37

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Prospects for snapper farming and reseeding in New Zealand

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Contents

Introduction

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MY own contact with fish farming was first made some 30 years ago when I was living at Port Erin, in the Isle of Man in the British Isles. My father was at that time Director of the University of Liverpool Marine Biological Station at Port Erin, and this station had a long history of rearing the flatfish plaice and lobsters for release into the sea to enhance natural stocks. Many millions of these animals had been released, but by the 1950s the programme had been stopped because of the lack of any evidence that it had fulfilled its purpose. A severe weakness of the programme was that there was really no way of assessing its success or otherwise.

During the 1960s the White Fish Authority developed a hatchery next door to the university laboratories, to supply young fish for their experimental programme on marine fish culture. From 1963 to 1966 I was working for my Ph.D. at the university laboratory and so was able to observe the activities of the White Fish Authority at close quarters. I have tried to keep abreast of developments in marine fish culture since then, though I feel that I have slipped behind a bit in recent years.

Therefore, for personal reasons, I welcome the chance to attend this workshop and to welcome the participants. I believe that the time is appropriate to look at the merits of culturing snapper. There is now considerable experience overseas, in Japan, on which we can draw and which could save New Zealand from a long and costly experimental phase. In addition, our wild snapper stocks are clearly under some pressure in many areas and cannot, unaided, provide our fishing industry with additional resources. Further, high quality snapper command a high price on the Japanese market, a necessary prerequisite for covering the high costs which can be expected in farming a predatory, slow-growing fish such as snapper.

Already, and inevitably, the question of economics has arisen. Clearly, any fish farming venture which cannot justify its existence on economic grounds will find its survival threatened, particularly today when the influence of the dollar has probably never been stronger. For commercial enterprises the issue is clear cut: be profitable or be wound up (unless losses can be traded against tax on other branches of the business).

For government ventures, however, it is less clear where the economic benefits may be, particularly if one considers reseeding programmes. A reseeding programme involves no direct income to a fish culturing unit and could therefore be judged to be a dead loss. The income to the government comes indirectly via taxes on the increased revenue generated by the fishing industry as a result of improved fish stocks, and this is difficult to measure. There are, of course, other benefits of a fish culturing programme, such as generation of employment, not only in the culture unit but also in industries supplying the unit with equipment and facilities; and from a political point of view the visibility of such a unit is useful in that the government is seen to be doing something to help the industry. Perhaps this workshop will establish whether a government-run fish rearing unit would be helpful to the industry.

Even if such a unit were never to produce fish for industry, it could still provide valuable information to the fishing industry, particularly in the areas of feasibility studies, the advancement of technology, and improving our knowledge of the fish themselves, which are rarely available, live, for study by fisheries scientists. Such knowledge can result in spin-off benefits in many ways which are not directly quantifiable, but which, in the long run, can result in improvements to the industry and to the quality of life of the public as a whole.

There are many ways of developing a fish culture programme. The one which, if profitable, would no doubt appeal to individual companies would be to raise animals through to harvest on the company's premises. This approach has the attraction of being self contained and of giving all the benefits to the company concerned, but it also means the company must know how to handle the fish at all stages of development from egg to final harvest.

More straightforward for individual companies could be the purchase of juvenile stock for rearing through to harvest. Such a system would need specialist fish hatcheries to provide juvenile stock and would eliminate the need for individual companies to provide facilities for growing fish at all stages of their development and to maintain a brood-stock. Specialist fish hatcheries could perhaps be run by the government or, alternatively, by private enterprise.

A further option is to release juveniles into the sea at a suitable age for subsequent harvesting with the wild stock. For obvious reasons this option would not appeal to individual companies, particularly as considerable experimental work would be needed to establish the best size and time for release of the fish.

I hope that this workshop will evaluate the various options, identify the problems associated with them, and give a clear indication of where we should be going in developing snapper farming in New Zealand.

The snapper fishery and management implications of reseeding

R. O. Boyd

Fisheries Management Division,
Ministry of Agriculture and Fisheries, Auckland

THE snapper, *Chrysophrys auratus* (Forster), is New Zealand's most important coastal marine fish. The domestic fishing industry is highly dependent on snapper, which dominates commercial finfish landings both in weight and value (Table 1). Snapper also undoubtedly supports New Zealand's most important recreational marine fishery, though no quantitative data have been collected on recreational snapper catches.

Over the past decade it has become apparent that the snapper resource is being exploited at or near its maximum sustainable level. Although there has been a large increase in fishing effort in our coastal fisheries in recent years, commercial snapper landings have remained fairly constant; they have fluctuated around 15 000 t per year. In the various catch regions around the country, slight declines in snapper catches in the more heavily fished areas have generally been balanced by increased catches in previously lightly exploited areas. The net effect has been little overall change in total snapper production since the early 1970s. (There was a notable exception last year, when snapper landings fell by a massive 25%. This appears to be an anomaly which cannot be attributed to any single factor, and it will not be considered further in this discussion.)

In view of the intensive fishery in our coastal waters, I think it is safe to suggest that there is little prospect of discovering significant new, unexploited snapper stocks. It is also unlikely that we can expect to take much more (or even as much as we have been taking in some areas) from our present snapper fisheries. Thus, New Zealanders appear to have reached the limit in their snapper fishery, with further expansion of catches quite improbable.

TABLE 1: Commercial landings of finfish in New Zealand 1979 and 1980 (provisional)

	Quantity (t)		Value ($ × 1000)	
	1979	1980	1979	1980
Snapper	16 417	11 937	13,233	11,257
Barracouta	6 970	8 803	748	999
Tarakihi	4 055	4 721	2,290	3,338
Trevally	5 676	4 315	2,473	2,249
Gurnard	3 511	3 368	1,400	1,544
Kahawai	3 072	3 264	453	483
Mackerel (horse)	2 366	2 774	252	275
Hake	2 395	2 657	575	996
Red cod	4 933	2 639	907	617
Hapuku	1 760	2 224	1,538	2,541
All other species	24 971	35 485	11,628	18,740
	76 126	82 187	35,497	43,039

In spite of this limit to production, demand for snapper remains high. Snapper is an important fish on the domestic market, but even more important as an export commodity. The export market has expanded as a result of decreased supply overseas and good marketing by the New Zealand fishing industry. To meet the growing export market, snapper have been diverted from the traditional domestic market. However, more snapper could probably still be marketed if production from the commercial fishery were higher. As a result, some sectors of the industry have supported the concept of a snapper reseeding programme as a means of increasing commercial production.

Recreational fishermen have also voiced interest in a programme to enhance their fishing success. Intensive fishing of our coastal waters by commercial fishermen, plus increased competition between recreational fishermen, has resulted in a reported decline in catch success for individual fishermen. A snapper reseeding programme is seen by many as one means of restoring the recreational fishery to historical levels.

Superficially, a snapper reseeding programme appears to provide the simple solution to increasing the production from the fishery. By reseeding, I mean supplementing the natural production of juvenile snapper artificially, probably by use of a hatchery and rearing ponds to raise juvenile snapper from eggs. At an appropriate size these juvenile fish could be released into the natural environment and thus add to the production of juveniles from natural spawnings.

Basis for reseeding

Although the concept of a reseeding programme seems simple enough, there are many complicating factors. Perhaps the most fundamental of these is that any proposal for reseeding or enhancement of fish stocks depends on the stocks being below their maximum historical level. A reseeding programme can restore a fish stock only to its natural (maximum) size. The natural environment in which our snapper has evolved has limited the total size of the resource. It is most unlikely that we could expect to increase the production of snapper beyond the capacity of its natural environment.

