Variation in settlement of both starfish and scallops between bags held at the same depth may relate to orientation of the bags to the current, the degree of fouling, and the extent to which the polyethylene film becomes folded within the bag. The same factors may influence the variation in spat numbers in bags suspended at different depths. In addition, behaviour of larvae of both scallops and starfish must also influence their initial vertical distribution in numbers. The decrease in the numbers of spat and starfish toward the lower end of the line may be related to factors associated with bottom conditions. Increased turbidity near the bottom with consequent clogging of the meshes in the bag could prevent successful settlement and subsequent survival in these bags.

Vulnerability of small scallops to starfish predation in the upper bags could be reduced. *A. vulgaris* spawns mainly in August and has a larval period lasting for about 3–4 weeks (Evans, Scaplen and Idler, 1973). The protracted major spawning of the giant scallop usually begins somewhat later, reaching a peak in September in Port au Port Bay (Naidu, 1970). The larval period, as determined by the time lag between peak spawning and peak settlement, is about 40–45 days at 10–12°C. Setting of collectors could thus be delayed until about one week after peak scallop spawning. This would give the gear sufficient time to 'condition' in the water and reduce pre-settlement fouling that can exclude successful settling of seed scallops. The need for correct timing of setting out of collectors has been demonstrated in Japan where forecasting techniques based upon gonadal index, cumulative water temperature, and size composition of swimming larvae have been developed (Itò, Kanno and Takashashi, 1975).

Protected collectors, while retaining scallops after byssal detachment, also tend to prevent the escape of young starfish. Predation by starfish is thought to be the most important factor influencing survival of spat in this study, especially in the upper 10 bags. Starfish abundance was probably underestimated since their remains decompose and disappear from the bags. Dead scallops under 1·5 mm could also be lost, but cluckers or disarticulated valves of larger spat would be retained. As the two species appear to have different rates of settlement at different depths, as indicated by the relative abundance of starfish and scallops, it would be advantageous to have the first collecting bag deeper than 8 m.

On the basis of these observations it is suggested that, in Little Bay Mortier, spat collectors be set immediately after peak scallop spawning in depths exceeding 8 m. The lower limit will depend on water depth and siltation rate. In addition, the polyethylene sheets should be secured inside the bags (*eg*, by sewing) to reduce folding within the bags.


## 5 Acknowledgements

The authors wish to thank the Newfoundland Department of Fisheries for allowing access to the scallop spat-collecting facilities at Little Bay Mortier. The assistance of technical staff from the Newfoundland Biological Station and the Marine Sciences Research Laboratory is gratefully acknowledged.


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# Pearl Farming in Japan

*S. Mizumoto*


*Abstract*

Several species of pearl oyster, *Pinctada fucata, P. maxima, P. margaritifera, Pteria penguin* and *Hyriopsis schlegeli*, are used for pearl farming. The first four species are marine bivalves; the fifth is a freshwater species. Procedures used in *Pinctada fucata* pearl farming consists of preparation of host shell, nucleus insertion, convalescence, nurture and cultivation of mother oysters.

In Japan, the maximum annual pearl production is presumed to be about 35 tons for the *Pinctada* pearl, and 10 tons for the freshwater species.

Major problems facing future pearl farming are security of good culture grounds and preservation of their environmental conditions. Continued studies on the environmental conditions of pearl farming grounds and pearl quality are being conducted in Japan. As a result of these studies and efforts to maintain the culture grounds, good prospects may be expected for pearl farming.

**Culture des huîtres perlières au Japon**

*Résumé*

Plusieurs sortes d'huîtres perlières. *Pinctada fucata, P. maxima, P. margaritifera, Pteria penguin* et *Hyriopsis schlegeli* sont utilisées pour la culture des perles. Les quatre premières espèces sont des bivalves marins. la cinquième est une espèce d'eau douce. Les méthodes appliquées pour la culture des perles de *Pinctada fucata* consistent en préparation de la coquille hôte, insertion du noyau, convalescence, soins et culture des huîtres mères. Au Japon, la production annuelle maximum de perles est

évaluée à environ 35 tonnes pour les huitres *Pinctada* et à 10 tonnes pour les espèces d'eau douce.

Les principaux problèmes que se poseront à la culture des perles sont la sécurité des bons sites de culture et la préservation des conditions du milieu. Des études permanentes sur les conditions de milieu des aires de culture des perles et sur la qualité des perles sont en cours au Japon. Grâce à ces études et aux efforts déployés pour préserver les aires de culture, la culture des perles se présente sous une perspective favorable.

