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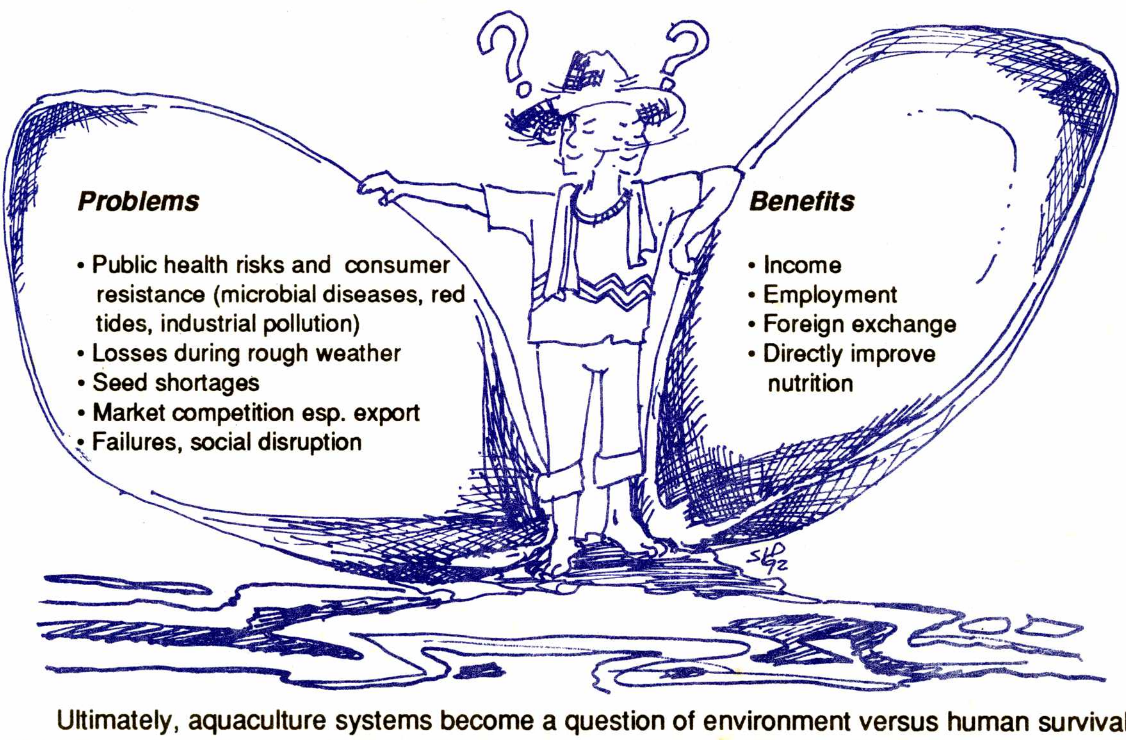
MOLLUSC CULTURE



Ultimately, aquaculture systems become a question of environment versus human survival, and mollusc culture in coastal waters will not be an exception. It will be a choice of feeding 11 billion people by year 2100 as the United Nations predicts, or preserving what's left of our natural resources. This is staggering since scientists estimate that only 1-2 billion people can be supported by the planet earth in relative comfort. However, a middle ground is possible: sustainable aquaculture technology.

The issue presents a middle ground in terms of mollusc culture and discusses: (1) the benefits in terms of production that translate into peso-dollar revenue and human protein and (2) the industry problems and constraints. The technology on mussel culture developed by SEAFDEC Aquaculture Department, and the mariculture of giant clams for food and stock replenishment are highlighted. Public health risks, including paralytic shellfish poisoning, are also covered.

Molluscs: status, problems, and future in Asia

The aquaculture industry among developing Asian and Pacific countries has been growing faster than any other farmed food commodity group. Figure 1 compares production and growth of beef/veal, chicken, aquaculture, pig meat, and total fisheries from 1977 to 1987. From the latest available data, the average annual growth rate of the aquaculture sector during the above period was 15.1% compared to 8.9% for pork, 7.1% for chicken, and 4% for both beef/veal and total fisheries.

Mollusc culture expanding

Mollusc culture in particular has steadily increased in the last few years. Total world landings, from capture and culture, increased from 3 603 426 t (1980) to 4 524 929 t (1986), an average growth rate of 3.95% yearly.

In the mollusc fishery sector, aquaculture production is high. Over 2.8 M t of mollusc were cultured in 1985 (Fig. 2) which accounted for over 65.5% of the year's total production of 4.4 Mt. Molluscs are cultured in numerous countries in both northern and southern hemispheres. However, culture activities have extensively developed in the Asian region, particularly in East and Southeast Asia. Figure 3 shows the 1985 mollusc aquaculture production by continent. Asia produced the most from culture followed by Europe and North America. The landings for the three continents in 1985 were 2 094 913 t, 591 476 t, and 176 810 t, respectively, which accounted for 72.6%, 20.5%, and 6.1% of total production. Mollusc culture output in Oceania in the same year amounted to 20 511 t or 0.7% of world culture output.

Aquaculture production in Asia in 1985 by major resource group is shown in Figure 4. Finfish and seaweed culture in Asia are the most important groups in terms of landings accounting for 44% and 34%, respectively. Mollusc production ranks third, contributing 20% of total aquaculture output in 1985.

Bivalves

Bivalves are widely harvested from natural fisheries or cultured belong to the families Ostreidae, Mytilidae, and Arcidae.

Among the oysters two génera predominate, *Crassostrea* and *Saccostrea,* whereas only few species belonging to the

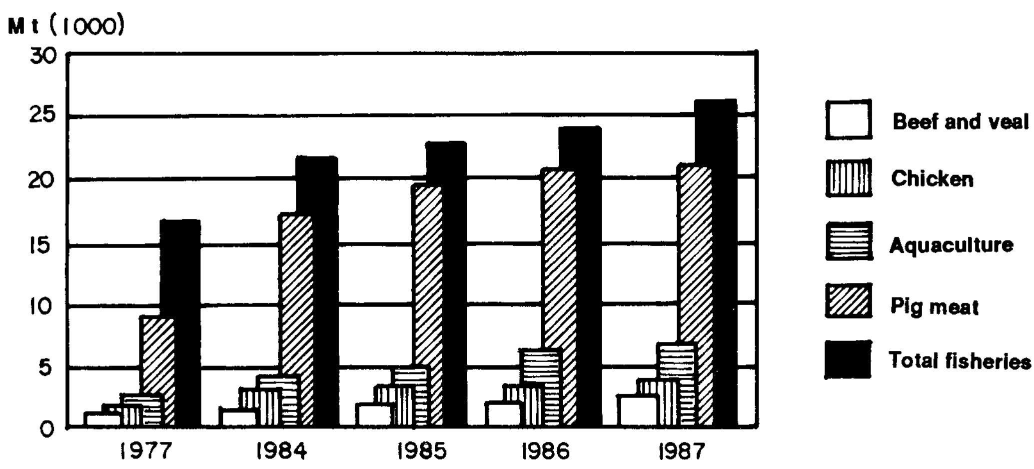


Fig. 1. Total production of meat and fish in developing Asian-Pacific countries.

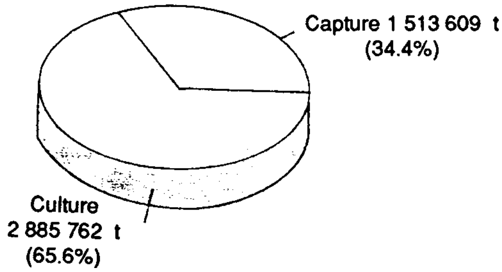


Fig. 2. World mollusc landings from capture and culture fisheries, 1985.

genus *Ostrea* are cultured. The *Crassostrea* species of commercial importance in northern Asian countries such as China and Korea are *C. rivularis, C. gigas,* and *C. plicatula.* Important subtropical and tropical oyster species include mainly *C. belcheri, C. echinata, C. iredalei, C. lugubris, C. madrasensis, Saccostrea cucullata,* and *Ostrea folium.*

Among the mussels, species belonging to the genera *Mytilus* and *Perna* are captured and/or cultured in the region. Species belonging to the *Mytilus* genus, such as *M. edulis* and *M. crassitesta* tend to be temperate water species, in contrast to the more tropical species belonging to the genus *Perna,* such as *P. viridis* and *P. perna.*

Numerous cockle species are of commercial importance in Asia. The most important ones belong to the genera *Anadara* and *Arca.* One species of major importance is *Anadara granosa* or blood cockle which is extensively cultured from southern Korea to Malaysia. Numerous other species are of commercial importance in the region. Among these are several species of clams, scallops, and pearl oysters.

