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Management Problems in Mussel Farming

Management problems in mussel farming

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ABSTRACT

Mussel farming can provide an alternative to the fluctuating supply of wild mussels. Cultivation on suspended ropes facilitates not only continuity of production but also faster growth, a better product, lower mortality, fuller use of the water column and the use of previously unproductive areas. The biological requirements for a successful industry are met by the rapid growth, adequate reproductive capacity, high density and good quality of both of the two common New Zealand species, the green-lipped mussel *Perna canaliculus* and the blue mussel *Mytilus edulis aoteanus*. The hydrographic requirements for sheltered water with suitable temperature, salinity and turbidity presents no problems. Socio-economic requirements however are more complex. The established internal market is based on large 130 mm mussels whereas 80 mm mussels could be produced more economically. The "alternative use potential" of proposed mussel farming areas for fishing, navigation and recreation must be considered as well as the use of adjacent shoreline. Practical problems faced by mussel farmers include the provision of flotation, acquisition of seed mussels, fish predation, over-crowding and localised pollution. Bulk harvesting of the 80-100 mm mussels after the 14-18 month growth period, whilst they remain in peak condition, is a problem that will require increased mechanisation within the industry.

WHY FARM MUSSELS IN NEW ZEALAND?

To answer this question we should first look briefly at the history of the mussel fishery. There has long been a steady demand for mussels in New Zealand. This demand was met until 1961 by a steadily increasing yield from the dredge fishery in the Firth of Thames *(Fig. 1)*. The rapid and complete collapse of the Firth fishery in the mid 1960s was fortunately compensated by the opening up of new mussel beds in places such as Tasman Bay, the Marlborough Sounds, Kaipara Harbour and Foveaux Strait, but since then production has fluctuated markedly and irregularly. A small harvest of mussels from licensed hand picking has also declined in recent years as the more accessible picking areas have become severely depleted.

A developing interest in mussel farming coincided with the collapse of the dredge fishery. The first commercial mussel raft was established in the Hauraki Gulf in 1965 immediately after the decimation of the Firth fishery, and the first one in the Sounds in 1969 when the Tasman Bay fishery seemed to be declining in the same way *(Fig. 1)*.

An alternative to these fluctuating and possibly declining supplies of wild mussels can be provided by mussel farming. This has proved highly successful over many years in Europe, where there is an apparently insatiable demand for mussels. The greater part of this demand is supplied by two huge industries; one in Holland, where the mussels are cultivated on the seabed in shallow inland sea areas; and the other in Spain,

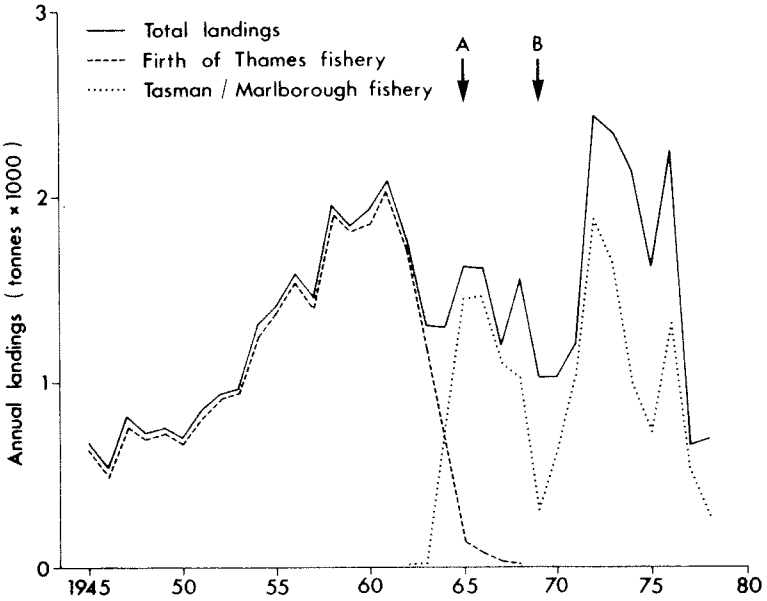

Fig. 1: Annual landings of green-lipped mussels **Perna canaliculus** *in New Zealand. Arrows indicate the establishment of the first commercial mussel rafts in the Hauraki Gulf (A) and the Marlborough Sounds (B).*

where the mussels are grown in suspended cultivation. Some idea of the scale of these countries' production can be determined from the following figures. Out of the total world catch of around 500,000 tonnes of mussels the Dutch and Spanish industries each produce about 100,000 tonnes whereas New Zealand produces a mere 2,000 tonnes.