At present there is little evidence that the snapper resource has been reduced much below its maximum historical level. Total annual catches of snapper are close to their historical maximum and have remained fairly static for a number of years. Present production from some stocks is below the maximum historical level (for example, in the Hauraki Gulf), but generally it is still within the range of periodic fluctuation recorded over the past 50 years. What is more important is whether the total resource base has been reduced. Some of the recent decline in catches can be attributed to growth overfishing by excess fishing effort. There is no evidence to suggest that there has been recruitment overfishing. On-going studies of the annual production of juvenile snapper in the Hauraki Gulf show that they are no less abundant now than in previous years (L. J. Paul pers. comm.).

I believe there is little evidence to suggest that our snapper resource has been reduced significantly below its historical level. Total catches remain quite good, and the production of juveniles appears to be at a healthy level. For this reason, I suggest that a snapper reseeding programme would be unlikely to succeed at present. It is doubtful that the natural environment would have the capacity to rear any more juvenile snapper than it does now.

Management implications

Although I have suggested a fundamental reason why snapper reseeding may not be feasible at this time, I would like to discuss some of the fishery management implications of such a programme. There are technical complications in managing an enhanced fishery which must be considered if we ever wish to proceed with reseeding our natural fish stocks.

• **Migration.** As fishery managers, perhaps we should first consider whether we know enough about the movement and migration of snapper. When we design a reseeding programme, it will be important to know to which fishery or area the increased production will contribute. At present we know little about which area juvenile snapper will recruit to as adults. Studies have been conducted in the Hauraki Gulf which show that juvenile snapper there appear to remain at least as long as they can be detected as separate year classes (Paul 1976). However, such information does not show that these juveniles remain in the gulf throughout their adult life. Some information is also available from the tagging of adult snapper and this suggests that most adults in the Hauraki Gulf do not travel very extensively (Paul 1967, Crossland 1976, Tong 1978). From this information, it appears that there is a reasonable chance that any juveniles released would remain in the same general area. However, there are no studies to confirm or deny this trend for other regions. More specific information to measure the movements of juvenile snapper and the fisheries they recruit to as adults is thus required before a snapper reseeding programme can be designed. This information will also be crucial to managing the fishery. It is essential to know where reseeding is likely to produce its benefits so that the fish can be caught without overexploiting the other unenhanced stocks.

• **Density-dependent and compensatory mortality.** The next problem for fishery managers is how to release large numbers of juvenile snapper in a way that will maximise their survival. At the same time, any deleterious effects on the natural stocks of juveniles must be avoided. It has been well documented overseas that predators take a larger toll of juveniles when they are released in bulk. Such compensatory predation may build up the population of predators to the point where the natural stocks suffer. Other density-dependent factors can depress the survival of both the hatchery produced and natural juveniles; these include competition for food and space, disease, parasitism, and cannibalism by adults. All of these tend to reduce survival, and considerable problems may be experienced in designing the release of hatchery juveniles to prevent them.

• **Reduced heterozygosity.** Another complex technical problem in fishery enhancement programmes is the reduced heterozygosity of hatchery fish. When juveniles are raised in an artificial and protected environment, many survive which would not under harsh natural conditions. Hatchery fish have been found to have a lower than natural rate of survival once released. This problem can be compounded by inbreeding of hatchery stock. What results is a fish eminently suited to hatchery conditions, but less able to cope with the natural environment. The net result has often been an inflated prediction of the potential contribution that hatchery fish will make to the fishery. Fishery managers have had to cope with a highly variable survival of hatchery fish as a result of reduced heterozygosity and vigour, and this unpredictable production complicates the exploitation of enhanced fisheries.

• **Mixed stocks and exploitation rates.** The introduction of large numbers of hatchery fish into an existing fishery creates considerable complexities in the day to day management of the fish stocks concerned. Because a hatchery can produce large numbers of juveniles from only a few adults, hatchery fish can sustain a high rate of exploitation. Only a few need to survive to restock the hatchery. The natural (wild) fish cannot sustain such a high rate of exploitation, as the lower survival of their spawn necessitates a much larger spawning stock.

The mixture of hatchery and natural stocks in the environment creates a management dilemma. To harvest the hatchery stock at its optimum level requires a high rate of exploitation, but this would result in overfishing of the natural stocks. Production of juveniles in the hatchery could be increased to compensate for overfishing of the natural stock, but this could prove both dangerous and expensive. If, for any reason, hatchery production failed, the entire fishery would be endangered. This option is simply too risky to be acceptable.

• **Measuring production and fishery contribution.** The last technical problem I would like to consider is how to measure the production from a snapper reseeding programme. Any fishery manager needs to know which fish stocks are being exploited or where production is coming from. In addition, whoever funds a hatchery programme will undoubtedly want to measure the cost-benefit of the production.

There are considerable technical difficulties in measuring hatchery benefits. The only certain way is to tag or mark the fish as juveniles and ultimately detect the tags in the hatchery fish when they are caught as adults. This is costly; it requires extensive sampling programmes in the commercial fishery, because any tag suitable for a juvenile fish is difficult to find in an adult. It is unlikely that any alternative means of measuring the results of a hatchery reseeding programme would be acceptable to fishery managers. Increased production could be masked by natural fluctuations in catches, and it would be dangerous for fishery managers to permit increased catches until they had a true measure of the hatchery contribution to the fishery.

Summary and conclusions

There are several difficulties associated with a snapper reseeding programme. It is not at all certain that snapper stocks could be enhanced, as they do not appear to be below their maximum level. There is evidence that a high level of fishing effort has reduced the size and abundance of adult snapper, yet the production of juveniles and total catches are being maintained at or near historical levels.

If a need could be shown and we initiated a snapper reseeding programme, considerable technical problems would be experienced in managing the snapper fishery. Management would certainly be more complex than now, even if we could predict the results of hatchery production and then measure it when it occurred.

My personal view is that, rather than considering snapper hatcheries and reseedings, we could achieve the same benefits at a much lower cost by applying good management to our fisheries. The key to maintaining snapper production at its maximum historical level is protecting the natural stocks from depletion through overfishing and at the same time preventing the degradation or destruction of the fisheries habitat. If we can achieve this, we can begin to exploit the stocks more rationally to produce their maximum social and economic benefits.

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Discussion

Mr Ritchie (Fisheries Management Division, Whangarei) commented that reseeding would just provide extra food for predators. He wondered whether reduced heterozygosity could be overcome by changing the breeding stock.

Mr Boyd replied that the problem was more one of reduced vigour, and that farmed stock suffered from this because they were not subjected to the same hardships as natural stock and they also benefited from disease control. He emphasised that the first requirement was to learn to manage the fisheries effectively before starting to look at some of the more difficult problems of enhancement. If the snapper fishery were managed well, perhaps there would be no need for reseeding.

Dr Colman (Fisheries Research Division, Wellington) asked if there were any examples of reduced heterozygosity in wild stock in the marine environment, to which Mr Boyd replied that it was a problem in Pacific salmon on the west coast of North America.

Dr Smith (Fisheries Research Division, Wellington) said that for Japanese snapper, levels of genetic variation were similar in hatchery reared and wild stocks. Studies had been made of fish of similar age from hatcheries and from the wild, and genetically they were indistinguishable.

Mr Boyd commented that the term reduced heterozygosity, even in salmonids, might be a misnomer, and that it might be more correct to refer to reduced vigour.

Dr Smith responded that some salmonid work was based on 6 parental fish, but the Japanese snapper hatcheries had at least 20–40 breeding individuals and they changed the breeding stock every so often by taking in fish from outside. He said the breeding programme had been carried on for about 20 years, but genetic studies had been made only in the last 2 or 3 years.