Among the clams, important genera are *Meretrix, Paphia, Mactra, Venerupis, Donax,* and several others. Three genera of scallops predominate in the region: *Pactinopecten, Chlamys,* and *Amusium.* The pearl oysters *Pinctada margaritifera, P. maxima,* and *Pteria penguin* are of major importance.

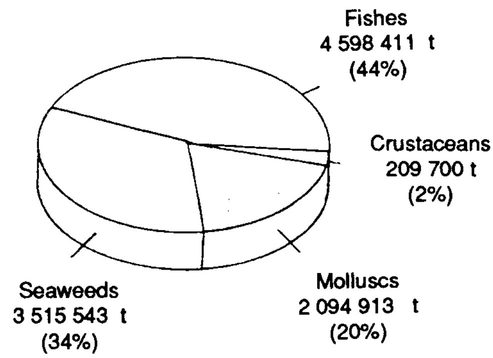


Fig. 4. Aquaculture production in Asia, 1985.

Gastropods

While there is a large number of commercially important bivalves, there are few gastropods and these are mostly collected from natural fisheries. Among this group, abalones are the most important as they are highly valued as a food item and command good prices. The most important abalone species belong to the genus *Haliotis* among which *H. discus* and *H. diversicolor* predominate. Culture of abalone is carried out in temperate Asian countries, mainly in China, Korea, and Taiwan, whereas in some tropical countries, such as the Philippines, abalones are exclusively harvested from natural fisheries. The inter-

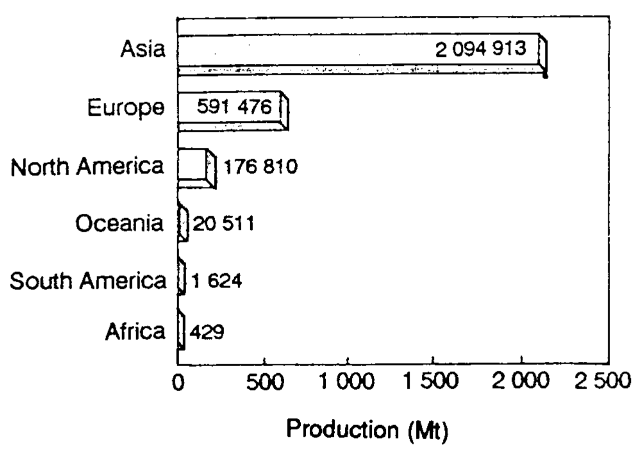


Fig. 3. Mollusc aquaculture production by continent, 1985

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est in this culture system among Asian tropical countries is growing.

Figure 5 illustrates the proportions of the more important mollusc species relative to the total landings in 1986. The Pacific oyster *C. gigas*, the common mussel *M. edulis*, and the blood cockle *A. granosa* accounted for over 50% of the landings in 1986.

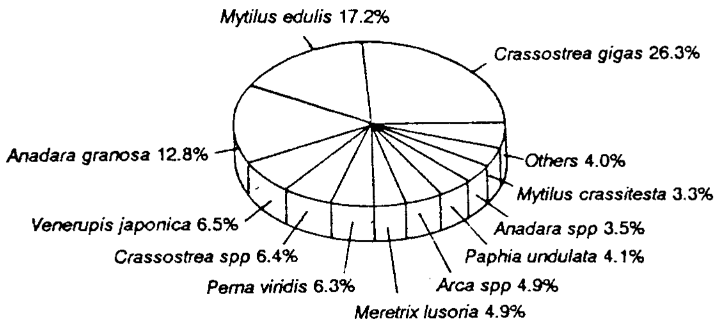

Fig. 5. Landings of top mollusc species in Asia, 1986

Problems

The mollusc industry offers great potential in many countries in Asia and the Pacific for increasing domestic food supply and foreign exchange earnings. In order to realize this potential, mollusc aquaculture programs have been launched in several countries and some have achieved good results in terms of species cultured, production, and export. However, the industry is facing a number of problems and constraints which vary in magnitude and severity according to area and country. The problems of the industry may be grouped into three: (1) environmental, (2) biological, and (3) social and institutional.

Environmental constraints include those phenomena caused directly or indirectly by man which induce deterioration of the mollusc natural environment. The most evident factor causing rapid environmental deterioration is pollution from inorganic or organic substances. The most fertile grounds for both capture and culture of molluscs are typically intertidal areas, estuaries, and shallow areas along the coast. Unfortunately, these areas are often polluted by land runoff or direct discharges of sewage, heavy metals, and xenobiotics. Another serious problem is the occurrence of red tides which renders mollusc inedible due to the accumulation of toxic substances. Also, adverse weather conditions can cause serious losses from both capture and culture fisheries.

Biological constraints are numerous and variable. In mollusc culture, a major constraint is lack of seeds as well as limited availability of suitable culture grounds.

Social and institutional constraints are also numerous and vary from country to country. The lack of trained personnel in some countries is at present the major problem. The limited demand of molluscs in general, due to culture-related preferences as well as health considerations, is also a limiting factor in the development of this industry.

Figure 6 lists the major constraints to the development of the mollusc industry. The percentage values were extracted from a survey conducted in fifteen East and Southeast Asian and Pacific countries partly aimed at identifying constraints in the mollusc industry. Limited seed supply appears to be the most serious constraint, followed by lack of trained personnel and poor quality control. All the constraints are interrelated which suggest that a multi-disciplinary approach is essential to solving industry problems.

Potential

There is considerable potential for further expansion and development of the mollusc culture industry in the region. To underpin this potential, many of the governments in the region have either ensured or will ensure that the following minimum conditions or actions will be provided or taken:

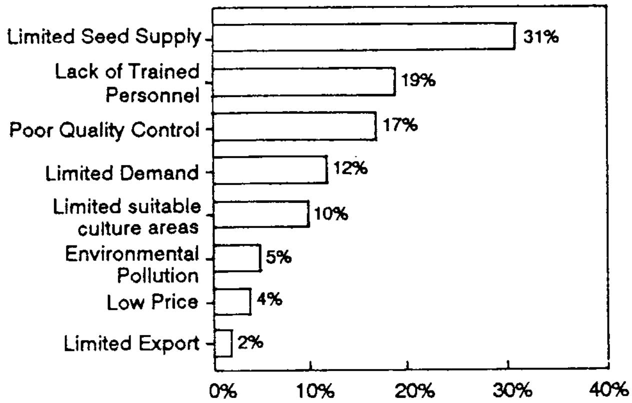

Fig. 6. Major constraints in the mollusc industry and their degree of importance.

1. **Seed supply.** Inconsistency of seed supply could be minimized through efficient management of spatfall areas and reseeding programs to create additional natural beds.
2. **Research.** Applied research on the biology, culture techniques, and post-harvest handling of mollusc should be intensified.
3. **Sanitation**. Quality control and sanitation techniques need to be improved to enhance marketability of fresh molluscs for both local and export markets.
4. **Marketing.** Markets for certain species should be developed through campaigns as well as product development to diversify the existing market which is limited to specific areas and communities.
5. **Government/Public Involvement.** Coordination among government agencies and the private sector should be maintained to prevent and/or combat pollution which could assist in developing and expanding the industry.
6. **Training.** Training programs and extension work should be carried out for the target groups especially fishermen, technicians, and extension workers.

Source: A Lovatelli. *Bivalves: status, problems and future in Asia.* **INFOFISH International** 2/90.

Focus: Philippine Mollusc Industry

The mollusc industry contributed to the economic development of the country in terms of food production and dollar earning. The industry has continuously provided cheap but nutritious food. Production was 22 528 Mt in 1981 which increased to 41 700 Mt in 1985. Mollusc and shellcraft products exported in 1987 earned an estimated US$26.55 M.

Aquaculture production of oysters and mussels is from 69-99% of total production. From 1981 to 1985, production increased yearly by 14% but decreased in the succeeding years by 25% yearly. In 1985, the country produced 1.4% of total world production of oysters and 3.7% of mussels. In the same year, the country ranked 8th in total world production of both species.