A much greater control over continuity of production is only one of the advantages to be gained from farming mussels. Other advantages of a suspended cultivation system (the type of mussel farming system most suited to New Zealand conditions) include:

i) a faster growth rate: since the mussels are in a more ideal environment away from bottom siltation they are capable of feeding for 24 hours a day.

ii) a better product: as a consequence of the faster growth rate the mussels have thin shells, a high meat:shell ratio and a more tender meat quality.

iii) lower mortality: the mussels are removed from bottom dwelling predators and parasites (though this may be offset by the presence of other predators such as fish).

iv) a large proportion of the water column can be utilised in a three-dimensional culture system as opposed to the two-dimensional on-bottom cultivation, and,

v) the system offers the possibility of utilising areas previously unproductive at least in terms of mussels.

Having outlined some of the advantages to be gained from farming mussels I will now examine some of the management problems that have been encountered during the development of mussel farming and show how some at least have been overcome.

I intend to look at the problems on two different levels. Adopting the politically expedient principle that matters of national importance take precedence over those of "the ordinary bloke", I will first discuss problems pertaining to the development of the mussel industry as a whole and then go on to the problems of the mussel farmer.

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INDUSTRY PROBLEMS

Working from the premise that mussel farming by suspended cultivation *is* desirable in New Zealand, the initial management problem was to establish that the basic requirements for aquaculture could be met by New Zealand mussels under New Zealand conditions. These requirements are many and varied but can be broadly classified under the headings of biological requirements, hydrographic requirements and socio-economic requirements.

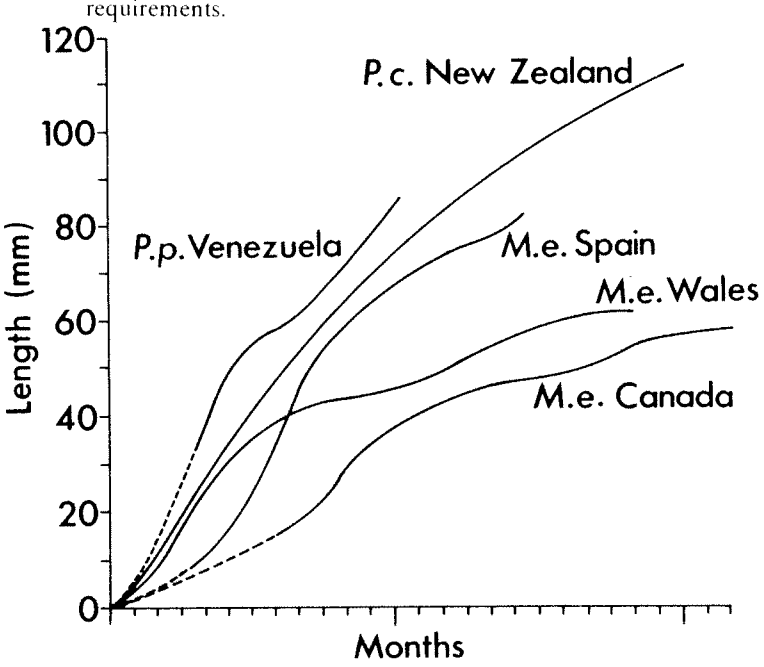

Fig. 2: Growth of mussels in suspended cultivation in various parts of the world. P.p. = **Perna perna;** *P.c.* = **Perna canaliculus;** *M.e.* = **Mytilus edulis.** *(From Hickman, R. W. (1979) Allometry and growth of the green-lipped mussel* **Perna canaliculus** *in New Zealand. Mar. Biol. 51: 311-327.)*

a) Biological requirements

It is fundamental that any mussel being considered for cultivation must have a rapid growth rate, a high reproductive capacity and be of good quality. In these respects both of the 2 common New Zealand species, the green-lipped mussel *Perna canaliculus* and the blue mussel *Mytilus edulis aoteanus* have proved to be excellent species for cultivation. Studies on growth rate have shown it to be comparable to that in other parts of the world where mussels are grown in suspended cultivation (*Fig. 2*).

Reproductive capacity is adequate, as evidenced by successful spat catching operations in the Marlborough Sounds over several years and also by hatchery rearing experiments.

The green-lipped mussel in particular maintains a high level of condition or quality throughout the majority of the year. In the Marlborough Sounds the level of condition considered minimal for harvesting in Europe is exceeded for up to 11 months of the year.

