture in suspension with ear-hangings was made, using spat from hatcheries rather than collectors. With this method, it was possible to reduce the length of the production cycle from a 4-years period to 3 years, substantially improving the cash flow of the enterprise. Spat had to be purchased at a price of CAN$9.00 for a 1000 spat, which was lower than the production cost of a potential scallop hatchery.

CONCLUSION

None of these scenarios has yet proven the profitability of the scallop culture in Quebec. However, many research areas have been identified in order to enable scallop culture to become profitable and viable. The design of equipment at lower costs, the mechanization of car-hanging, the implementation of the bottom culture at natural sites are avenues presently being explored by Quebec researchers.

New bivalve open-sea rearing techniques in the Mediterranean (J. Defossey)

Open-sea bivalve mollusc culture in the Mediterranean has until recently been limited to the rearing of the mussel *Mytilus galloprovincialis* on subsurface long lines. In 1988, 110 long lines produced a total of 2000t, with a value of approximately US$2 million.

An examination of capital costs and problems related to floatation systems stimulated various technological improvements, namely:

- Subsurface long lines were fitted with 200l "pencil type" buoys, thus eliminating the "shake off" phenomenon caused by big swells.
- Larger floatation units were incorporated at the start of the rearing cycle and thereby saved considerable extra handling during the initial grow-out stages.

As a further diversification IFREMER has also carried out trials in open-sea conditions for the rearing of flat oysters and scallops.

Spat of the flat oyster (*Ostrea edulis*) was collected on processed mussel shells which were laid in metal cages at 20m. By September, the average shell size was about 5mm with a wide spread due to successive settlements. Autumnal storms caused severe problems notably with shell abrasion and often destruction of the metal cages. Spat of this size was also too small to be cemented on to ropes for lagoon cultivation and the only other way was to re-seed them in Brittany where survival rates were very variable.

If 5mm oyster spat are to be of sufficient size for successful rearing in the Mediterranean they must be ongrown on collectors during winter. Thus, IFREMER opted to use plastic collectors coated with lime and placed in galvanized metal containers which were heavily ballasted to withstand violent storms. Oysters were removed from these collectors at about 15mm, before shell deformations could occur, and then put out in mesh bags for intermediate cultivation on the same structures until September. At this stage the oysters were sufficiently large to be cemented to ropes for lagoon culture or laid in bags to be placed in containers for open-sea culture.

From 1990 on, it is intended to transfer the technology to the industry for pilot-scale evaluation and as an alternative for mussel farming. This will be within the framework of CEPRALMAR, the organization charged with Marine Cultivation Development in Languedoc-Roussillon.

An experimental scallop research programme was launched in 1987; this was designed to test the performance of hatchery-produced spat of three scallop species (*Pecten maximus*, *Patinopecten yessoensis*, and *Pecten jacobaeus*) for offshore rearing.

As heavy mussel settlement was encountered down to 15m, long line and ear-hanging techniques were impractical and special containers to hold spat at 20m were utilized. These were similar to those used for flat oysters and could be readily handled with lifting gear from mussel boats. Although, only a 2-year cycle with *P. maximus* and 1 year with *P. yessoensis* has as yet been completed. Preliminary results suggest that a 5-month intermediate cultivation phase followed by 30 months ongrowing is a common feature to all three species.

A 40% survival rate up to 30mm in the first year of cultivation of *P. maximus* in the Mediterranean was considered satisfactory. At the same time a 72% survival rate was obtained after 8 months for *P. yessoensis* but with lower growth rates than in commercial Japanese cultivation. In the second year a decreased growth rate was recorded from July to November with *Pecten maximus*. It is suspected that it may have been caused by temperature variations from 15 to 23.5°C at 20m. The next sampling will provide a comparison as to the performance of *Patinopecten yessoensis* under similar conditions.

Further studies over the next 2 years should provide more detailed information regarding growth, survival, and possible production costs for both *Pecten maximus* and *Patinopecten yessoensis*. It is also hoped to elucidate the feasibility of hatchery spat production for *Pecten jacobaeus*.