In 1981, 427 ha out of a potential area of 11 600 ha was used for oyster farming. Mussel was cultured in 217 ha of the potential 6878 ha. The average size of a mollusc farm is 2.5 m^2 operated on a part time basis by fishermen who have other sources of income.

Source: RF Agbayani and FF Abella. 1989. *Status of sanitation and marketing of mollusc in the Philippines.* In: **Report of the Workshop and Study Tour on Mollusc Sanitation and Marketing**; 15-28 Oct 1989; France. Bangkok, Thailand: Regional Seafarming and Development and Demonstration Project, Network of Aquaculture Centres in Asia; 98-110.

Mussel Farming

Mussel farming depends entirely on one natural phenomenon: spatfall. This is the period when mussel larvae are developed enough to cease their floating existence, settle, and attach themselves to solid surfaces. Successful collection of these spats is essential for mussel farming. While the technology to artificially produce the spats in controlled conditions is available, it is not yet economically viable and is probably not necessary considering the abundance of natural spats. The mussels need not be grown in the same area where the spats are collected, and in some cases it is actually more desirable to have a separate growing area. Here in the Philippines, however, all successful mussel farming ventures have been conducted in the spatfall areas. Thus, at the moment, the presence of natural mussel spatfall should be considered a primary criterion in determining the viability of a potential mussel farming project.

Site selection

The following parameters must be considered in site selection:

1. Sufficient breeding stock and spatfall.
2. Protection from strong winds and waves. Area must be sufficiently enclosed to retain larvae.
3. Enough tidal range to change water completely and frequently; strong tidal current (>2 cm/s); and depth of at least 2 m at low tide.
4. Sufficient food in the water. (Generally, clear waters do not contain enough food to sustain optimum growth. Greenish water is one indication of food availability.)
5. Distance from river mouth as abrupt salinity changes is possible.
6. Proximity to market.
7. Absence of sources of pollutants.

Selection of suitable collector materials

Mussel farming depends largely on placing the right type of collector in the right place at the right time or season to collect young mussels or spats. The material which was proven most effective is coconut husk because of its hairy, fibrous nature that is very attractive for mussel larvae to settle on. Furthermore, coconut husks are readily available in the Philippines and are easy to prepare. The husk is stripped from the coconut shell and shredded. The only difficulty with coconut husk, however, is that it does not last long in the water, so that usually the mussels will have to be "re-laid" or transplanted.

Other suitable materials as collectors are cabo negro, old frayed ropes, etc.

Farm construction and operation

Basic considerations

1. Cultures should always be under water even at low tide. Mussels that attach and survive above the lowest tide level are generally stunted or deformed.

2. Cultures should always be in an off-bottom position to prevent potential predators such as starfish, crabs, snails, and other organisms from crawling up the culture ropes.

3. Materials used should be durable enough to last at least until the mussels are harvestable.

4. Clusters of mussels on a rope should be adequately spaced to avoid contact with each other through wave action.

5. Structures must always be positioned so as not to obstruct navigation.

6. Cultures should be laid perpendicular to wave action and lined up in the direction of current flow.

7. The environment of a mussel farm degrades with continued use. It is advisable to

have an area 2-3 times larger than actual culture site to allow the farm to be moved from one section to another.

Materials and design. Raft or suspension culture of mussels consists of growing mussels on ropes hung from rafts or other similar floating structures. A basic raft design is sketched in Figure 1 and an attached culture rope in Figure 2. The method of mooring a single raft or a series of rafts is presented in Figure 3.

Spat collectors (coconut husk) are inserted in the lay of ropes to collect mussel spats. These spats are allowed to grow for 4-5 months and are harvested when they reach 37-60 mm in length.

Spatfall period can be predicted with a fair degree of accuracy after a few years of observation. Thus in Bacoor Bay, farmers generally lay their stakes before April and in November. In Sapian Bay, the periods of highest spatfall intensity are from February to March and again from September to October. In Himamaylan River, the spatfall occurs in March with a lower-intensity spatting in October. Generally, for greater chances of spat settlement, the collectors or ropes should be installed not earlier than February and not later than March to catch the first spatfall which is usually the heavier one. For the secondary spatfall, ropes should be laid not earlier than September and not later than November.

General farm management

A raft-farm is easy to maintain due to its independence from the tide. The most important thing to watch for is timely laying of collectors. Once the mussel spats have settled on the collectors, maintenance of the farm consists of the following procedures:

1. Thinning out collector ropes and transplanting the young mussels to grow-out ropes.

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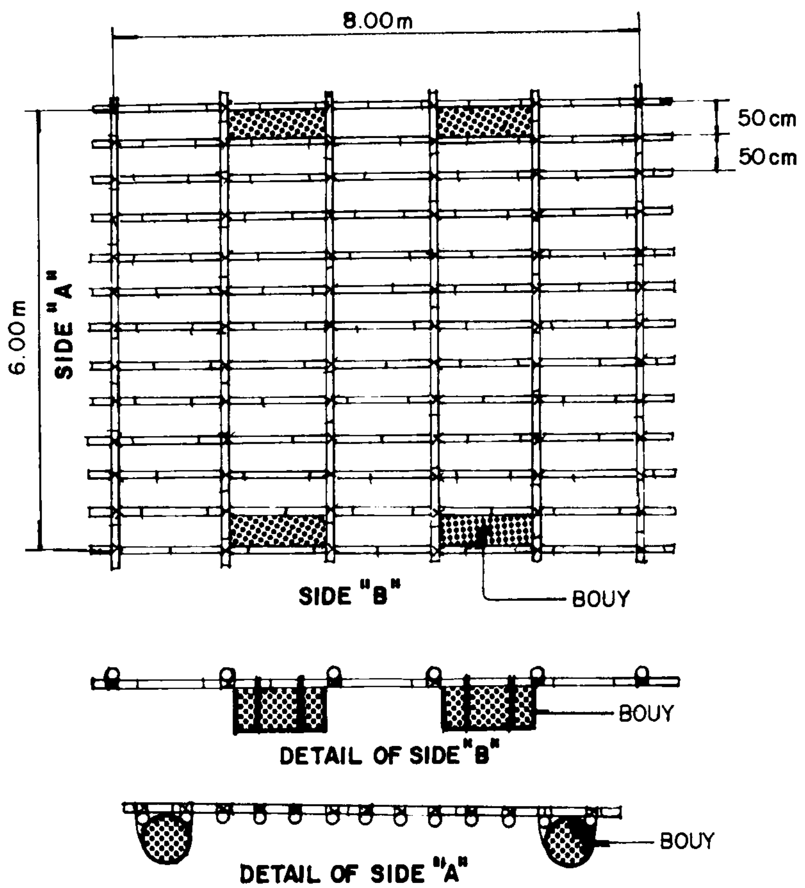
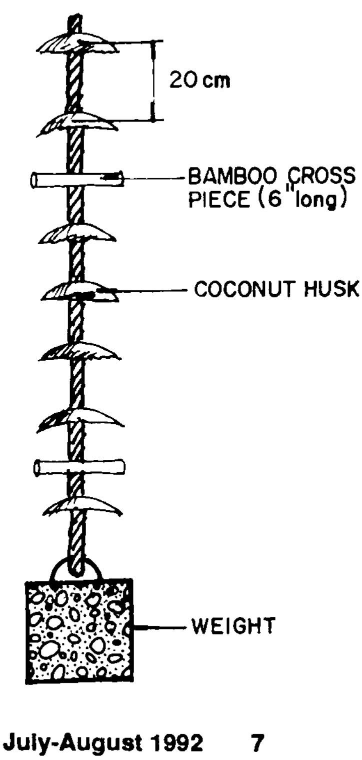


Fig. 1. Construction detail of a mussel raft using bamboo framework and floats.

Fig. 2. Detail of a 2-m culture rope.