Also mussels thrive in the high population densities which are a necessary part of any intensive culture system.

b) Hydrographic requirements

The essential requirement for mussel farming is an extensive area of water adequately sheltered to permit the maintenance of the farming equipment, but with sufficient water circulation and primary productivity to enable rapid mussel growth. Other aspects of water quality such as temperature, salinity and turbidity, and susceptibility to pollution must remain within tolerable limits.

A 1972 survey of the North Island undertaken to assess the extent of the coastal waters potentially suitable for suspended mussel cultivation (and based mainly on hydrographic considerations) identified areas totalling about 9,800 ha.[3] This of course does not include the Marlborough Sounds. For comparison the Spanish mussel rafts, which produce over 100,000 tonnes annually, occupy an estimated area of about 10,000 ha. In fact the waters of the Marlborough Sounds and the rias of N.W. Spain have very similar surface areas.

So from an industry management point of view it would seem that New Zealand has no problems as far as suitable species or suitable waters are concerned.

c) Socio-economic requirements

Here the picture is rather different. The prime requirement for success in any aquaculture enterprise is that it should be economic, and a major factor determining economic viability is a readily marketable end product. I have already suggested that there is an established internal market for mussels of about 2,000 tonnes, which is presently under-supplied by the dredge fishery. There is thus an internal market basis for the establishment of mussel farming, and both government and private enterprise assessments predict considerable future export potential once the home market has been catered to.

However marketing is not without its problems, due in part to the fact that the traditional in-the-shell market is for large (say 130 mm) dredged mussels. Fishing Industry Board cost analyses have indicated that the mussel farmer could expect a much better return from growing 100 mm or even 80 mm mussels than from supplying the traditional large mussels. The difference in costs (1978 figures) is about 18c to produce a kilogram of 80 mm mussels, 20c for 100 mm mussels, and 30c for 130 mm mussels.

At a conference on aquaculture held in Wellington in September 1979 it was stated by the President of the Marlborough Sounds Marine Farming Association that "the problem is to define in what form the market requires the product" and "to a large extent the answer is *'in the form in which we present it'*, thus the future of the industry is very much in the hands of the processors and marketers" [2].

Most of the rest of the socio-economic requirements relate to the acceptability of mussel farming and involve the concept of "alternative use potential". This is something I touched on earlier when I mentioned that one of the advantages of suspended mussel cultivation was the possibility of utilising areas previously unproductive of mussels. Immediately obvious alternative uses for potential mussel farming areas include commercial and sport fishing, navigation and recreation, and of course other types of aquaculture.

However, the "alternative use potential" of an area should also take into consideration the adjacent land. Actual and imagined conflicts of interest have been suggested between mussel farming and the following activities: agriculture, forestry, industry, residential sub-division and nature and recreational reserves.

If we add to these 2 lists a full list of all the government departments, agencies and local authorities with specific interests in marine farming (which in the Marlborough Sounds alone number at least 15) we get some idea of the constraints which have been very largely responsible for the relatively slow establishment of mussel farming in New Zealand.

I can put this rate of development into perspective by again comparing New Zealand and Spain. The first mussel rafts were established in the rias of N.W. Spain in 1946 and after 10 years there were 400 rafts with an annual production of 4900 tonnes[1]. The first decade of mussel farming in the Marlborough Sounds saw the establishment of about 40 production units with a yield (for 1978) of 800 tonnes.

Also, it was only in August 1979 that a Marine Farming Plan for the Marlborough Sounds was finally gazetted (*Fig. 3*) determining the areas that will not be available for marine farming licences for a period of 5 years.

The figure also shows the locations of licence applications for mussel farms, presently totalling 274, of which 115 are granted or under offer to the applicant. The next few years should thus see a very rapid expansion of the mussel crop as all these farms become productive.

The fear has often been expressed that the whole of the Marlborough Sounds will be taken over by mussel farms. The actual areas available and suitable for marine farming occupy only a very small proportion of the surface area of the Sounds. In the Pelorus-Kenepuru Sound there are currently 259 licence applications, which if we take an average of 3 hectares per farm, amount to 777 hectares or about 2% of the total water area of the Sound. In Spain the equivalent figure can be as high as 8%.

PRACTICAL MUSSEL FARMING PROBLEMS

In order to discuss this with some logic I will attempt to follow through the sequence of the mussel culture operation, pointing out the problems which can crop up; though I hasten to point out that I am *not* a mussel farmer and my expertise is perhaps more academic than practical.