**Cultivo de perlas en el Japón**

*Extracto*

Para el cultivo de perlas se utilizan diversas especies de ostras perlíferas: *Pinctada fucata, P. maxima, P. margaritifera, Pteria penguin* y *Hyriopsis schlegeli.* Las cuatro primeras especies son bivalvos marinos, y la quinta una especie de agua dulce. Los procedimientos utilizados para el cultivo de la ostra perlífera *Pinctada fucata* consisten en la preparación de las conchas-soporte, inserción de un núcleo, convalescencia, alimentación y cultivo de ostras reproductoras.

En Japón se supone que la producción máxima anual de perlas es de unas 35 toneladas de perlas de *Pinctada* y 10 toneladas de la especie de agua dulce.

Los principales problemas que se plantearán en el futuro para la cría de ostras perlíferas serán conseguir buenas zonas de cría y conservar el medio ambiente. En Japón siguen realizándose estudios sobre las condiciones ambientales de los criaderos de perlas y la calidad de estas últimas. Como consecuencia de estos estudios y de los esfuerzos por mantener las zonas de cría, es de esperar que la cría de ostras perlíferas ofrezca buenas perspectivas.

## 1 Introduction

The techniques of pearl culture are reasonably well known today. For example, almost thirty years ago Cahn (1949) described the basic techniques developed in Japan, and Alargaswami (1970) and others have not only extended this description but have provided additional information on pearl culture in other parts of the world. Nevertheless, for the purposes of a worldwide review of the status of aquaculture it is considered desirable to present a brief account of this example of a highly specialized type of aqua-farming in which the end product is not food but a luxury item whose derivation is dependent upon a complicated set of procedures involving extreme manipulation of the cultured organism.

The pearl culture industry generally uses only five species of bivalve molluscs. Four of these are marine oysters: *Pinctada fucata, P. maxima, P. margaritifera* and *Pteria penguin*; the fifth is a freshwater mussel, *Hyriopsis schlegeli.*

Marine pearls are cultured on the southwest coast of Japan, in the Republic of Korea and in China using *Pinctada fucata* and *Pteria penguin. Pinctada maxima* is used in south Pacific waters (Australia, Burma, Indonesia, and the Philippines). *P. margaritifera* is used in the Okinawa area, Tahiti and Fiji. Freshwater pearls are produced in Japan using *Hyriopsis schlegeli,* and another species of limnetic mussel is used in China.

Additional notes on these species follow:

(*i*) *Pinctada fucata.* This is the species most commonly used for pearl culture in Japan, and the techniques of this culture which produces spherical pearls have been developed primarily with this species. The major producing area for this species in Japan used to be Mie Prefecture, but new farming grounds have been established in the Shikoku and Kyushu areas, because of the deterioration of farming areas and water pollution.

(*ii*) *Pinctada maxima.* About 70–80% of the world's pearl production using this species is cultured in Australia. This species makes the largest round or half pearls having a maximum diameter of 18 mm and a silvery-white colour.

(*iii*) *Pinctada margaritifera.* This species, the 'blacklip pearl oyster' is most suitable for the production of steel-black pearls and half pearls.

(*iv*) *Pteria penguin.* This species, known as 'Mabe' in Japan, is cultured to obtain large-sized half-round pearls. In the Amami-oshima areas of Japan, growers can obtain the spats artificially *in vitro* and use them for culture.

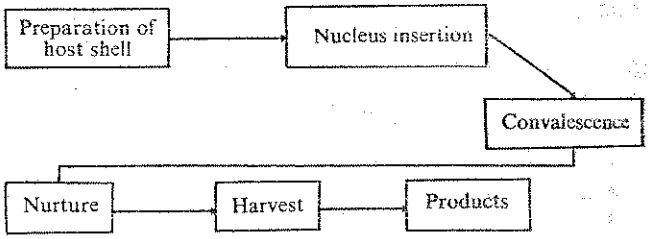
(*v*) *Hyriopsis schlegeli.* Pearl culture with this freshwater mussel has been attempted for 45 years in Lake Biwa near Kyoto and its farming has been extended to several other places during the last decade. For the most part, an artificial nucleus is not employed and the techniques used are different from those used with other pearl-forming molluscs. The colour of the pearl is salmon pink, the shape and size are variable, and they are much appreciated as distinctive pearls.

In China, many freshwater pearls are produced with other species, but the details are not well known to the author.

Table I shows the amount of pearls produced in Japan.