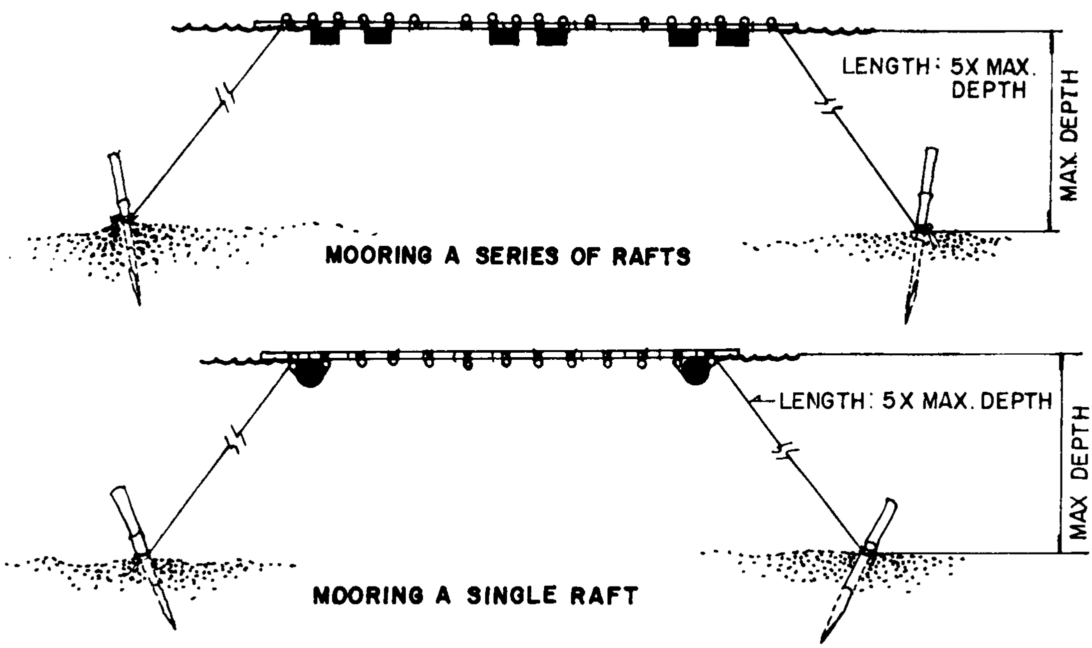


Fig. 3. Method of mooring a series of rafts or a single raft.

The thinning and transplanting operations should be carried out before the coconut husks start to decay. During transplanting operations, the young mussels must be protected from the heat of the sun and from the wind, while they are out of the water. For this purpose, a small hut may be constructed on the raft.

2. Adding additional buoys whenever necessary.

As the mussels grow, the ropes get heavier and additional buoys must be provided to keep the bamboo framework above water and prevent the ropes from sinking to the bottom.

3. Protecting the mussels from predators and ridding them of parasites, pests, and silt.

Grow-out ropes should be inspected regularly for crabs, sea urchins, and other predators. These may be removed by hand. Other pests growing on the shells of the mussels or on the ropes may be removed by scraping them off with a knife or by exposing the ropes for a short period during the early morning or late afternoon when the sun is not too intense.

Pests and other foulers growing on mussels or on the ropes reduce yield through crowding or smothering newly settled spats, or by reducing movement of water and food. Furthermore, these organisms add weight and represent extra expense in terms of additional buoys or floats. Likewise, ropes may have to be shaken periodically to dislodge silt that settled on the shells.

Perhaps the greatest harm that can be done to a mussel farm is caused by human poachers. As the raft method of culture allows for easy harvest, by the same token it is also easily poached. To discourage poaching, the farm must be guarded at all times, especially when the mussels have grown to marketable size. In this regard, the raft-hut used for transplanting operations may serve as a floating guardhouse.

4. Replacement of pegs.

The grow-out ropes should be inspected regularly to see if the pegs are still doing the job of supporting the mussel clumps. Decayed pegs should be replaced. If necessary, additional pegs may be provided to support exceptionally large mussel clusters.

Harvesting

Transplanted mussels grow faster than mussels which settled and grew on the same surface. They may be harvested 4-6 months after spatfall. Mussels ideally measure 40-60 mm at harvest (consumers prefer medium or bite-sized mussels). The mussel should be harvested before they grow too big to be acceptable in the market.

Also, the mussels should not be harvested when they are too thin. "Thinness" or "fatness" of mussels is indicated by the degree to which the meat shrinks after cooking. A "fat" mussel is full-bodied and attractive in appearance; males have a rich, creamy appearance while females are filled with bright-orange eggs in almost every part of its body. The flesh of fat mussels shrinks only slightly after cooking.

In contrast, the flesh of thin mussels is "watery" and transparent. There is very little distinction between males and females and the flesh shrinks to less than half its original size after cooking. Mussels cultured on ropes grow very rapidly due to the abundance of food and the absence of crawling predators. These off-bottom mussels generally taste better because they do not contain mud.

When detaching mussels from the rope, care must be taken not to injure them by pulling out their byssus threads. These threads are a very important part of their bodies and they die within a few hours if these threads are violently pulled out to include the muscular support. For this reason, the mussels should be scraped with a sharp knife or bolo and never pulled off the ropes. Alternatively, the mussels may be taken off the ropes by grasping their byssal attachment rather than the mussels themselves when pulling them off the rope. If possible, mussels should be harvested and transported to market in clusters as clustered mussels effectively conserve moisture and thereby live longer. Removing clustered mussels from the rope is relatively easy as the cluster readily slips off. During transport to market, the mussels should be kept in moistened jute sacks protected from the sun. The mussel clusters should be broken up just before they are displayed for sale, again with a sharp knife or a pair of scissors.

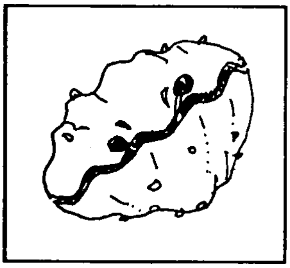
At least 10-15% of the mussels should remain after harvest to serve as breeding stock to produce spats for the following season.

Source: WG Yap, AL Young, CF Orano, and MT de Castro. 1979. ***Manual on mussel farming.*** Aquaculture Extension Manual No. 6. SEAFDEC Aquaculture Department, Tigbauan, Iloilo. 17 pp.

"The poor getting poorer but with the rich getting richer, it all averages out in the long run."

Source: *SCN News* (United Nation's Newsletter), No. 7, mid-1991.

Mariculture of giant *clams*



Mariculture of giant clams stems from the need to replenish wild stocks depleted by overharvesting and to provide an alternative source of protein and a means of livelihood for fishing communities specifically in the South Pacific and Southeast Asia.

Culture systems and techniques vary from one site to another. These are modified to suit the specific conditions of the locality (water quality and source, available electric power, etc.), the accessible materials and equipment, and the giant clam species available for broodstock. The following techniques were developed at the University of the Philippines Marine Science Institute Marine Laboratory in Bolinao, Pangasinan. Giant clam species cultured so far are *Tridacna maxima*, *T. squamosa*, and *Hippopus hippopus*.

Seawater system

A steady supply of clean, running seawater is essential to any hatchery. The seawater system currently in use provides a 12-h continuous flow of seawater daily.

Broodstock

As a rule, *T. squamosa* greater than 16 cm, *T. maxima* greater than 12 cm, and *H. hippopus* greater than 16 cm in length are used for broodstock.

Broodstock are collected and brought to Bolinao, Pangasinan. Clams intended for spawning are held in raceways, and these are immediately taken back to the field after spawning. All broodstock are tagged and measurements of length and height are taken every 5-6 months or before every spawning.

Biopsy and spawning induction

Before clams are induced to spawn, they are thoroughly scrubbed to remove all dirt and organisms attached to their shells. "Scales" of *T. maxima* and *T. squamosa* are removed to prevent accumulation of dirt, parasites, and other encrustations.

The clams are biopsied using a needle to select only individuals with mature gonads (e.g., with ripe eggs and sperm). Gonads are considered mature if sample shows that there are more than 300 eggs/ml of samples and that greater than 50% of the eggs viewed are slightly oblongate to spherical in shape. Diameters of mature eggs measure about 95-112 µm for *T. squamosa* and *T. maxima*.