One of the most significant events which assisted the development of mussel farming in New Zealand was the introduction, by the Fishing Industry Board in 1974, of the long-line system of buoyed cultivation ropes. Prior to 1974 large rafts similar to those used in Spain had been tried. What type of flotation to use is the mussel farmer's first problem. The long-line system (*Fig. 4*) offers the advantages of low capital cost, simplicity of design, ease of establishment and maintenance, and most importantly is generally considered to be more aesthetically acceptable than rafts. Most mussel farmers have opted for long-lines although some still prefer

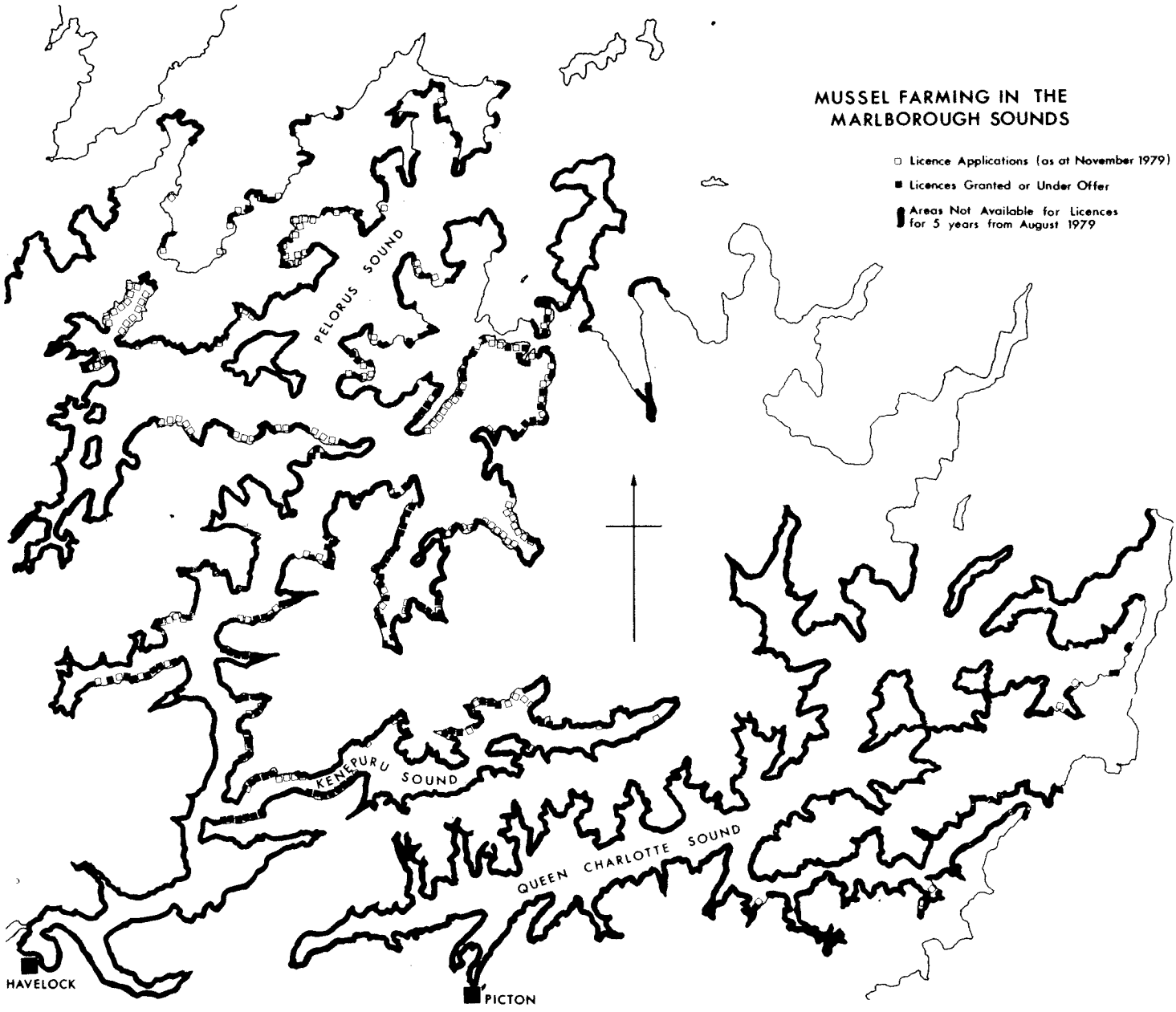

Fig. 3: Map of the Marlborough Sounds showing the areas not available for marine farming licences. (Drawn from Marlborough Sounds Marine Farming Plan No.MAF 147, Sheets 1-59).

moderate sized (say 8 m x 6 m) rafts, and small rafts (say 3 m square) are used to support heavy concentrations of spat catching ropes.