Mr Jarman (N.Z. Fishing Industry Board, Wellington) inquired whether there was any evidence of reduced vigour in aquaculture other than that of salmon. Mr Boyd replied that he was not aware of anything other than salmon, but that it was difficult to measure because mortality might occur for a variety of reasons, such as predation, competition for food and space, etc., and it was difficult to separate these factors. It was often a combination of factors which reduced survival.

Mr Mace (Fisheries Management Division, Nelson) said that he wished to comment on Mr Boyd's premise that the stock size of snapper could not be increased. He said this might be so in the Hauraki Gulf, where the fish were relatively dense, but in more southern areas such as Tasman Bay fish were widely dispersed outside the spawning season and there were very large fluctuations in the success of spawning. He suggested that the carrying capacity of the environment for juvenile fish might be more important than that for adults. If the juveniles could be reared through the vulnerable stage, perhaps the size of the stock could be enhanced. He also raised the point that separate management of hatchery reared fish and wild fish would have to be done differently for a multi-age stock like snapper from the way it was done for salmon, where all returning fish were of the same age.

Mr Boyd replied that it was true that the detailed work done on salmonids could not always be equated with the requirements for snapper. He said that there were no obvious stock differences in snapper, but that there might be genetic differences. The problem was one of how to get the maximum benefit from hatchery reared fish (by catching most of them) and at the same time not overfish natural stocks.

Dr Colman commented that this became a serious problem only if the hatchery reared stock was of a comparable size to the wild stock, with which Mr Boyd agreed, but added that there was no point in having a hatchery raised stock if it was not substantial.

Mr Mace added that the fish would not be returning to the hatchery, as salmon did, and so catching would have to start earlier to get the best exploitation rate.

Mr Boyd, referring back to Mr Mace's comment about increasing stocks in the Tasman Bay area, returned to the point he had made in his paper, that there might be variation in year class sizes, but that in the long term the environment set the limits for stock size, and that no one could expect to enhance stocks beyond their historical maximum. Some enhancement could be achieved at times when year classes were weak and the environment could carry more fish, but this was only in the short term. He suggested that someone should try to find out if it was survival of spawn that affected the size of the stock or overall environmental factors, but he cautioned that this might be impossible to answer.

Dr Colman wondered what was known about variation in the environment and its capacity to carry juvenile fish. Mr Mace said that the juvenile and adult environments might be different. For instance, with salmonids the carrying capacity of the juvenile environment tended to be limiting. He suggested that something similar might happen with snapper.

Mr Boyd said that salmon enhancement had been done because, in Canada, for instance, stocks had fallen well below their historical maximum levels. He said that the recent decline in the snapper fishery looked too sudden to be just a decline in the number of fish, especially in a multi-age stock. It could have a number of causes, but more analysis was needed before an explanation could be attempted. Because the statistics for each year covered part of 2 seasons, it was difficult to tell without more investigation whether the decline was in just 1 season or whether it was a trend.

Snapper farming and reseeding in New Zealand: an industry viewpoint

N. E. Jarman

New Zealand Fishing Industry Board, Wellington

THE industry viewpoint on any form of aquaculture or fishing can be summarised briefly: the exercise is unwarranted and unnecessary if, at the end of the time concerned, realisations or the potential for realisations do not exceed costs. All other aspects are irrelevant if this criterion cannot be met.

Before dealing specifically with the question of snapper, I want to make a general comment in relation to any form of aquaculture. At present some enthusiasts can perceive opportunities for development, but often their enthusiasm is not tempered by sufficient knowledge of the biology of the species or of the technology of the cultivation, or by an appreciation of the economic realities of the whole exercise. Furthermore, it is not always recognised by those encouraging such activities that there are real restraints relating to social expectations as they are affected by alternative uses of the environment or to the need for changes in New Zealand law because current legislation may not provide for different approaches to the use of the environment.

With all this in mind, the Fishing Industry Board (FIB) recently decided that its most useful contribution would be to consider these 2 aspects: the restraints (scientific, technological, social, and legislative) and the economic realities. Accordingly, Jock Lockley, who is shortly to retire from the position of Technical Manager of FIB, has been concentrating on preparing a check-list of all species which could conceivably be cultivated in New Zealand and spelling out the known constraints, other than economic, which would prevent them from being cultivated now. We intend to follow this up by considering superficially the economic situation for each of these species. By taking into account expected market realisations, and by broad considerations of the likely costs of raising these species, we hope to be able to provide a rough order of priority for the species which look most likely to be potentially profitable. This information will be incorporated into the separate restraints study, which could then be used by FIB, the Ministry of Agriculture and Fisheries (MAF), and the industry to devise action programmes to overcome the restraints applying to those species showing the most economic potential.

Consideration of economic realities is not something which remains solely the concern of FIB or the industry. The same dictates, though not always in strict accordance with the desires of the industry, presumably determine the way in which government considers possible returns from any investment in time or facilities which may be asked of it. This is particularly valid in relation to snapper, since much work would need to be done by MAF before any practical decisions could be taken by the industry.

With snapper there are 2 possibilities: the first is to raise them through their hatchery stage and, at an appropriate time determined by economics and the mathematics of survival, release them into the sea, where it would be hoped they would grow at no further cost to government or industry; the second option is to raise the fish right through to marketable size. The question of which, if either, should be done is primarily resolvable in economic terms. Up to a certain stage, snapper need to be fed on a variety of plankton, which would need to be cultivated separately. They subsequently become less demanding with regard to food, and in Japan they are then fed on ground-up fresh fish. Other speakers will talk about the time to raise snapper to commercial size, and it will be possible to make estimates about the cost of feeding them over this period.

There are no major problems regarding ownership if snapper are cultivated to full market size, but there is some doubt as to whether the realisations achieved would make the whole process economic. There is limited practical experience with this in Japan, and it is not yet possible to indicate that such operations are economic. Furthermore, snapper raised to market size in Japan can be delivered alive to Japanese fish markets. Product in this form will naturally receive a much higher price than snapper placed on the market in any other form. However, I think the cost implications and technological problems associated with delivering live snapper from New Zealand to Japan make that market segment unavailable to us. Consequently, we will be unlikely to have any market options other than those currently available. That is, the price we receive for our cultivated snapper is not likely to be substantially greater than that which we now get for high quality air freighted, chilled, line-caught snapper.

There is an additional problem with cultivating snapper, and that is achieving the same colour as the wild fish. I understand that the lack of colour of cultivated fish depresses their price relative to that of snapper caught in the wild.

The other option in cultivating snapper is to raise them to a stage at which a large proportion of them could be expected to survive if released into the sea. Their release should be preferably in a partially enclosed area, such as the Hauraki Gulf, in the hope that not only would a reasonable number survive, but also sufficient would remain more or less in the same area. The success of such augmentation would depend on whether enough additional snapper would be caught to outweigh the cost of raising the fish.

A major consideration would be to decide who should hatch and breed the snapper. No fishing company would be prepared to stock areas such as the Hauraki Gulf at their own expense and make the fish available to the industry as a whole. It is inconceivable that government would reserve an area such as the Hauraki Gulf solely for 1 interest, despite any investment it might have made in augmenting the resource.

Therefore, government or some private organisation would need to grow the fish to the appropriate size for release for augmentation and the costs would be borne by those fishing in that area, as some form of additional licence fee. Given the economic constraints affecting government activities and the expectation that such constraints will continue in the future, the whole proposal seems to depend on whether any commercial organisation would consider it likely that they could obtain, through licence fees, sufficient income to cover their costs in raising the snapper and provide them with a profit related to their effort and investment.

There is not yet sufficient information from Japan to indicate whether their culture of a similar species to our snapper is likely to be economic. There is at least a suggestion that much of the present work is largely a political gesture towards the Japanese fishing industry, rather than a hard-headed approach to running a profitable enterprise.