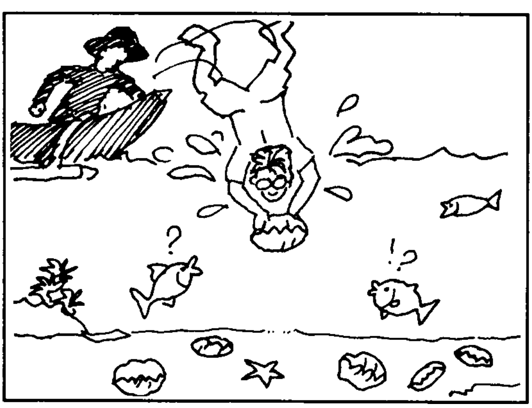
Mature clams are transferred to plastic tanks filled with 0.02-µm filtered seawater (FSW) and induced to spawn. Serotonin (2 ml of 0.02 mM) injected intragonadally was used in previous inductions. Lately, gonad slurry (obtained from frozen gonads of clams that died) has been used to induce spawning in mature clams. Gonads of *T. maxima* were able to induce spawning in the same species and in *T. squamosa* and *H. hippopus*. The macerated gonad is dissolved in FSW, and small amounts squirted into the inhalent siphons or injected directly into the gonads. Mature clams usually expel sperm with forceful jets of water after 5-15 min. Eggs are spawned 1 - 1 1/2 h after sperm is released. Sperm is collected from each clam and the tag number noted. As soon as the clam releases eggs, it is transferred to a clean container with FSW and allowed to finish spawning. After spawning, eggs and sperm from different individuals are mixed and counts of eggs per individual are taken. The fertilized eggs are then transferred to the outdoor culture tanks filled with 0.5-µm filtered seawater. Nylon filter bags become necessary to keep out sediments, possible predators, and other eggs and larvae. Filtered seawater is allowed to flow every two days after the eggs have become veligers, but a nylon sieve is placed at the outflow to retrieve larvae carried with the waste water.

T. maxima, unlike the other two species, spawns with a gentle stream of water from the exhalant siphon. The eggs usually sink to the bottom of the container or onto the mantle of the spawner.

Larval rearing

Development stages (egg, gastrula, trochophore, veliger, pediveliger, juvenile) are identical for all giant clam species, although developmental and growth rates may vary with species and culture conditions.

The larvae are left untouched (except for daily water samples to obtain counts and to determine the stage of the larvae) until they have become veligers, which is about 2-2.5 days after fertilization. The larvae are fed with the unialga *Isochrysis galbana* at concentrations of 10^3 -10^5 cells/ml every other day until they metamorphose. At the same time, freshly isolated zooxanthellae (*Symbiodinium microadriaticum*) scraped from the mantles of adult clams are added to the water. The symbiont concentrations used so far have been low (3-4 x 10^2 cells/ml) because only a small portion of the mantle could be obtained at a time, and only once per clam. It was observed that the clam species from which zooxanthellae is taken need not be the same as the recipient as the symbiont would also be accepted. However, zooxanthellae from the same species has been observed to establish symbiosis more readily. From the different batches reared, it seemed that the larvae fed zooxanthellae from the same species of clam had faster growth rates and settled earlier than those provided with zooxanthellae from a different clam species.



Mortalities are about 99% from egg to juvenile. The greatest number of deaths occur when trochophores develop into veligers, and in the period from the pediveliger stage through metamorphosis into juveniles. Feeding with *I. galbana* and zooxanthellae helps increase survival rates although the addition of nutrients in the water (with *I. galbana*) contributes to profuse algal growth along the sides and bottom of the tank.

Harvest

The juveniles are harvested 3-4 months after fertilization, when they are 1-10 mm in size. Although keeping them longer in the culture tanks will allow them to grow larger and will make harvesting easier, greater mortalities occur. Deaths are caused by a variety of factors such as fouling of the algal mat (an aggregate of diatoms, skeletons of different invertebrates, and debris), predation by pyramidellids, and competition for space and possibly nutrients with other invertebrate larvae that pass through the filters. It was observed that the juveniles crawl on top of the algal mat so that they are not actually smothered. However, as the algal mat thickens, the lower layers decay and cause fouling. Sometimes, gas bubbles accumulate under the mats causing some portions of the algal mat with clams attached to rise to the surface and expose the clams to the sun's heat. If not removed immediately, the clams will die.

Harvesting is done by using a rubber hose to siphon off the bottom of the tank into appropriate-sized nylon sieves. The clams are then separated from the algae and resettled on pieces of coral rubble in a clean tank with flowing FSW where they are allowed to grow to bigger sizes before being transplanted to the ocean nursery. Spats have been observed to crawl from one place to another in search of a suitable substrate. They appear to prefer rough surfaces with pits, cavities, or edges which is why pieces of coral rubble were chosen for settling "plates". During the grow-out period, the tank and the substrates are cleaned regularly and when necessary, the

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Public Health Aspects

Bivalves such as the green mussel *Perna* are mostly cultured in coastal and estuarine areas and may thus be exposed to industrial waste and sewerage discharges. Studies on European mussels have shown their high tolerance to a wide range of environmental contaminants and their ability to accumulate pollutants from the environment. To not only ensure the wholesomeness of the product but also assist in the choice of sites for farming the mussels, there is a clear need to monitor heavy metals and other possible pollutants in prospective or existing culture areas. Depuration techniques are extensively studied in connection with European mussel industries but so far have received little attention in tropical regions.

Bacterial contamination

The presence of bacterial and viral pathogens is usually the consequence of sewage pollution. The level of pollution is often closely related to the discharge of freshwater from land. This makes it in some cases mandatory to develop guidelines to restrict harvesting of mussels following periods of heavy rainfall. Contamination with bacterial and viral pathogens presents a major risk to the consumer, especially when the mussels are eaten raw or only lightly cooked. Viral infection from eating oysters leading to infective hepatitis has been well documented. Lack of awareness of the possible linkage between human fatalities and the consumption of mussels might be the primary reason that so far no reports exist on bacterial disease transmitted through consumption of any of the *Perna* species.

Depuration of mussels is recommended when they are to be eaten raw or semi-cooked. Studies in Singapore showed promising results when highly polluted mussels, stocked at a density of 100 kg/m^3 water in a recirculating seawater system, were depurated to acceptable limits (<20 MPN *Escherichia coli*/g flesh) within 48 h. The water was sterilized by means of ultraviolet radiation. Waterflow was maintained at 3 m^3/h, with complete replacement of water after 24 h. Other researchers evaluated the organoleptic properties of *P. viridis* depurated in stagnant water and sucrose solution (200 ppm) and found color, texture, flavor, and general acceptability not affected by the depuration. They noted, however, a significant change in fat and protein content after 24 h depuration.

Paralytic shellfish poisoning

Many countries with good prospects of culturing *Perna* have become increasingly aware of the grave public health and economic problems associated with the sporadic outbreak of paralytic shellfish poisoning (PSP). Bivalves, including *Perna*, can carry substances poisonous to humans as a result of bio-accumulated toxins produced by a small number of species of dinoflagellates, notably those belonging to the genus *Gonyaulax* (or *Protogonyaulax*), *Gymnodinium*, and *Pyrod-*

To eat or not to eat ...

inium. Throughout the Indo-Pacific region, *Pyrodinium bahamense* var. *compressum* is considered the major causative organism of PSP. However, it has been suggested that *Protogonyaulax tamarensis* triggered a few cases of PSP in Thailand in 1983. The toxins isolated from infected molluscs were in general derivates of saxitoxin, neosaxitoxin, or gonyautoxin. They belong to the class of neurotoxins which cause symptoms such as weakness of the limbs, fatigue, and numbness and tingling in the fingers, toes, lips, and tongue of humans. The toxins are heat-stable, but detoxification down to acceptable levels within 6 to 7 days can be achieved by treatment with ozone or PVP-iodide-iodine complex.

Researchers suggest that standardized toxicity testing be applied such as the standard mouse bioassay technique advocated by the AOAC (Association of Official Analytical Chemists). The toxicity threshold set by the United States Food and Drug Administration for closure of mollusc beds is fixed at 80 µg toxin/100 g mussel flesh. Depending on the method applied, this represents approximately 400 mouse units (MU) per 100 g mussel flesh.

The blooms of dinoflagellates that can pose an increased risk of PSP are usually called "red tide". This phenomenon seems to be, therefore, of primary importance in any monitoring program. Some researchers suggest aerial surveys, flown at an altitude of 300 m, to be most useful in detecting and monitoring red tides. However, PSP can occur, as in Malaysia, without any visible planktonic bloom. This might happen either because the concentration of dinoflagellates can reach toxic levels before their presence is manifest in red tides or because of the long retention period of the toxins in the molluscs, which can last for several months. The possible absence of clearly distinguishable indicators make standard monitoring programs indispensable. Plankton and sediment samples should be collected regularly together with oceanographic data. Their evaluation should enable the timely closing of mussel farming areas and the launching of public awareness programs.