## 2 Farming procedure

As *Pinctada fucata* is the main species used in pearl production, and as the major techniques have been developed with this species, it will be used as an example to describe pearl farming procedures. Each step in pearl culture is dependent upon a knowledge of the biology and life history of the pearl oyster, and careful adherence to each step in the procedure is very important for producing pearls of good quality. The steps are as follows:




### 2.1 *Preparation of host shell*

The best site in the body of this pearl oyster for insertion of a nucleus for pearl formation is the gonad. When a gonad contains eggs or sperm, it is difficult to obtain good results in this operation and one can not expect to grow pearls of good quality. The period that the gonad is devoid of gametes comes just after spawning and has short duration. There is, therefore, a necessity to extend this limited period for the nucleus-insertion operation artificially. Two methods are used to improve gonadal conditions for the operation; suitable conditions for the operation can be expected using either treatment:

(*i*) *Inhibition of maturation.* This treatment is usually applied to oysters for the operation in April-May. During the previous season, after spawning, oysters with no eggs or small eggs are selected and placed under low temperatures to inhibit gonad maturation.

(*ii*) *Acceleration of maturation.* Under this treatment, early maturation of the gonad is expected and the oysters are spawned before the operation. Normally, the oysters are put in a cage where they are a little crowded and placed in warm temperatures in the sea. If conditions are suitable, early maturation can be expected. After they mature, the oysters are stimulated to induce spawning. Usually,

TABLE I
NUMBER OF MANAGEMENT UNITS AND QUANTITIES OF CULTURED PEARLS PRODUCED IN JAPAN (1926–73)

| Year | Pearl cultured with *Pinctada fucata*[1] | | Pearl cultured with *Hyriopsis schlegeli*[1] | | Pearl cultured with *Pinctada maxima*[2] | | |
|---|---|---|---|---|---|---|---|
| | *Number of management units* | *Quantities of cultured pearls produced (kg)* | *Number of management units* | *Quantities of cultured pearls produced (kg)* | *Number of management units* | *Quantities of cultured round pearls produced (kg)* | *Number of cultured half pearls produced* |
| 1926 | 33 | 251 | | | | | |
| 1927 | 42 | 220 | | | | | |
| 1928 | 47 | 668 | | | | | |
| 1929 | 50 | 241 | | | | | |
| 1930 | 62 | 307 | | | | | |
| 1931 | 51 | 405 | | | | | |
| 1932 | 108 | 1 370 | | | | | |
| 1933 | 147 | 935 | | | | | |
| 1934 | 320 | 1 691 | | | | | |
| 1935 | 222 | 2 906 | | | | | |
| 1936 | 258 | 2 651 | | | | | |
| 1937 | 274 | 4 071 | | | | | |
| 1938 | 289 | 4 081 | | | | | |
| 1939 | 281 | 3 930 | | | | | |
| 1940 | — | 3 470 | | | | | |
| 1941 | 336 | 2 959 | | | | | |
| 1942 | 107 | 2 261 | | | | | |
| 1943 | 107 | 1 580 | | | | | |
| 1944 | 107 | 731 | | | | | |
| 1945 | 107 | 275 | | | | | |
| 1946 | — | 188 | | | | | |
| 1947 | — | 450 | | | | | |
| 1948 | 187 | 934 | | | | | |
| 1949 | 314 | 1 875 | | | | | |
| 1950 | 359 | 3 750 | | | | | |
| 1951 | 700 | 7 500 | | | | | |
| 1952 | 1 200 | 10 500 | | | | | |
| 1953 | 1 200 | 13 328 | | | | | |
| 1954 | 1 456 | 16 890 | | | | | |
| 1955 | 1 643 | 24 525 | 6 | 112 | | | |
| 1956 | 1 734 | 26 444 | 6 | 176 | | | |
| 1957 | 2 574 | 29 701 | 9 | 356 | | | |
| 1958 | 3 001 | 47 662 | 23 | 423 | 2 | 18 | 26 184 |
| 1959 | 3 084 | 50 119 | 37 | 1 189 | 2 | 25 | 30 263 |
| 1960 | 3 484 | 59 486 | 37 | 922 | 2 | 39 | 27 862 |
| 1961 | 3 637 | 71 894 | 37 | 1 082 | 2 | 58 | 37 893 |
| 1962 | 3 817 | 78 032 | 40 | 1 019 | 3 | 97 | 128 992 |
| 1963 | 4 079 | 86 407 | 41 | 1 972 | 5 | 76 | 150 230 |
| 1964 | 4 302 | 87 021 | 46 | 1 564 | 6 | 119 | 181 439 |
| 1965 | 4 620 | 111 460 | 46 | 2 602 | 8 | 139 | 185 323 |
| 1966 | 4 710 | 127 460 | 48 | 2 836 | 6 | 173 | 209 103 |
| 1967 | 4 666 | 122 451 | 48 | 3 961 | 7 | 130 | 205 996 |
| 1968 | 4 606 | 99 717 | 53 | 4 669 | 7 | 174 | 346 338 |
| 1969 | 4 226 | 95 745 | 57 | 5 902 | 6 | 229 | 390 520 |
| 1970 | 3 635 | 74 678 | 58 | 6 884 | 8 | 272 | 177 472 |
| 1971 | 2 962 | 48 601 | 61 | 7 173 | 6 | 308 | 118 338 |
| 1972 | 2 823 | 42 296 | 61 | 7 218 | 5 | 437 | 118 003 |
| 1973 | 2 526 | 34 436 | 62 | 6 848 | | | |