I cannot predict what FIB's 2 approaches to considering aquacultural priorities will reveal in relation to snapper. Other target species, such as scallops and paua, may well show a greater potential return for investment and research than snapper.

An interesting sidelight which may provide some commercial opportunities within New Zealand relates to the feed requirement of young snapper fry raised in commercial quantities by either government or private enterprise hatcheries. Whether we are considering young paua, young oysters, or young snapper, during the early stage of their life cycle they require as their main source of food a variety of plankton. It was interesting to note in Japan that the space required to grow large quantities of such plankton was a major constraint to expanding fish culture. At 1 prefectural research station young snapper were, as an alternative, being fed on yeast, which required further augmentation by addition of certain required fatty acids. Perhaps some work should be done on investigating the possibility of producing semi-dried cakes of various species of algae. If this were technically feasible, we could conceivably grow the algae in bulk more easily than some other countries could. Obviously, much technical work and close economic analysis would be needed. In any case, it is important that work be started on developing the techniques for large-scale production of algae and other planktonic foods.

In conclusion, if it is decided that work on snapper should proceed, certain key points need to be considered:

1. An economic study must be made of the likely costs, yields, etc. involved in rearing snapper to a suitable size for release or raising them to full market size.
2. If the economic analysis is favourable, work should be started on techniques of raising young snapper. Much of the technology is already known, but further work will be needed to adapt it to our species of snapper.
3. Consideration will need to be given to the optimum size at which snapper should be released.
4. Consideration must be given to survival rates under natural conditions, with tagging experiments indicating whether any snapper released will remain close to their point of release. This will be necessary to justify additional licence fees which would need to be set to provide a return for the organisation growing and releasing the fish.

There is much work to be done, but I emphasise that we must be as sure as we can that possible economic returns will justify all such work.

Hatchery rearing and reseeding in Japan

P. J. Smith

Fisheries Research Division,
Ministry of Agriculture and Fisheries, Wellington

THE red sea bream (*Chrysophrys major*) is the most important hatchery reared marine finfish in Japan and has been cultured on a commercial scale for almost 20 years. Hatchery production is now about 22 million seedlings per year and supplies both farming and reseeding ventures. The red sea bream is closely related to the New Zealand snapper (*Chrysophrys auratus*) and the 2 species are phenotypically very similar. Details of red sea bream larval rearing and reseeding are relevant to potential snapper farming developments in New Zealand.

This paper is concerned with red sea bream rearing and reseeding in Shizuoka Prefecture, but it requires a brief perspective of aquaculture in Japan. Marine and freshwater aquaculture produce some 8% by weight and 20% by value of the total fisheries production of Japan. In the late 1960s, with declining fish catches, heavy industrial pollution of some coastal waters, loss of nursery grounds to land reclamation, and a worldwide move towards 200-mile exclusive economic zones, the Japanese Government initiated an ambitious plan to enhance coastal fisheries. This was to be achieved partly by stricter regulations on fisheries, pollution control, and construction of artificial reefs, but primarily through reseeding or the releasing of millions of juvenile fish and invertebrates into the coastal waters. Species to be reseeded were selected for their high market value and included abalone, crabs, prawns, and red sea bream. Research on these aquaculture species is carried out in 7 National Fish Farming Centres and the technology applied in regional saibai gyogyo (rearing and releasing) centres. At present 22 such centres are in production, with plans for a total of 35, 1 in each coastal prefecture.

The Shizuoka Prefectural Saibai Gyogyo Centre

The Shizuoka Prefectural Saibai Gyogyo Centre is situated on the Izu Peninsula some 100 km south of Tokyo on the east coast. The centre was completed in 1978 at a cost of about NZ$1.65 million. Two-thirds of the building costs were met by central government and one-third by the prefectural government; running costs are provided by the prefecture. It employs a full time staff of 18, with additional part time workers for seasonal jobs. The centre is run on a team approach to accommodate the shifting workload imposed by the spawning biology of the species being reared. The main species are red sea bream (spring spawner), prawn *Penaeus japonicus* (summer spawner), and abalone *Haliotis discus* (winter spawner), which are produced for release into the coastal waters of Shizuoka Prefecture. In addition, some yellowtail (*Seriola quinqueradiata*) are on-grown from wild-caught seed and pufferfish *Fugu rubripes* are cultivated on an experimental scale.

Adult brood-stock and egg production

The red sea bream year starts in April-May with adults spawning in outdoor concrete tanks. Three circular tanks of 60-t seawater capacity are used to hold the adult brood-stock (Fig. 1). The fish are reared from hatchery produced juveniles, but a different year class is stocked in each tank. During the second year, before spawning, the numbers are reduced to about 40 fish per tank and a sex ratio of approximately 2 females to 1 male. Under these conditions spawning takes place naturally without the need for hormone treatment or hand stripping. Spawning generally occurs after sunset and the free-floating, pelagic eggs are collected by plankton trap the following morning. Only those eggs floating in the top 10 cm or so are collected, and they are weighed to

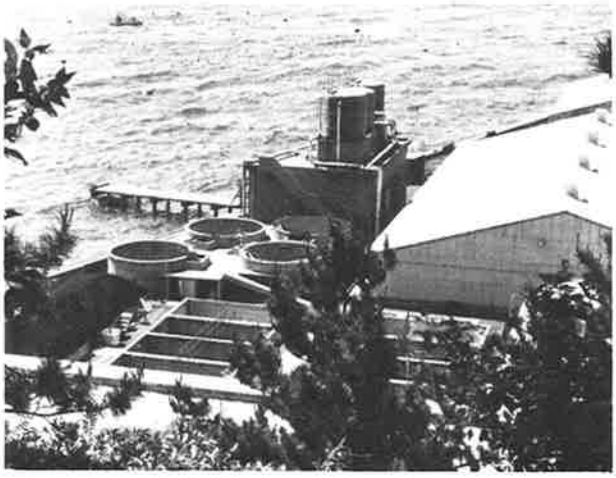

Fig. 1: The Shizuoka Prefectural Saibai Gyogyo Centre. Adult red sea bream are held in the circular tanks, *Chlorella* are cultured in the open concrete tanks, and the red sea bream larvae are reared in tanks under shade netting to the left of the *Chlorella* tanks. The large building is used for abalone culture.

estimate numbers. At this stage the eggs may be either stocked directly into the larval rearing tanks or held in an incubating net, with a flow of aerated sea water, for 24 hours. From this net the floating eggs are stocked into the larval rearing tanks, the non-viable eggs sinking out.

Larval rearing

The larvae are reared in outdoor concrete tanks 8 by 9 by 2 m with a seawater capacity of 90 t. The tanks are shaded from direct sunlight by fine netting, and the water is precultured with *Chlorella*, which has a beneficial effect on larval cultures, probably stabilising pH and absorbing toxic wastes. The *Chlorella* is also a food source for rotifers introduced into the tanks and is added on most days throughout the larval rearing period to maintain the density at about 500 000 cells per millilitre.

The sea water is aerated and circulated by 16 air stones. Water exchange is not started until 5–10 days after hatching and is slowly increased to 1 tank exchange per day after 20 days and up to 3 exchanges per day 40 days after hatching. The tank bottom is siphon cleaned each day from the twentieth day after hatching.