Trace metals

A substantial number of investigations has been carried out to determine concentrations of trace metals in *Perna*. This was born out of concern over the far reaching implications for human health of the mass-culture and marketing of marine organisms that could contain potentially dangerous levels of heavy metals.

So far no generally accepted standards exist for upper limits of heavy metal concentra-

(next page please)

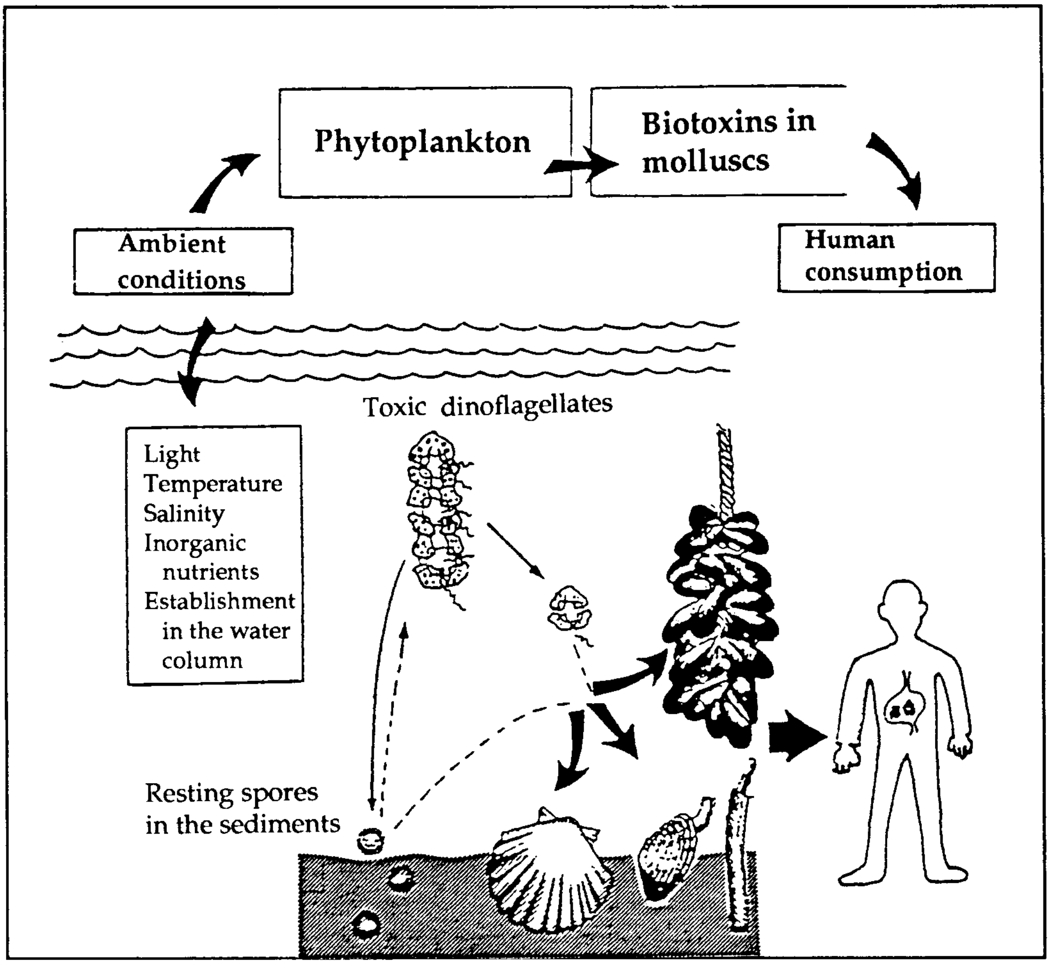
Giant clams ... from p. 11

clams are thinned out to prevent overcrowding. Transfer to the ocean nursery is done as much as possible without detaching the juveniles from the original substrate so that the transition is accomplished smoothly.

In conclusion, culture of giant clams requires a system that can deliver clean flowing seawater to suitable tanks for rearing clam eggs through larval stages to juveniles. The technology itself is relatively easy to learn, although the hatchery aspect may require more equipment and know-how than is available to coastal inhabitants and may have to be provided by better funded government or private institutions. The need for serotonin, which is expensive, to induce spawning can be dispensed with by using gonad slurry from one or two sacrificed clams.

Future work should focus on improving survival during the larval stages possibly by providing better sources of nutrition, and on inducing early settling and metamorphosis of pediveligers so that the clams grow bigger at an earlier date and can thus be harvested sooner.

Source: MJ Trinidad-Roa and EO Alialy. *Mariculture of Giant clams (Family Tridacnidae) in Bolinao, Pangasinan.* p. 28-35. In: **Proc. Symp-Workshop on the Culture of Giant Clams (Bivalvia: Tridacnidae);** Silliman Univ, Dumaguete City; March 15-17, 1988. Los Baños, Laguna: Philippine Council for Aquatic and Marine Research and Development and the Australian-Centre for International Agricultural Research; 1989. 131 pp.



Pathway of biotoxins: from water to shellfish to man *(Modified from JA Ferragut. 1989. Mollusc sanitation and marketing in Spain.* In: **Report of the Workshop and Study Tour on Mollusc Sanitation and Marketing**; 15-28 Oct 1989; France. Bangkok, Thailand: Regional Seafarming and Development and Demonstration Project, Network of Aquaculture Centres in Asia; 98-110.)

tion in bivalves. The reason for this has to be seen in the fact that only the final concentration of contaminants in humans is of real concern. Recommendations on maximum tolerable levels of contaminants in humans are published by the World Health Organization. Relating this to recommended upper concentration limits of heavy metals and other contaminants in bivalves on a global scale is impractical. National differences in consumer preferences have to be considered when determining the respective thresholds of tolerable contamination. Regulations, therefore, vary from country to country.

In Thailand, trace metal concentrations in *P. viridis* and other economically important mollusc species have been investigated. Results suggest that contamination of *P. viridis* with trace metals is at acceptable levels. Researchers who investigated environmental pollution at various coastal stations along the Island of Penang, Malaysia in 1978 determined trace metal contents in cultured *P. viridis*. Except for nickel (Ni) at 46 ppm, total trace metal content was still within acceptable limits.

It was also found that there is a marked increase in the levels of chromium (Cr) and copper (Cu) in mussels during the rainy season and this is related to the reduced salinity of the water. A similar pattern of seasonal variation in the levels of trace metals in *P. viridis* was observed in India. Low pH values during the rainy season is a possible reason for increased dissolution of precipitated forms of trace metals. This coupled with industrial effluents carried by freshwater discharge and increased rate of filtration in mussels would necessarily result in higher concentrations of trace metals in *P. viridis*. Investigations in the contents of trace metals in *P. viridis* in Manila Bay, Philippines, also noted an increased heavy metal level in the mussels during the rainy season. Lower concentrations (in relation to dry flesh weight) during summer were probably a mere "dilution effect", caused by the mussels being in better condition.

Pollution monitoring

Bivalve molluscs are commonly used as sentinel organisms to monitor aquatic pollution by conservative contaminants which they accumulate above ambient levels. Whether any of the *Perna* species can act as bio-indicators largely depends on their capacity to reflect efficiently and accurately ambient concentrations of the pollutants. A researcher investigating cadmium content in *Mytilus* worldwide also included some information on *P. viridis*. He found a highly significant relationship between cadmium concentrations in mussel soft tissue (Cd_{mussel}, in µg/g dry weight) and seawater (Cd_{water}, in µg/l) of the form:

$$Cd_{mussel} = 0.39 + 0.074\,(Cd_{water})$$

This relationship suggests that in mussel breeding areas, a standard of 150 ng/l should be proposed as the upper limit for cadmium content of the seawater.