[1] Statistics compiled by the Japanese Ministry of Agriculture and Forestry and by the Fisheries Agency
[2] Statistics compiled by the Japan Export Overseas Pearl Producer's Association

changing the hanging layer of their cages is sufficient stimulation. After spawning, the oysters are placed under conditions which promote recuperation from the treatment. When they resume a normal condition, they are ready for the nucleus-insertion operation.

2.2 *Preparation for nucleus-insertion*

2.2.1 *Opening of host shell.* Before the operation, many host oysters must be prepared. The oysters are placed in a shallow tray with the hinge or dorsal portion of the shell downward and covered with sea water. Within a few minutes, the valves start to open. Shell openers are gently inserted between the valves to open them wider and a bamboo wedge or key is then applied to keep them open.

Other methods may be employed to open the shells but the mortality rate for oysters prepared by this procedure is lower than when others are used.

2.2.2 *Preparation of graft tissue.* Proper preparation and careful insertion of the graft tissue governs, to a large extent, the production of the pearl. The graft tissue is obtained from the pallial zone of living oyster mantle. The oyster is opened carefully with a sharp knife and the adductor muscles are cut from their point of attachment to the shell. The major care in this operation is to remove the mantle without injury. All extraneous matter is scraped out using the blunt edge of a scalpel.

A strip about 2–3 mm wide is then cut from the pallial zone of the mantle. Every operation must be performed carefully and gently because rough treatment can damage the epithelium in the pallial zone of the mantle. The strip is cut into pieces 2–3 mm square. The size of these squares is determined by the size of the nucleus to be used. each graft being sufficiently large to cover one third of the nucleus.

Under moderate temperature, 17°–22°C, the graft tissue will live for about two hours if kept moist with sea water.

2.2.3 *Preparation of the nucleus.* Layers of nacre bind most satisfactorily with calcareous substances; for the final product the nuclear material should have the same or similar characteristics of deposited nacre. The shells of other molluscan species are therefore used for the nucleus.

In preparing nuclei the donor shells are cut into small cubes of the general size required and then placed between two sheets of iron. As the upper sheet is revolved, the cubes are ground between the plates and against one another to produce rough spheres. Further finishing work is done to make them smooth but a high polish is not essential. Although the general size of the finished product is determined by the size of the original cube, some variation occurs, and finished nuclei are graded according to their diameter.

2.2.4 *Surgery on the oyster.* The organ in which the nucleus or nuclei will be inserted is the gonad. As other organs, such as the adductor muscle, hepatopancreas, intestine and byssus gland are located around the gonad, the surgery must be performed without injury to them. The number of nuclei to be inserted depends upon the size of the nuclei. Two to five nuclei are put into an oyster if they are 3 mm or less in diameter; one nucleus is inserted when it is larger than 3 mm.

The operation is usually carried out during the period from spring through autumn but it should not be done during the hot summer or rainy season.

2.2.5 *Insertion of nucleus.* When the partly open pegged oyster has been placed in an oyster clamp and the graft tissues have been prepared, the operator smooths back the mantle folds with a spatula exposing the foot and main body. An incision is made in the gonad, the graft mantle tissue is then inserted and nucleus-insertion follows. The graft tissue must be placed on the nucleus.

A highly skilled technican can insert from two to five nuclei in an oyster, usually completing these operations on 25–40 oysters per hour.