Eggs are stocked in the tanks at a density of 20 000–30 000 per cubic metre and hatch after about 2 days at 15–16 °C. The newly hatched larvae, 2–3 mm long, are nourished from the yolk sac for 2–3 days and then start feeding. Rotifers are added to the tank at the time of hatching to ensure a plentiful supply at the onset of feeding, a critical stage in larval development. Initially each larva may eat 20 rotifers per day, but this rises to more than 200 per day at 2 weeks of age. Given that each tank contains about 2 million red sea bream larvae, rotifer production is a major culture operation. Nine indoor 50-t capacity tanks are required for rotifer cultures. The rotifers are cultured on yeast (Fig. 2), each tank culture running for about 30 days and being harvested every 3 to 4 days. However, on this diet alone, rotifers are a poor food source for red sea bream larvae and so for the 24 hours before they are put into the larval tanks the rotifers are concentrated into 1-t tanks and cultured on *Chlorella.*

This in turn entails the large-scale production of *Chlorella.* At the peak of the red sea bream rearing season fourteen 50-t capacity outdoor tanks are used for *Chlorella* culture. Fifteen days after hatching, and at a larval size of 6 mm, *Tigriopus* (a marine copepod) is added as a supplementary food source with the rotifers. *Tigriopus* is cultured on alcohol fermentation wastes, though the culture system is not perfected. Rotifers are added until 35 to 40 days after larval hatching and *Tigriopus* until the end of the tank-rearing phase, 40 days after hatching. The density of rotifers and *Tigriopus* in the tanks is carefully

Fig. 2: Rotifers are cultured in indoor 50-t capacity concrete tanks. Yeast is added daily as a food supply.

monitored to ensure adequate numbers are present as larval food.

Nauplii of the brine shrimp *Artemia* may be supplemented as a food source between 20 and 35 days from hatching. Although they produce good growth rates, they can result in high larval mortalities if they are used continuously for more than 4 or 5 days.

Thirty days after hatching, when the larvae have reached a size of about 10 mm, finely minced fish, clam, and shrimp are added to the tanks to wean the larvae on to the juvenile diet. The amount of fish (sand eel, mackerels, clam, and shrimp) is slowly increased as the volume of rotifers and *Tigriopus* is reduced. After about 2 weeks the larvae, or fry at this stage, have reached a size of about 15 mm and have been weaned on to a diet of minced fish, ready for transfer to sea cages.

On-growing juveniles in sea cages

Fry are removed from the larval rearing tanks by lowering the water level and scooping up the fish in buckets. Some are transported by boat to sea cages in neighbouring bays and others are taken by road to more distant sites. For road transport fry are carried at a density of 25 000–30 000 per tonne of sea water. Oxygen is bubbled into the water and a small volume of ice added.

Sea cages are in sheltered bays with minimum wave action, but good tidal circulation. They are typically between 3 by 3 by 3 m and 10 by 10 by 5 m with a 2-mm mesh. Fry are stocked at an initial density of 2000–4000 per cubic metre; density depends on size and water quality. As they grow the density is reduced by transfer to other cages and the mesh size is increased. Fry are fed 4 times a day on minced fish. Growth is rapid, from about 15 mm in June to

5–10 cm by August. At this size the juveniles are ready for release.

Release of red sea bream

The minimum recommended release size is 4 cm, though 8 cm is preferred. Sea cages close to the release area are towed to the release site. Alternatively, juveniles may be removed from the cages and transported in seawater tanks to the release site. About 10% of the released fish are tagged with a small plastic anchor tag. Fishermen are employed for this and 20 people can tag 50 000 fish per day. Fish are removed from the cages by raising the nets and scooping up in buckets. The fish are held in a gloved hand to reduce scale and skin damage, tagged, and then placed over the side of the vessel.

Release sites are selected from ecological surveys based on diving observations and trial fishing. Sites ranging from artificial reefs to kelp stands to mud bottoms have been tried in the past few years. The most successful returns have been made from natural nursery areas, which are usually sand-mud bottoms surrounded by natural reef and with a minimum depth of 5 m.

It is recommended that both commercial and sports fishing be banned within 3 km of the release site for 11 months from the release date.

Monitoring of the release programme

The aim of the reseeding programme in Shizuoka Prefecture is to enhance the local coastal fishery. Annual catches fluctuated above 100 t until 1963, after which they steadily declined to about 50 t. On the Izu Peninsula catches have declined from a maximum of 240 t to 30 t in 1980.

The Shizuoka Saibai Gyogyo Centre became operational in 1978 and has rapidly achieved a high seed production with a million red sea bream releases planned for 1981. The release programme is monitored by the Shizuoka Prefectural Fisheries Experimental Station Izu Branch. This station, with a staff of 13, is responsible for biological research on the commercially important marine fish resources which include abalones and sea breams. Before the red sea bream release programme, a tagging study was carried out on wild fish to estimate growth and mortality rates and movements. Juvenile red sea bream were tagged in an attempt to estimate the effect of juvenile releases into the fishery.

Experiments on tagging juvenile red sea bream have been critical to estimating the effectiveness of reseeding operations. Monitoring of the early reseeding programmes in the Seto Inland Sea was done by plotting the total landings in the fishery against the annual release numbers. However, the apparent positive correlation between landings and reseeding cannot be directly attributed to reseeding, as a number of independent variables (year class strength, fishing regulations, and improvement in the environment, notable in the Seto Inland Sea) affect the fishery.

The tagging programme is also not without difficulties. The rapid growth over the first year produces a high tag loss, though fish can be recognised by a scar on the dorsal surface. Tag loss is estimated from experiments with fish held in floating cages and from the ratio of scarred to tagged fish landed in the fishery. It can be as high as 65% over 1 year and 78% over 2 years. Another source of error is that not all tag recaptures are reported by fishermen. Results from experimental fishing and from observations in commercial processing stations suggest that 50% of the recaptured tagged fish are not reported. In addition, there is a high initial mortality (about 30%) from handling stress and predation so that the effective number of fish released is less than the actual number. Alternative tagging and marking methods are being studied.

The effectiveness of the release programme can be illustrated with an example from Kanagawa Prefecture, which, with Shizuoka Prefecture, conducts a release project on the mid-Pacific coast of Japan. The first release of 202 400 fish was made in 1977, then 272 200 in 1978, and 656 900 in 1979 off the west coast of the Muira Peninsula. The expected return to the 1980 fishery is as follows:

(effective number of fish released × true recapture rate × mean weight)

1-year-old fish released in 1979

$$656\,900 \times 0.7 \times \frac{0.23\%}{0.5} \times 104 \text{ g} = 220.0 \text{ kg}$$

2-year-old fish released in 1978

$$272\,200 \times 0.7 \times \frac{0.29\%}{0.5 \times 0.3} \times 387 \text{ g} = 1425.6 \text{ kg}$$

3-year-old fish released in 1977

$$202\,400 \times 0.7 \times \frac{0.1\%}{0.5 \times 0.1} \times 800 \text{ g} = 2266.9 \text{ kg}$$

Total 3912.5 kg

There are area differences in growth rates and recapture rates which relate to conditions at the release site and obviously produce changes in the net return to the fishery. In 1 area 3-year-old fish had reached 1500 g; in another the returns of 1- and 2-year-old fish reached 3%. However, it is estimated from this initial programme that a release of 1 million juveniles each year would produce an increase in net landings of about 35 t per year. With the high market demand for red sea bream and declining coastal fishery, this figure is sufficient to justify the continuation of the rearing and reseeding programme.

Acknowledgment

I thank Mr M. Hataya, Shizuoka Prefectural Saibai Gyogyo Centre and Dr M. Kawajiri, Shizuoka Prefectural Fisheries Experimental Station for providing information used in preparing this paper.

Discussion

Mr Boyd (Fisheries Management Division, Auckland) asked what types of tags were used by the Japanese. Dr Smith replied that they were plastic anchor tags. Internal metal tags were also being considered, but about half the returns were from sports fishermen, who would have trouble detecting the metal tags. Ideally, if all fish went through 1 or 2 sheds, they could be run through a metal detector. Fin clipping and marking with dyes had also been considered, but these were not very permanent.