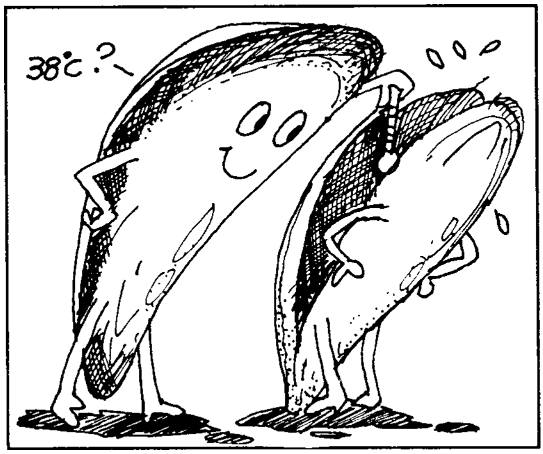
It was shown that the uptake of lead in *P. viridis* is almost linear over a period of seven days. In addition, *P. viridis* was considered very suitable for the monitoring of copper, organochlorine pesticides, and PCBs. Other researchers who studied the reaction of *P. viridis* to different water soluble fractions of diesel fuel noted that byssal thread production and, hence, attachment, was significantly depressed in all but very low concentrations of the toxicant. A similar effect on byssus production was observed under ammonia stress.

P. viridis showed continuous uptake of mercury when it is exposed to a concentration of 100 ppb over a period of 45 days. Depuration was a very slow process. Even after 151 days of continuous self-cleansing, 15.3% of the total mercury body burden remained unpurged. Because of this, *P. viridis* could be used as a bio-indicator for cadmium, cobalt, chromium, copper, nickel, and lead, but was unsuitable for iron, manganese, and zinc.

Researchers also investigated the load of fecal coliforms in the waters around Hong Kong. Though tremendous differences in bacterial contamination between sites existed, they found a close relationship between the number of fecal coliforms in the water and in bivalves, one of which was *P. viridis*.

Investigations on the influence of sex, size, and substrate on the bio-accumulation of heavy metals in *P. perna* along the coast of Rio de Janeiro, Brazil showed substrate-specific differences in the uptake of Fe and Ni. Concentrations of Ni are positively and Fe and Cu are negatively correlated with size of *P. perna*. However, no sex-related differences in heavy metal uptake can be established. Investigations into the bio-accumulation of radionuclides along the Rio de Janeiro coast (Brazil) in *P. perna* revealed significant levels of ^{210}Polonium. This endorsed an earlier assumption that *P. perna* might be a valuable bio-indicator for radioactive pollution of the marine environment.

Source: JM Vakily. 1989. ***The Biology and Culture of Mussels of the Genus Perna.*** International Center for Living Aquatic Resources Management, Manila, Philippines and Deutsche Gesellschaft Fur Technische Zusammenarbeit, GmbH, Eschborn, Fed. Rep. Germany. 63 pp.



PSP Hotline

Eating molluscs contaminated by a naturally occurring, toxic organism can cause serious illness, even death.

How can I tell if it's safe to gather mollusc?

The only really sure way is through laboratory testing of the molluscs. Paralytic shellfish poison (PSP) can be present with no apparent signs in molluscs.

What is the best way to keep informed on current condition?

Call government agencies. Two major agencies are concerned with the inspection and quality control of fish and fishery products: (1) the Department of Agriculture - Bureau of Fisheries and Aquatic Resources (BFAR) institutes guidelines on fresh, frozen, and chilled fishery products; (2) the Department of Health - Bureau of Food and Drug Administration takes responsibility for the dried, canned, and other processed fishery products. There is also an inter-agency committee composed of four government agencies that undertakes close monitoring and surveillance of the areas affected by "red tide."

Because conditions change rapidly, you should call these agencies each time you plan to gather shellfish. The agencies provide information which can considerably reduce the risk of paralytic shellfish poisoning.

What about "red tide"?

Paralytic shellfish poison is rarely associated with a red tinge to the water. Don't assume the molluscs are safe if the water is not red. Reddish coloration of the water is more commonly associated with similar, but non-toxic organisms.

What causes the toxin?

When conditions such as sunlight, water temperature, and nutrients are favorable, a microscopic, poison-producing dinoflagellates can reproduce very rapidly in sea water. When molluscs feed on this plankton, they accumulate the toxin.

Are all molluscs at risk?

No. Only clams, oysters, mussels, and scallops can become contaminated by the toxin. Crab, shrimp, abalone, and finfish are not affected.

How will I know if I've eaten a toxic shellfish?

The PSP toxin temporarily affects the nervous system of humans and other warm blooded animals. Early physical symptoms include tingling and numbness of the lips and tongue. Depending on how much toxin is consumed, symptoms may progress to tingling of fingers and toes, difficult breathing, and loss of control in the arms and legs. Death can occur when the respiratory system becomes paralyzed.

What should I do?

If any of the early symptons occur after eating shellfish, induce vomiting and get medical help immediately.

There is no known antidote.

Mollusc can also be contaminated by other toxic substances. Gather shellfish away from sources of pollution.

Sources: (1) *PSP Hotline*, **Red Tide Newsletter**, Vol. 5, No. 1, 1992 and (2) RF Agbayani and FF Abella. 1989. *Status of sanitation and marketing of mollusc in the Philippines*. In: **Report of the Workshop and Study Tour on Mollusc Sanitation and Marketing**; 15-28 Oct 1989; France. Bangkok, Thailand: Regional Seafarming and Development and Demonstration Project, Network of Aquaculture Centres in Asia; 98-110.

An Action Program for Mollusc Sanitation

Considering that public health provisions are an essential component in the chain of activities involved in production, harvesting, and marketing of bivalves for human consumption.

Considering that unfortunately, the public health component is often minimized, or in some countries even overlooked in the development and management of mollusc cultures or harvesting activities.

Considering that without an effective mollusc sanitation program that will assure a product having an acceptable health risk for the consumer, no system of mollusc production and marketing - regardless of the opportunities and efficiency of its other components - is acceptable by current standards, the following are recommended:

• Countries should identify the national infrastructure(s) (agency/ies) capable of effecting the assessment of water quality, monitoring culture and harvesting activities, and providing adequate surveillance of the chain of supply from production to retail (including maintenance of product identity and testing mollusc for contaminants at the marketing stage).

• Development of regional and national training activities geared to organize and implement national fish sanitation programs.

• Development of general (regional) guidelines for the elaboration of basic legislation covering the sanitary control of production and marketing of mollusc bivalves.

• Information exchange should be promoted and assisted.

Source: Regional action program for shellfish sanitation in Asia. p. 8. In: ***Report of the Workshop and Study Tour on Mollusc Sanitation and Marketing***; 15-28 Oct 1989; France. Regional Seafarming Development and Demonstration Project, Network of Aquaculture Centres in Asia, Bangkok, Thailand. 212 pp.

Aquaculture Clinic gives way to the urgent appeal of fisheries scientists to ban the use of chemicals in aquaculture. Sept-Oct AFN *Clinic* will tackle **aflatoxin** from a discussion with AQD Associate Scientist Myrna Bautista. - Ed.

<u>SEAFDEC/AQD and UPV scientists</u>

NO to pesticides and antibiotics in aquaculture

The use and abuse of antibiotics, non-biodegradable pesticides, and other disease-control chemicals (e.g., malachite green, formalin, methylene blue, potassium permanganate, etc.) in aquaculture pose definite, real hazards to farm workers, the cultured animals, consumers, and the aquatic environment. The application of these hazardous substances in many aquaculture farms in Region VI causes great concern among scientists at the SEAFDEC Aquaculture Department and the College of Fisheries of the University of the Philippines in the Visayas (UPV).

WE, THEREFORE, STRONGLY URGE THAT ANTIBIOTICS, NON-BIODEGRADABLE PESTICIDES, AND DISEASE-CONTROL CHEMICALS BE BANNED FROM USE IN AQUACULTURE.

1. Non-biodegradable pesticides are commonly used to eradicate unwanted fish and other pond pests. These pesticides are a health hazard to farm workers and product consumers. Discharge of these pesticides contributes to land and coastal water pollution. Molluscicides (e.g., Gusathion, Aquatin) used in ponds cause abnormalities such as soft-shelling and organ disruption in shrimps, and consequently, significant losses due to the lower market price.

As alternatives, biodegradable, naturally-occurring, plant-derived pesticides such as tea-seed cake, derris roots, and tobacco dust can be used. The application of calcium carbide and ammonium sulfate in combination with lime can effectively control pests in many fish and shrimp ponds. Handpicking of unwanted fish and snails may be time-consuming, but can generate employment in the farm. Improvement in the physical design of ponds and water management practices can mini-

(next page please)

mize the occurrence of pests. Biological control measures, e.g., stocking natural predators of unwanted species (e.g., sea bass to tilapia), can be employed.