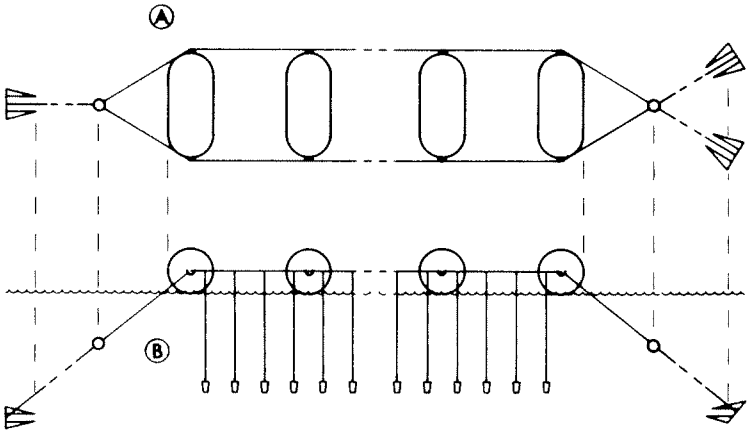

Fig. 4: Diagrammatic representation of a mussel longline. A, surface view, showing floats, paired horizontal lines and two alternative mooring arrangements. B, side view, showing weighted vertical growing ropes at 0.5 metre spacings. The typical longline is 110 metres in length with 50 floats; the length of the mooring lines is 3 x the depth.

Spat catching, or the provision of adequate supplies of seed mussels, is the next problem for the mussel farmer. Since mussels have a 3-4 week free-swimming stage in the earliest part of the life cycle, the mussel farmer should not assume that he will be able to catch his supply of seed *in situ* on his own lease, even though adult mussels may be present in the area.

Mussel settlement is determined by a variety of factors, including water temperature and currents, wind and the behaviour of the mussel spat themselves. Settlement varies with season, with depth and with the different mussel species and can also be affected by competitive settlement of other marine species.

Spat catching systems endeavour to present the most acceptable settlement medium, which presently seems to be a black polypropylene rope incorporating sacking offcuts, at the right season (either autumn or spring), at the right depth (top 2 m for blue mussels or down to 5 m for greens), and at a site having the right hydrological conditions.

The Fishing Industry Board has expended considerable efforts over the past 5-6 years in establishing when, where, and how mussel spat can be caught in the Marlborough Sounds[8]. Through the operation of a forecasting service, based on the numbers of mussel spat in water samples and the numbers settling on experimental collectors, run in conjunction with communal spat catching long-lines, it has so far been possible for the mussel farmers to obtain sufficient ropes with settled mussels. Whether the 3 sites currently used for spat catching will be able to supply future needs is open to speculation. It may be necessary to investigate possible catching sites over a much wider area or to look more closely at alternative seed supplies. Seed attached to stranded seaweed occasionally washed up on west coast beaches has in the past been used to stock mussel ropes and is a possible resource that merits further examination[4][6]. Hatchery rearing of green-lipped mussels is also being attempted as a possible back up to a large scale mussel industry.

Assuming a successful catch the mussel farmer would expect to remove his settled ropes from the communal long-line to his own farm within 6-8 weeks, by which time the mussels should be 1-3 mm in length. Two main problems can affect the mussel ropes during the first few months growth. Fish predation has been found to be extremely severe in some areas. Spotty *(Pseudolabrus celidotus)* and snapper *(Chrysophrys auratus)* are the chief culprits and could present a continuing problem, since large snapper are known to be capable of feeding on mussels up to at least 90 mm in length. Fish predation is most common in shallower water and the most effective procedure to overcome the problem seems to be to lift the mussels closer to the surface and away from the seabed by looping the standard 4 m long growing ropes in half or by tying them across between the 2 main lines.

The use of protective nets around the ropes has been tried with limited success due to rapid fouling of the nets and restriction of water flow.

There exists of course the possibility of actually fishing the problem species and perhaps supplementing the farm income!