Mr Jarman (N.Z. Fishing Industry Board, Wellington) inquired about the cost, under Japanese conditions, of breeding 1 million fry per year. Dr Smith replied that it was difficult to cost out, as the hatchery had been initially built by the central government, but was now run by the local prefectural government. He said that once the building had been established, the main cost would be the salaries; there were 18 full time staff.

In response to Mr Jarman's query as to how long the snapper were held in the cages, Dr Smith replied that they were kept from mid June until the release period in August-October.

Mr Jarman commented that in yellowtail culture the Japanese felt that it was necessary to get the trash fish cost to below the equivalent of about 10–11c per kilogram to make feeding economic. He observed that this would not be very profitable for the person supplying the trash fish.

Dr Smith added that feeding caged fish on minced fish was made more expensive by the fact that additional nutrients had to be supplied because growth defects had been observed in yellowtail culture when trash fish alone was used as feed. Multivitamins and minerals were added because the mortality rate was over 50% when minced sardines were the only food used.

Snapper culture in sea cages

L. D. Ritchie

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Ministry of Agriculture and Fisheries, Whangarei

IN a paper to the Aquaculture Conference in Wellington in September 1979, I outlined possibilities for marine finfish culture in New Zealand and concluded that snapper and yellowtail kingfish offered the greatest scope and potential for "fattening on". I suggested that sea cage or embayment culture, as widely and successfully practised in Japan, in conjunction with trap nets as an integrated fishery venture, provided an approach with good chances for success.

Since that conference nothing has caused me to change my mind. I maintain that serious culture trials for snapper other than in sea hung netting cages are not very relevant and will do little to further the progress of commercial snapper culture in New Zealand.

To place snapper culture in perspective we must examine the reasons and advantages for attempting to farm marine fish at all. Briefly, they are:

- To extend a high demand resource which is at or near its maximum yield in its natural environment.
- To tailor the product to the market requirement.
- To provide employment.
- To provide industry particularly suitable for regional development.
- To use a readily available and unutilised resource (clupeioid fishes).
- To provide a marine industry with the minimum of adverse environmental impacts and pollution and a requirement for maximum water quality.

We should also examine in more detail the reasons for preferring cage culture to other methods and reasons for integrating cage culture with trap nets. (The following points apply to yellowtail kingfish as well.) Cage culture offers:

- Minimal cost (see below).
- Minimum pollution. Even intensive culture of hundreds of thousands, or millions, of fish offers few waste disposal or water pollution problems if the cage complex is well sited. Under such heavy culture conditions scarification of the sea floor beneath or shifting of the cages may be necessary every few years.
- The possibility of siting cages near a major food source (for example, a trap net or a bait fishery) or a processing establishment. This reduces travelling time and transport costs.
- Simple, well proven technology with simple maintenance and servicing requirements. The necessary handling skills are easily acquired and many aspects, for example, netting, rope, floats, anchors, are familiar to fishermen.
- The possibility of being carried out at many localities, so that optimum environmental conditions can be determined.
- Minimum environmental and aesthetic problems. (I suspect that any snapper farm would excite far more interest from tourists, the public, and environmentalists than it would attract objections.)

In contrast, tank culture would entail large construction and siting costs, major pollution problems, considerable technology, complex servicing, and multiple-step feeding requirements. Maintenance of optimum temperature would also pose problems that would probably be expensive to overcome.

Regrettably, closed bay culture, in which a bay or inlet is cut off by a net, as described by Ritchie (1980), is unlikely to proceed at present in New Zealand because of conflict of water use and user group interests. This could, I believe, be alleviated by integrated planning and good publicity aimed at increasing public awareness of the desirability of all forms of aquaculture as sound conservation-based industry.

Details, including a diagram, of a suitable experimental cage culture set-up are given by Ritchie (1980). Briefly, it consists of a buoyed and floating heavy rope frame anchored in 7–10 m depth. Within the frame, netting cages, individually complete with floats and small weights to help maintain shape, are attached. Cage size is 5 by 5 by 5 m with varying mesh size to suit fish size. Present (October 1981) costing for the 25 by 10-m structure is as follows (supplied by Leigh Distributors Ltd., netmakers, Whangarei):

24-mm synthetic rope for frame and anchors	$550
6-mm synthetic rope for net panels, 650 m	$65
300-mm diameter double lug floats for frame	$900
100-mm diameter net floats	$160
Netting (depending on types available)	$1,500–$2,500
Leads, 100 g	$240
Labour, 565 h	$4,500
Total about	$8,000–$9,000

I am convinced that a similar cage complex integrated with a trap net remains the ideal mechanism for initial snapper farming trials in New Zealand. The advantages of this system are that 1 or more trap nets would supply:

- a smallish, but constant catch of prime species, such as snapper, kingfish, trevally, and tarakihi and probably seasonal catches of skipjack, yellowfin tuna, squid, grey mullet, and blue mackerel;
- juvenile stock, both kingfish and snapper, for cage fattening on (additional juvenile snapper could be obtained by beach seine, if necessary);
- feed fish, such as mackerels, pilchard, anchovy, sprat, piper, and saury for the caged fish.

The advent of marine fyke nets (underwater trap nets), at considerably less cost than earlier trap nets, makes the above proposition even more attractive. There are, however, many unknowns, one of which is reaction from fishing interests and the public to the use of wild juvenile stock for fattening on.

Steps in the development of snapper and kingfish culture are given by Ritchie (1980). It is obvious that initial trials must be based on wild juvenile stock. All that is required is for a company with vision to try it out, because without the invaluable data on feeding, growth, and servicing costs that would result from such a project, snapper culture in New Zealand cannot be realistically evaluated.

Reference

RITCHIE, L. D. 1980: Marine finfish farming: some thoughts on New Zealand potential. *In* Dinamani, P., and Hickman, R. W. (Comps.), Proceedings of the Aquaculture Conference, pp. 57–63. *Fisheries Research Division Occasional Publication, N.Z. Ministry of Agriculture and Fisheries, No. 27.*

Discussion

Mr Paul (Fisheries Research Division, Wellington) said he liked the idea of cage culture much more than reseeding, but what about the possibility of large predators like sharks, for instance, tearing the nets open. He wondered if there had been any problems of this nature in the Japanese cage culture.

Mr Ritchie replied that apparently there had not, and he doubted whether it would be a problem here, because in many years' experience of diving on trap nets he had found that sharks tended to avoid the nets. They quickly went into stress and died if they became entangled in the nets.

Dr Smith (Fisheries Research Division, Wellington) commented that "human sharks" could give more trouble, and it was agreed that people might damage the nets because they might not like the idea of a large net full of fish to be sold commercially. Mr Ritchie said that this problem could probably be circumvented if the project were set up on a regional development basis, which would ensure local support.

Mr Lynch (Fisheries Management Division, Wellington) added that site selection would be an important factor because the public was generally not keen on the idea of large nets or other marine farming gear.

Mr Lockley (N.Z. Fishing Industry Board, Wellington) referred to the trap net which had been operating and asked whether many juvenile snapper had been caught in it. Mr Ritchie replied that there had not been many, and another supply, such as from a beach seine, would probably be needed. Juvenile kingfish could be supplied from the trap net because they were very seasonal and occasionally large numbers of them were caught.

Dr Colman (Fisheries Research Division, Wellington) observed that the trap net would be an integral part of the operation and asked whether it would be necessary to rely on it as an additional source of income. Mr Ritchie affirmed this and added that the profit would probably come from the trap net and the cage venture would be an extra.

Dr Colman said that the cost of setting up the cages had been mentioned, but he wondered about costs of maintenance. Mr Ritchie replied that a cost he had not mentioned was that of additional nets. Fish would need to be transferred to another net at about 2–3-month intervals so that the nets could be changed for cleaning. In Japan anti-fouling was used, but this might be more expensive than changing nets.