Ongrowing of the ormer *Haliotis tuberculata* in Jersey, Channel Islands (S. Bossy)

Part of the overall governmental development plan in Jersey for the local fisheries is to broaden the base of the industry. Fish farming is seen as very relevant in this respect. Oyster farming (*C. gigas*) is already well established. In 1984 it was decided to experiment with a "pump priming" exercise using the ormer, *Haliotis tuberculata*. This species is well known in the Islands, commands a high market price of £17-22.kg^{-1} "shell on" and a supply of juveniles has become available from the University of Galway, Shellfish Research Laboratory at Carna. Juveniles at 10mm shell length were transported by road and air in September from Carna to Jersey in the now traditional method using oxygenated plastic bags 1/4 filled with seawater. Mortality was negligible on a 12-h transit.

The ormers were first introduced into modified plastic water storage bins hanging 1m beneath pontoons in the shelter of a yacht marina. These bins were perforated with many holes and had a lattice of shelves made of upturned plastic guttering fitted inside. The ormers in this situation did not grow well compared with later work probably due to the anti-fouling present in the marina and lack of water flow through the bins. The bins were then moved to harbour approaches and to avoid silting were adapted to be positively buoyant and were suspended from weighted ground lines. The ormers in this situation grew better, however, numerous problems occurred with the mooring of the cages and tangles were very frequent. It was then decided to weight the bins on the outside with concrete collars and set them on the sea bed.

In each trial shelving was provided for the internal attachment of the ormers. The weighted bins worked relatively well although they were very heavy and awkward to handle once out of the water. It was then an obvious move to adapt the cages already extensively used as traps by the local fishing industry for the capture of lobsters and crabs. Modified D-shaped pots were covered with 6mm or 10mm plastic mesh. The cages were rubbered up and fitted with bridles and leaded backline, a rigging which is exactly as per normal Channel Islands crabbing gear. This was an interesting cross fertilization of technology between the capture fishing industry and fish farming. These cages have stood up well to bad conditions including hurricane force winds and three knot tides. Internally the cages are fitted with two layers of shelves and upturned plastic guttering spaced apart to allow the food to fall down between them. Obviously internal configurations can be changed to meet needs of different species and size stages.

As ormers have a strong attachment to their substrate regular grading can be quite damaging to stock. It has now been determined within the overall grow-out programme that only one grading is necessary at 30mm in shell length. To minimize stress on the animals timing of grading is important and should take place out of the reproductive season (June to September) and at a time when air and sea temperatures are similar and the ormers can withstand exposures of up to half an hour without any serious effects.

Feeding is to satiation which is about once per week in summer and once per fortnight in winter. Growth rates have been good, approximately 20% faster than that of the natural growth rate as reported by Forster (1967). Market size of 50g (65mm shell length) is reached by 50% of the stock in 3.5 years from seed of 10mm. If seed could be produced in warm water conditions to give 10mm animals in 6 months then a 4-year egg to market size is possible. Our team is very pleased with the cages and only very small modifications have occurred in the last 2 years.

Future work should be directed towards faster growing animals (genetic manipulation) and identifying a stable source of food, either by culture and/or use of an artificial diet.

Discussion with the floor

The discussion started with a question concerning the vulnerability of ***Pecten maximus*** during transportation. Among cultivated mollusca this problem mainly relates to pectinid species, as their structure makes them highly sensitive to desiccation. From exchanges between the audience and the panel it was evident that these species should not be out of water for longer than 12h and elevated temperatures must be avoided. Failure to meet these requirements, especially for animals destined for relaying, inevitably results in poor survivorship. Timing is less critical with animals destined for the market; however, it was noted that, as a fresh product, pectinids should be sold quickly and that transportation times to processing plants should also satisfy these requirements.

The session then discussed the dangers of transplanting exotic and indigenous species between countries and even from one location to another within a country. From a legal point of view, it is currently the responsibility of each country to formulate and implement its own regulations. However, firm guidelines for protocols and practices, have been established by the International Council for the Exploration of the Sea (ICES). Although these are non-mandatory many countries are signatory to the ICES agreement. The rules provide for a strict quarantine regime and ecological evaluation for any introductions. Genitors should only be imported directly into approved quarantine facilities and an F1 generation produced in quarantine. No field trials into the wild should be permitted unless the F1 generation has full veterinary clearance. The general opinion was that the risks in exotic introductions are very obvious but careful observance of ICES regulations should reduce these to an acceptable level.