2.3 *Convalescence*

The operated oysters are placed in culture cages, consisting of heavy wire frames (68 × 60 × 30 cm) covered with fine mesh wire netting, each of which can hold 50–60 oysters. The cages, suspended horizontally from rafts, should be placed in an area with calm conditions to avoid disturbance for four to six weeks after the insertion operation.

During this period of convalescence, the oysters recover from the operational shock and repair whatever injuries have been sustained. At the end of this period, the cages are lifted and the oysters are inspected. All dead shells are removed and the cages are transferred to ordinary culture rafts.

2.4 *Pearl formation on the nucleus*

In oysters where the operation has been successful, the graft tissues begin to grow; they form 'pearl-sacs' which completely cover the nuclei. After the sacs are formed, the epithelial cells secrete a nacreous or pearly substance and deposit it on the surface of the nuclei. It usually takes three to four years for pearls of commercial value to develop.

2.5 *Subsequent culture*

The cages are suspended from rafts or long lines at a depth of 2–3 m. At least three times a year, the cages are lifted, all encrusting marine organisms are removed from the oysters, and the cleaned oysters replaced under the raft. A few oysters are picked out to determine the rate of pearl growth. Normal harvesting operations begin in October and continue until the middle of January.

2.6 *Nurturing procedure*

2.6.1 *Facilities.* At one time the sowing method was applied in nurturing pearl oysters but, at present, all pearl farming uses a hanging method with rafts or long lines.

(*i*) The use of rafts: Two kinds of materials are generally used for raft construction: logs or bamboo. (Steel pipe has been used recently but its use is not yet common.)

*Log rafts.* Cypress or cedar logs are used for these rafts. The standard size of a log raft is about 6·4 × 5·5 m and four floats are attached underneath the raft. A hundred ropes are usually hung from a raft and each rope holds a cage. A standard-sized cage, about 70 × 45 cm, composed of synthetic fibre net, contains about 60 oysters.

*Bamboo rafts.* Two poles of bamboo trunk, 9–10 m long, are tied together, and put on the surface of the water parallel to each other at intervals of about 2 m. Usually 15–20 ropes with cages are hung on a raft of 15 m length. The raft can float on the surface without floats.

(*ii*) The use of long lines: A rope is attached to a spherical plastic float. This system, which is stronger than rafts in rough weather, is placed outside a bay or inlet. The cages that hang under the rope are similar to those used with rafts.

2.6.2 *Hibernation.* The pearl oyster was originally a semi-tropical or temperate organism. Optimal temperature for its growth is 20°–25°C; the minimum is 8°C. In winter time, therefore, it is common practice among growers to let these oysters hibernate—placing them in warm water to keep physiological conditions normal.

2.6.3 *Other specialized treatment.* The growth rate of pearl or nacre on the nucleus and the quality of pearl produced depend upon water conditions and usually waters which provide a good growth of pearl do not always produce good quality pearls. Conversely, waters which produce pearls of good quality are not suitable for good growth. Therefore, growers move their oysters to different places to obtain better products. When farming begins, the growers first put their oysters in places where they will get good growth; later they transport them to areas where a better quality of pearl is expected.

These differences are due to water quality, especially to its fertility, and sometimes the oysters are moved a few hundred kilometres to achieve these ends.

**3 Enemies and damages**

There are many constraints on pearl farming. Among natural factors, damage from parasites is the most serious problem. Among the parasites are polychaete worms which are harmful to pearl formation and the physiological functions of oysters. Oysters invaded by polychaetes are first soaked in fresh water to make the shells close tightly so that the oyster itself may avoid the effects of salt water. They are

then soaked in highly concentrated salt water for 20–25 minutes to eliminate the polychaete.

Trematodes also sometimes cause serious damage to the oysters. The only practical control of these parasites is to transfer the pearl oysters from infected to non-infected waters in September; the month when trematode invasion normally takes place. (It is impossible to remove the host fish from coastal areas.)

Unsuitable physical and chemical environmental conditions are also serious hazards for pearl oyster farming. Among these factors are: decrease in salinity, high water temperatures, cold tides, red tides, hydrogen sulphide and pollution by domestic and industrial effluents. Areas where these unsuitable conditions can be frequently observed should be avoided by pearl farmers.

### 4 The supply of mother oysters

Although native oysters were previously used, today's supply comes mainly from oyster farms because of the decrease in natural stock.