Dr Colman asked if cage culture paid in Japan, and Mr Ritchie replied that this was difficult to assess, but it was probably marginal.

In response to Mr Paul's query about keeping flounder in cages, Mr Ritchie said that wild flounder seemed to fill the market, and as flounder was not an export fish, there seemed little point in considering cage culture.

Potential disease in snapper farming

P. M. Hine

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Ministry of Agriculture and Fisheries, Wellington

IN May 1976 Larry Paul and I examined 2100 snapper from closed areas in the Hauraki Gulf for darkish lumps, thought to be a disease, in the gonads. About 20% of male fish were affected. Between 1972 and 1980 I also received samples of spherical nodules, up to 7 mm in diameter, found under the backbone in snapper from areas such as the Marlborough Sounds, Wanganui, Gisborne, and Hauraki Gulf.

In view of growing interest in snapper farming, we decided to survey snapper from January to June this year to determine the status of parasites and diseases of these fish as potential problems in snapper farming.

Parasites and diseases

You may wonder how we can determine the likelihood of a disease developing in a farming situation by examining wild fish. Pathogenic status may be indicated by considering the site of infection, how the causative agent is transmitted, and its likely effect on a fish under stress (from knowledge of the changes in fish biochemistry and physiology caused by stress) and by studying published scientific papers on the pathogenicity of closely related organisms.

The known parasites and diseases of snapper are given in Table 1. This is probably not a comprehensive list. Species of *Vibrio* are ubiquitous in the marine environment and may be isolated from benthic invertebrates as well as the gut of apparently healthy fish. However, if a fish is stressed, and especially if it is physically damaged, the bacterium becomes pathogenic and invades the body, where it causes severe damage in all the organs, but especially those concerned with the immune response. Large congested external lesions allow secondary pathogens to invade and further debilitate the fish. Vibriosis is considered the most serious bacterial disease of marine fish.

Cryptocaryon irritans resembles *Vibrio* sp. in that it occurs in low numbers on unstressed fish and causes little harm, but host stress and buildup in numbers in closed circulatory systems alter the host-parasite equilibrium in favour of the parasite. It causes damage to the skin and fins, which allows secondary pathogens, including *Vibrio* sp., to invade. It is regarded as the saltwater equivalent of *Ichthyophthirius multifiliis* (white spot) on freshwater fish.

TABLE 1: Known parasites and diseases of snapper

	Site	Transmission	Stress	Pathogenicity
Bacteria				
Vibrio sp.	Systemic	Direct	√	+ + +
Protozoa				
Cryptocaryon irritans	Skin and fins	Direct	√	+ + +
Zschokella sp.	Gall bladder	Direct (?)	×	+
Monogenea (external flukes)				
Bivagina pagrosomi	Gills	Direct	√×	+(+ +)
Benedia sp. (*B. madai* or *B. pagrosomi*)	Skin	Direct	√×	+(+ +)
Acanthocotyle australis	Skin	Direct	√×	+(+ +)
Digenea (internal flukes)				
Lecithocladium magnacetabulum	Gastro-intestinal tract	Indirect	×	+
Nematoda (roundworms)				
Cucullanellus cnidoglanis	Gastro-intestinal tract	Indirect	×	+
Anisakis sp. larva	Encysted viscera	Indirect	×	+
Contracaecum sp. larva	Gastro-intestinal tract and viscera	Indirect	×	+
Philometra sp.	Gonads	Indirect	×	+ +
Unknown				
Granulomatous kidney disease	Kidney and (occasionally) spleen	Unknown	Unknown	+ +

+ + + Kills host.
+ + Seriously debilitates host.
+ Has no apparent effect on host.
(+ +) Under farmed conditions buildup of numbers increases surface damage, immune systems are suppressed, and therefore there is increased secondary infection.
√ Stress exacerbates disease.
× Stress has no observable effect.
√× Stress may make fish more prone to infection.

Zschokella sp. inhabits an unimportant site and belongs to a genus that is benign, even under conditions in which the host is stressed and crowded.

The 3 monogeneans live on the skin and gills of wild fish, where they appear to cause no damage. However, they have a direct life cycle and rapidly build up numbers in a closed circulatory system, where they cause surface damage to the host with their attachment organs. Stressed fish with suppressed immune systems are therefore susceptible to infection by pathogens via these surface lesions.

The 1 digenean and 4 nematodes require other animals in their life cycles and provided these are excluded from a farm, the parasites cannot multiply. Stress is not likely to alter the host-parasite relationship, as with *Vibrio* sp. and *C. irritans*; therefore these parasites are unlikely to cause a problem. However, *Philometra* sp., even in wild fish, causes a pronounced inflammatory reaction in the gonad that probably affects fecundity and may affect fertility. This is the parasite that causes darkish lumps in the gonads, mentioned above, and in May of this year it was found in 40% of male and 8% of female snapper at the same stations as those sampled in May 1976. It has therefore approximately doubled in incidence in 5 years. Next month we hope to determine its effects on spawning. The incidence of philometrosis declines from Northland (about 60% of male fish), to Hauraki Gulf (about 40% of males), to the eastern Bay of Plenty (about 12% of males).

Granulomatous kidney disease is readily identifiable by the hard nodular lesions in the kidney, underlying the backbone. The cause is unknown, but we suspect a fungus. It infects very young fish and spreads and grows slowly, causing a host response in which fibrous tissue is laid slowly around the organism to form the nodule. Because the disease is chronic, kidney function is not greatly impaired, though the large number of nodules (up to 120) appear to replace much of the kidney tissue. This disease occurs in all large (over 30 cm) snapper from North Cape to East Cape.

A point of interest is composition of the parasite fauna which, although well endowed with skin flukes, has a remarkably small helminth gastro-intestinal tract fauna. This is surprising, as the snapper diet is rich with the types of animals such parasites use as intermediate hosts. Observations on the fish suggest that the unusually small fauna may be due to scouring of the gut by the large quantities of shell and other hard fragments from molluscs, crustaceans, and echinoderms.

Treatment and management

Over the last 10 years there has been a change in trend in fish health science, from treating the disease to identifying the cause and removing it. Thus chemotherapy, though still used where appropriate, is not considered a solution (the disease may well reappear after chemotherapy is stopped). The 2 potentially most serious pathogens are stress mediated. This is true of many serious pathogens, and thus, if the cause of stress can be removed by altered management practices, the disease can be eradicated.

Stress can be due to a variety of causes; for instance, overcrowding, physical damage on handling, poor water quality (oxygen, pH, temperature, pollutants), poor diet, or extremely unusual environment (bright lights, no shade or shelter, continual disturbance, abnormal day-night light cycles). Abolishing the cause of stress has been found to be successful in treatment of many disease problems, and it is of paramount importance that aquaculture systems be designed with disease-stress in mind **before** they are built. In particular:

- systems should be designed to minimise handling;
- optimum stocking density should be determined by trials before large-scale implementation;
- water quality, around the year, should be checked and awaiting systems be ready to alter specific parameters (oxygen, temperature);
- if a closed system is used, filters must effectively remove micro-organisms and wastes;
- reticulation should permit isolation of individual tanks;
- fish should be maintained in surroundings as near as possible to those they inhabit in the wild;
- simple, commonly used remedies should be readily available for treatment or, occasionally, prophylaxis.

All but 1 of the diseases in Table 1 do not pose any great problem. Vibriosis can be treated with drugs or prevented by vaccination, and *C. irritans* and the flukes can be treated with simple chemicals. However, the granulomatous kidney disease requires further study and it is to this we are turning our attention.

Discussion

Mr Ritchie (Fisheries Management Division, Whangarei) asked how one recognised *Philometra*, and Dr Hine replied that this was not possible without cutting up the fish, though he thought that at certain times of year the worm might protrude from the vent of the fish.