The worldwide spread of *Bonamia* was cited as but one of many clear examples of the grave dangers resulting from not following recommended practices.

Arising from this part of the discussion further remarks were directed towards other challenges and problems encountered in the selection of new species and the development of appropriate cultivation technologies. Stress was laid on the necessity for detailed basic biological and ecological information supported by relevant technological innovation and economic evaluations.

Unfortunately time constraints precluded further elaboration on these points.

Concluding remarks and recommendations

Constraints in development of new species and cultivation techniques identified during the session relate to introductions and lack of pertinent information on their basic biology and ecological requirements. Economic and veterinary (zoosanitary) considerations are also of major importance.

The development of new molluscan cultivation practices has been hampered by shortfalls in these areas. For example in Europe, traditional extensive cultivation of oysters and mussels, utilized simple husbandry practices with low technological inputs. These initially succeeded because adequate sites were available and markets were not oversaturated. As a result most of the Research and Development effort was directed towards intensive fin fish aquaculture at the expense of development of intensive molluscan cultivation. The situation is now changing for both extant and new species as increasingly sophisticated approaches are resulting in better growth rates, survival, and return on investment. In addition with improvements in technologies new and underdeveloped coastal areas may soon be effectively utilized.

One of the panel contributions showed clearly that the ability to cultivate a new species does not always ensure profitability and demonstrated the necessity for objective cost benefit analyses.

Following from this, identification of optional biological conditions for all stages of the cultivation cycle (hatchery, nursery, ongrowing, etc.) must be clearly identified. "Seed security", control of production costs such as handling, assessment and minimization of various risks (storms, water quality, fouling, disease, etc.) are also essential considerations. These data should permit the design and rational implementation of optional production cycles for the various stages of the cultivated organism. An important component in this process is the need for better information and for communication between scientists, aquaculturists and end markets. These elements and their combined interactions can make the difference between failure and success.

In summary - assuming the biology of the animals lends itself to cultivation - the following requirements should be satisfied:

BIOLOGICAL FEASIBILITY

- Adequate food supplies in terms of both quantity and quality. The carrying capacity of the site and seasonal fluctuations in algal populations should maintain a positive energy balance. Also, low-cost techniques for bulk production of food must be further developed to support expansion of intensive cultivation.

- Predation, fouling, and diseases may have considerable effects on survival and growth. Protection against these may be costly.

- Availability of sites and/or substrates suitable for the species at all stages of its cultivation cycle (one of the panel papers indicated that Manila clams showed a superior performance if initially grown off bottom and were then transferred to sediments for final ongrowing).

- Strict adherence to veterinary/zoosanitary rules. Particularly in view of the clear tendency towards more intensive cultivation, adherence to these rules as well as those regarding the importation of exotic species should be mandatory.

- Awareness and sensible application of new biological techniques particularly in the areas of genetics and biotechnology.

TECHNICAL FEASIBILITY

Technical considerations were examined in some detail during the panel session and two main points emerged:

- The design of culture systems must take into account not only the biological requirements of the organism but also its ecological characteristics and preferences.
- Cost of handling at all stages of the production cycle should be kept as low as possible. Further improvements and innovations should be encouraged and evaluated.

ECONOMIC FEASIBILITY

Adequate marketing studies as indicated are a prerequisite before cultivation commences. Cost benefit analyses should be an ongoing component in any cultivation operation. Results from these may help to optimize technical standards and production schedules. As production levels increase for a new species marketing programmes may have to be undertaken.

ENVIRONMENTAL FEASIBILITY

Compatibility of cultivation practices with the environment and other water users (commercial and pleasure boating, leisure activities, tourism, aesthetic values, etc.) is essential, while maintenance of water quality and not overloading the carrying capacity of the site is vital to the success of any husbandry practice.

Studies to determine the causes, effects, and possible alleviation of effects on other issues, such as the increasing occurrence of toxic algal blooms, and evaluation of the possible future impact of transgenic species should be undertaken by appropriate national and trans-national agencies.

In conclusion, the success or failure of molluscan cultivation or indeed any aquaculture practice will depend largely on results from effective Research and Development programmes.

If adequately supported such fundamental work can stimulate and have a very significant impact to national economies. As already noted in the introduction, a twenty times multiplier on initial investment in R&D has been demonstrated for the US economy in 1987.

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