The free-swimming veliger larvae of the pearl oyster have a markedly negative phototropic behaviour just before setting and this reaction is utilized for the collection of spat artificially. Cedar tree leaves and palm tree bark are usually used as collectors. These materials are combined and put into the water during the spawning season, July-September. During this period, the spat attach on the collectors, and remain in place until late November when they become young oysters, about 1·5 cm long. They are then removed from collectors and transferred into rearing cages for growth. The cages are hung under rafts or long lines. It usually takes about two years for the host shell to develop to the stage required for pearl farming.

### 5 Future of pearl farming

Beautiful pearls are desired by many people. One cause of a slump in pearl farming in Japan was caused by an unsuitable price due to the increase in pearls of poor quality. Mere increased production of pearls in the future is not visualized; the aim of the industry should be to improve the quality of cultured pearls. If this planned production of pearls is carried out, pearl farming may have a bright future.

The maximum pearl production in the future is expected to be about 35 tons/year of *Pinctada* pearl, and that of the freshwater one about 10 tons in Japan. As a pearl market for *Pinctada maxima, P. margaritifera* and *Pteria penguin* pearls opens, production of pearls may be governed, to some extent, by supply and demand. If a method which includes artificial seed production technique is established more stable production of pearls may be expected in *Pinctada maxima* and *P. margaritifera*.

There may be considerable difficulties to apply the techniques established for *Pinctada fucata* to the culture of other pearl oysters. Physiological and ecological studies on each species will be required concerning pearl formation. Through these studies, new techniques which will be suitable for each species can be established.

For the further prosperity of pearl farming, not only must culture techniques be improved but, simultaneously, studies should be made in various areas and under different environmental conditions to resolve problems with respect to pearl qualities, *eg*, lustre and formation of the pearl layer. Finally, steps must be taken to secure good culture grounds and a continued vigilance exercised to preserve them from environmental deterioration.

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# Shellfish Purification: A Review of Current Technology

*S. A. Furfari*

*Abstract*

The controlled purification of molluscan shellfish by natural biological processes is widely known and has been researched since the turn of the century. The process is an integral and mandatory part of the shellfish industry in England, France and Spain. It is little known or practised in the USA and although sporadically used in Portugal, Japan and Canada, has never been an integral or major part of the shellfish industry there.

The need for purification arises from a need to protect public health from shellfish which are notorious for concentrating pathogenic micro-organisms from sewage-polluted sea water. Assessment of pollution in harvest areas is difficult and never certain. Purification may also be used to reduce the unknown hazard of viral pathogens, especially infectious hepatitis which is difficult to monitor either in the environment or in shellfish.

A synopsis of commercial purification plants shows that they have been operated for soft clam (*Mya arenaria*), hard clam (*Mercenaria mercenaria*), Pacific oyster (*Crassostrea gigas*), European oyster (*Ostrea edulis*), Portuguese oyster (*Crassostrea angulata*), mussel (*Mytilus edulis*), chirla (*Venus gallina*) and other species.

Development of purification plants in the USA has lagged and only the soft clam is currently being purified on a commercial scale. Possibly the industry is reluctant to invest in new purification plants because of belief that the massive sewage treatment plant construction programme now in progress in the USA will eliminate much of the hazard of polluted harvest beds. There is also some distrust of the value of viral depuration, especially of hepatitis. Nevertheless, operation of various plants (commercial and pilot) in both the USA and Canada has demonstrated the economic, technical and biological feasibility of the process in North America.

Despite all that is known about molluscan shellfish biology, no reliable biological or physiological phenomena quantitatively demonstrate successful purification of pathogenic micro-organisms. The only way to assure that purification has taken place is by the use of bacterial indicator systems.

Generally speaking, viral accumulation and depletion rates follow that of coliform for the species studied. The fact that virus can be removed is not at issue any longer. It is the initial level of virus in the mollusc that is the crux of the matter.

The engineering design and operation of a purification plant are predicated on maintaining the proper biological state of the molluscs, especially with respect to their excretory, nervous, respiratory, musculoskeletal and reproductive systems.

Fundamentals of plant design include: (*i*) plant siting (water supply—amount, type, method of delivery, *etc*); (*ii*) plant structure (materials, whether indoor or outdoor); (*iii*) plant layout (consideration of efficiency and product flow, and positive separation of purified from unpurified shellfish); (*iv*) handling (whether by carts, trolleys or belts, in baskets or in bags); (*v*) sea water systems (plastic pipe and advance engineering are recommended); (*vi*) water supply and treatment which will ensure that shellfish receive processed water comparable with their biological systems and not become contaminated in that water (temperatures of 10–20°C, oxygen content of 5 mg/l to saturation, turbidities of