The second problem is that of overcrowding, resulting from excessive settlement densities, which tends to reduce the growth rate and cause considerable variation in size of the mussels on the rope. Optimum settlement density is in the range 250-450 mussels per metre, the lower densities being preferable for the production of larger mussels.

Initially it was felt that handling during the growing cycle should be kept to an absolute minimum since labour is expensive. It is now generally considered that at least one thinning process will be required to maintain an optimum growth rate. The problem of how to re-attach the mussels thinned from one rope onto several new ropes has been solved in New Zealand by the development of a knitted cotton tube which will contain the mussels around the rope, but rot away in seawater within a few weeks, by which time the mussels have re-attached firmly to the rope.

Pollution and disease are potential problems in any intensive culture system. So far in New Zealand the mussel farmers have had little experience of either. Mussel farms are generally sited in areas free from pollution though run-off from flooding rivers could cause intermittent localised problems and perhaps prevent harvesting for limited periods.

An even more localised pollution problem which *must* be prevented comes from seabirds perching on the buoys and possibly contaminating the seawater with faecal coliforms. A variety of bird deterrents have been devised.

No identifiable outbreaks of disease have been recorded in cultivated mussels in New Zealand. Red tides, which have resulted in shellfish poisonings overseas, are not common in New Zealand waters though the enclosed warm waters of an area such as the Marlborough Sounds offer ideal conditions for dinoflagellate blooms.

Two parasites, a pea crab *(Pinnotheres novaezelandiae)* and a cercarian trematode *(Cercaria haswelli)* have been recorded in both cultivated and wild mussels, though they are much less common in the farmed variety and do not cause any significant detrimental effects on the meat quality[5].

Fouling of the mussel ropes has already been suggested as a possible problem at settlement time. The inter-relationships between mussels and fouling organisms such as hydroids, ascidians, tube worms, and barnacles are poorly understood. It is possible that hydroids may form a primary settlement surface for the mussel spat, but on the other hand fouling may severely limit the space available on the ropes for mussel settlement.

It has also been suggested that the presence of some fouling organisms may be the cause of a phenomenon termed "off-migration", when, after a successful catch, the spat apparently spontaneously detach from the ropes and are lost from the mussel farm.

Rapid growth of the fouling organisms resulting in smothering of the mussels can be a problem. This occurs more frequently after the spring settlement of mussels. The cooler water conditions after an autumn settlement seem to inhibit the

growth rate of the fouling organisms more so than the mussels, which allows the mussels to compete successfully. The type of rope used in spat catching may be important in limiting competitive species.

In general once the mussels reach about 15 mm their rapid growth rate enables them to grow unhindered by fouling. There is an opportunity for the elimination of fouling organisms during the thinning process, but in situations of heavy fouling this may not be an economic proposition if much labour effort is required.

If the mussel farmer can obtain a successful catch of spat and avoid problems during the growth period he can look forward to the prospect of harvesting, after 14-18 months, a crop of 20-25 tonnes of 80-100 mm mussels from his 400-rope long-line.

Harvesting is mainly done by contractors, rather than the farmer himself, since specialised equipment is required for lifting large numbers of heavily laden ropes and effectively declumping the mussels. The current relatively small production of farmed mussels has not necessitated the large scale mechanisation that is seen in the Dutch mussel industry. If, however, the New Zealand industry develops to its full potential, mechanisation for bulk harvesting, handling and processing will be necessary; and indeed is already being considered by the processing side of the industry. It seems likely that overseas experience in this field can be adapted to suit the local conditions and the New Zealand mussel species.

The aspect of harvesting most likely to cause problems is the need to harvest the mussels in good condition. Best condition occurs just prior to spawning. However, the mechanical shock of the harvesting process can cause the mussels to spawn spontaneously, resulting in an immediate loss of condition and an unpleasant appearance, perhaps making the mussels unmarketable. The long period of good condition which seems to be characteristic of the green-lipped mussel and its apparent ability to make a very rapid recovery of condition after spawning, should permit harvesting to be spread over a period of months, thus avoiding this problem.

After enumerating many of the pitfalls and problems of mussel farming I should like to finish on an optimistic note by quoting from Professor Iversen's classic hand-book *Farming the Edge of the Sea*[7] in which aquaculture is said to offer "no easy road to fortune - it can be made profitable but definitely requires choice of the right environment, selection of the right species, hard work and full and effective use of all available scientific knowledge. Given these essentials, prosperity can be achieved for the individual with marked benefit to the community."

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