2. Antibiotics have been indiscriminately used by local farmers to control a variety of microbial diseases in cultured shrimps and fish. Antibiotics like chloramphenicol, which are commonly used as a prophylactic treatment in shrimp hatcheries, have long been banned abroad for use in humans and domestic animals. The indiscriminate use of antibiotics leads to the development of highly resistant strains of pathogenic bacteria, which are unresponsive to existing means of control. Indeed, the risk to public health is great when broad-spectrum antibiotics are discharged nearshore through pond and hatchery effluents and create drug-resistant strains of bacteria causing human diseases (e.g., cholera, typhoid fever, tuberculosis). In addition, abuse of antibiotics can mean loss of farm income. In 1991, for example, shipments of locally grown shrimps were rejected by the Japanese market because of antibiotic residues.

3. Other disease-control chemicals have also been indiscriminately used in many hatcheries and farms. At low concentrations, these substances act as therapeutants against fungal infection and external parasites. However., long-term application can cause unwanted abnormalities in fish and shrimps. Some of these chemicals are also known to be carcinogenic.

The use of antibiotics and other disease-control chemicals can be totally avoided when pond and hatchery conditions are kept clean, and the growth of pathogenic microorganisms prevented. Stocking fish or shrimps at lower densities (i.e., within the carrying capacity of ponds) and employing proper water and feeding management schemes decrease the incidence of diseases requiring chemical treatment. Pond should be given sufficient time between croppings for accumulated organic matter to decompose and enrich the bottom. Crop rotation and polyculture of finfish and shellfish also maximize the natural productivity of a pond. Similarly, larvae can be grown in the hatchery under less intensive culture conditions not requiring disease-control chemicals. Constant exposure of seed stock to these chemicals decreases their resistance to latent pathogens during the grow-out phase of culture. The occurrence of bacterial disease in shrimp larvae can be effectively prevented if the broodstock are transferred after spawning or the spawned eggs are thoroughly washed to avoid contact of eggs with feces and other debris. Waste effluents from ponds and hatcheries should be treated before discharge to the surrounding area. There are existing methods of treating waste effluents.

In view of these hazards, we at the SEAFDEC Aquaculture Department and the UPV College of Fisheries urge aquaculture practitioners in the Philippines to learn a lesson from Taiwan. After two decades of unprecedented growth, shrimp production in Taiwan dramatically dropped in 1988 as a consequence of overstocking in hatcheries and ponds, poor feed quality, indiscriminate use of antibiotics, pesticides and disease-control chemicals, and coastal water pollution. Due to the excessively intensive method of farming, the rapid expansion of the Taiwan shrimp industry strained and eventually exceeded the limited resources (land, salt- and freshwater, spawners, fry, etc.) of the country. The culture environment deteriorated, diseases broke out, and mass mortalities resulted. This recent disastrous experience should, therefore, warn local farmers of the effects of poor farming practices such as the wanton use of antibiotics and non-biodegradable pesticides.

Our common stand to ban the use of antibiotics, non-biodegradable pesticides, and other disease-control chemicals in aquaculture requires firm government and public support to become truly effective. Environmentally sound farm practices will make the use of these chemicals unnecessary.

SIGNED:

Scientists at SEAFDEC Aquaculture Department

Flor Lacanilao	Avelino Trino
Luis Ma. Garcia	Oseni Millamena
Relicardo Coloso	Eduard Rodriguez
Celia Pitogo	Myrna Bautista
Mae Catacutan	Isidra Tuburan
Erlinda Cruz-Lacierda	Precilla Subosa
Neila Sumagaysay	Edgar Amar
Arnil Emata	Ilda Borlongan

Renato Agbayani
Susan Siar
Ronald Cheong
Veronica Penaflorida
Cesar Villegas
Clarissa Marte
Anicia Hurtado-Ponce
Jurgenne Primavera
Gerald Quinitio
Josefa Tan-Fermin
Armando Fermin
Emilia Quinitio
Ma. Teresa de Castro
Teodora Bagarinao
Perla Eusebio
Ma. Rovilla Luhan
Marietta Duray
Robmar Buensuceso
Fe Dolores Estepa
Demetrio Estenor
Nelson Golez
Milagros de la Peña
Wenresti Gallardo
Antonio Castillo, Jr.
Jocelyn Ladja
Noel Solis
Giselle Samonte
Gilda Lio-Po

Scientists at U.P. in the Visayas - College of Fisheries

Efren Ed. Flores
Valeriano Corre, Jr.
Liberato Laureta
Crispino Saclauso
Erlinda Ganzon-Naret
Evelyn Taberna
Jose Peralta
Carlos Baylon
Erlinda Panggat
Norma Fortes
Carmelita Benitez
Leonarda Mendoza
Leticia Serra
Caridad Jimenez
Soledad Santos
Arnulfo Marasigan
Jerome Genodepa
Rodolfo Ventura
Jose Ingles
Ricardo Babaran
Merlina Andalecio
Augusto Serrano, Jr.
Pepito Fernandez
Romeo Fortes
Leonor Santos
En. Emilia Santos
Nygiel Armada

SEAFDEC/AQD NEWS

SEAFDEC/AQD is NFRN member

Department Chief Dr. Efren Flores signed for AQD May 7,1992 membership to the National Fisheries Research Network (NFRN). NFRN is committed to support the general objectives and thrusts of the Fisheries Sector Program (FSP) of the Department of Agriculture.

The network is expected to achieve the following:

1. Implement and undertake research activities prioritized in the National Fisheries Research Program of the FSP in response to the needs of the regions concerned;
2. Facilitate exchange of expertise, methodologies/tools, and results of on-station and on-farm researches;
3. Effect sharing of resources and equipment by Network members especially in pursuit of a common project;
4. Institutionalize strong linkage between the Network and the fisheries industry and the clienteles of the fisheries sector, the fishermen and fishfarmers;
5. Foster inter-agency coordination and collaborative undertaking in serving the needs of the fishery sector.

Other NFRN members are Bicol University, Central Luzon State University, Mariano Marcos State University, Mindanao State University, Don Mariano Marcos Memorial State University, Silliman University, University of the Philippines - Los Baños, University of the Philippines - Diliman, University of the Philippines - Visayas, Zamboanga State College of Marine Science and Technology, Panay State Polytechnic College, and the Department of Agriculture.

Mollusc Culture Network Meeting

The second meeting of the Mollusc Culture Network, an organization of mollusc projects funded by the International Development Research Centre (IDRC) of Canada, will be hosted by AQD on October 14-22. Project scientists will discuss current research and future plans especially in light of the reorganization of programs by IDRC. The venue is Amigo Terrace Hotel, Iloilo City.

A workshop on *Participatory Research Methods for Coastal Resource Development* will also be held in the meeting. Rapid rural appraisal, agroecosystem analysis, gender sensitive analysis of resource utilization, and user involvement in technology development will be discussed. The workshop will help integrate the social and biological sciences to form the basis for future collaboration in coastal community work. Rationale for user involvement and methodologies that will help scientist understand the users' socio-cultural and biophysical environment will also be straigthened out.

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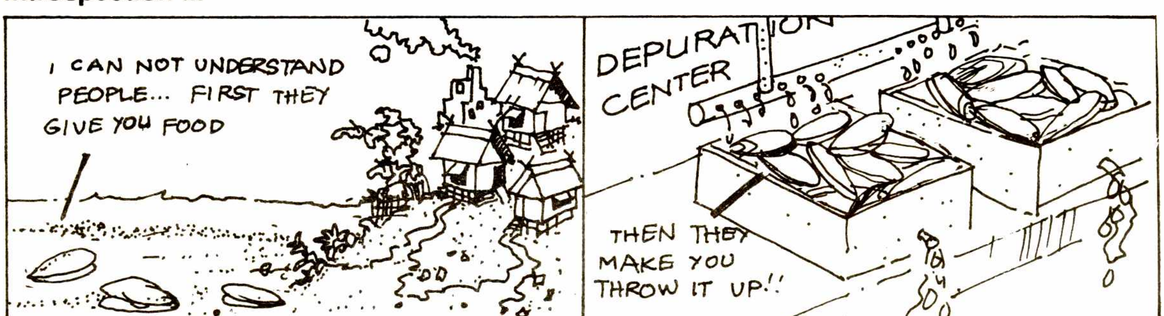
Introspection ...



by I. Tendencia