Mr Ritchie then asked whether, in cage culture, one should try to treat diseased fish or get rid of them and added that diseased fish would presumably have to be isolated for treatment anyway. Dr Hine agreed that this decision was always a problem in aquaculture, but it would probably be better to kill off diseased fish and runts. Their slow growth was not economic because their energy conversion ratio was too low.

Mr O'Sullivan (BP Chemicals NZ Limited, Wellington) inquired about the availability of the drugs required to treat fish diseases. Dr Hine replied that they were all available only on prescription. The system that had worked so far was that a ministry person had confirmed the need for a drug and had contacted someone from Animal Health Division, who would arrange for a veterinarian to prescribe the drug. He observed that veterinary students were now being given training in fish diseases.

In answer to a query about the method of administration of drugs, Dr Hine said they were given orally, in the food.

More concern was expressed about the roundworm *Philometra*, and a question was raised about its life cycle and whether it was affected by environmental factors. Dr Hine said that it had been studied only since 1976 and though it appeared to be on the increase in the Hauraki Gulf, it might just go through cycles of large and small numbers. He said that there seemed to be a higher incidence of it in more enclosed waters. Comparative studies had been made in Doubtless Bay and Rangaunu Bay, and the incidence was found to be greater in Doubtless Bay, which is more enclosed. Subsequently, the occurrence had been studied in bays right along the north-east coast, and it had always been higher in enclosed areas. In this respect the Hauraki Gulf could be considered to be an enclosed area.

Another questioner wondered if the incidence of the parasite had anything to do with man-made pollution, but Dr Hine replied that it did not. He said that the organism could be controlled in a farming situation because it was carried by a planktonic copepod, which could be excluded by filtration or other treatment. The parasite destroyed only the reproductive potential of the fish, which remained otherwise unaffected, and so in farmed fish which were not required as brood-stock it would not create a problem. The main concern was that it interfered with the reproduction of wild fish.

Mr Jarman (N.Z. Fishing Industry Board, Wellington) asked Dr Hine to comment on the Japanese experience of problems with disease in this type of fish culture, and he replied that from the evidence of several literature searches it appeared that similar pathogens were present here and in Japan.

Economic aspects of snapper farming in New Zealand

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THIS paper deals briefly with snapper farming in Japan and some fundamental economic aspects that might apply to farming in New Zealand. In view of the lack of promise arising from an initial investigation, a comprehensive costs and earnings study was not considered justified at this stage.

Farming in Japan

The closest parallel to farming New Zealand snapper (*Chrysophrys auratus*) is in southern Japan, where a close relative, red sea bream (*Chrysophrys major*), is farmed, often in combination with yellowtail (*Seriola quinqueradiata*), a different species belonging to the horse mackerel family and resembling a small tuna. Until the mid 1970s most of the sea bream fry used for farming was fished for, but now there is a growing amount of fry coming from commercial hatcheries for both farming and reseeding, with financial assistance from the Japanese government.

Farmers typically purchase fry from hatcheries at 5–10 cm long (4–6 months old); the cost is about 50c per fish. Survival to market size approaches 100% at this size. On-growing is in wooden or metal cages ranging from 5 by 5 m to 10 by 10 m in area and 5–10 m deep, according to the water depth. Buoys are used to float the cages. A Japanese farm may comprise 15 cages of 8 by 8 by 8 m, stocked with snapper and yellowtail.

The fish are held in these cages until they reach a marketable size of 1–1.5 kg, which may take 1–2+ years. Stocking of fish begins at 5–8 kg per cubic metre; that is, 2500–4000 kg in a cage 8 by 8 by 8 m, which represents some 85 000–135 000 fry at an average weight of 30 g.

In the past, the Japanese have fed cheap frozen fish such as anchovy and sand eel, but composite pellet food is increasingly being used. The weight of food required to produce a given weight of fish flesh is known as a conversion ratio. It depends on a number of things, the most important being the species of fish and nutritive value of the food. Thus, though a composite pellet food may appear to cost more than, say, trash fish, this may be compensated by a lowering of the ratio of the quantity of food required to produce a given weight of fish flesh. With trash fish a ratio of 4:1 may be achieved (4 kg of food to produce 1 kg of fish flesh); whereas a ratio of 2:1 may be possible with a high quality pellet food. Food costs in Japan typically represent about 50% of the total operating costs of a farm.

The economics of red sea bream farming in Japan depend on the product being considered a luxury item and thus commanding a premium price. The slow growth rate of the species, among other things, is stated to rule out profitable farming as a food fish. The species is prized not so much because of its flavour or appearance, but because it is associated with good fortune and is therefore popular for birthday and wedding celebrations. It is usually eaten as sashimi, though it is sometimes grilled. Significantly, market prices for farmed red sea bream are generally lower than for fish caught at sea, because both colour and flavour are deemed inferior to those of the wild fish. Fish suitable for sashimi fetch the highest price and have to be supplied in an exceptionally fresh condition. Large snapper 1–1.5 kg are preferred for this purpose, as they provide a better cutting recovery. Smaller fish for the ceremonial grilled dish are the next most valuable.

Japanese market prices

The following prices are quoted by Ashenden Associates (1979) and, though dated, are useful for comparison. According to the key Osaka wholesalers, market price levels for snapper in December 1978 were of the following general order:

	Yen per kilogram	Uses
Japanese natural (iced, unfrozen)	4,000	sashimi
Japanese farmed (cheaper because colour paler and flesh not as firm)	2,000–2,500	sashimi
N.Z. chilled (air freighted)	1,000±	sashimi grilling
N.Z. frozen (onshore processed)	350±	grilling kirimi
Argentine frozen	250±	grilling

The following recent information, kindly supplied by Mr Roger Crossman of Jaybel Nichimo Limited, is for red sea bream (1–1.7 kg) sold alive on the Tokyo market:

July-August, 800 fish sold per day, 2,500–2,800 yen per kilogram;

September-October, 2000 fish sold per day, about 2,500 yen per kilogram;

Farmed red sea bream production has climbed from 460 t in 1970 to 12 253 t in 1979 and is apparently levelling off.

Possibilities for farming snapper in New Zealand

The annual temperature range of water in the Hauraki Gulf is similar to that in many parts of southern Japan where farming is carried out, but there is currently no evidence that growth rates for farmed snapper in this country can match those achieved in Japan.

Table 1 provides a rough estimate of establishment costs for a snapper farm. Cages 8 by 8 by 5 m may cost between $4,000 and $5,000 each, including buoys and anchors. Anchorage costs would obviously vary considerably, depending on the exposure to weather and currents of the cages and on water depth. The other major capital item would be premises which could provide chilled storage and packing facilities for fish and freezer storage for fish food, though the development of acid-preserved feeds may obviate the need for this.

According to Japanese references, feed usually represents about 50% of total operating costs (Table 2). The cost of suitable feed could vary from 30c per kilogram for trash fish, which would be suitable only for fish larger than about 10 cm (30 g), and $1.20 per kilogram for an average priced composite pellet feed. Fish farmed below the 10-cm size would require special feeds according to size, and these could in some instances be very expensive. Conversion ratios could vary according to feed and 2:1 seems the best that could possibly be achieved with a good quality composite feed; only 4:1 or 5:1 may be attainable with trash fish.

TABLE 1: Estimated establishment costs for a snapper farm

Item	Cost ($)
5 cages* 8 by 8 by 5 m @ $4,500 each	22,500
Licence fee	500
Marine lights	500
Chiller, packing, and storage rooms, staff amenities	50,000
Tools and gear	3,000
Boat	15,000
Vehicle	5,000
Other	500
Total capital establishment costs	100,000

*A farm would probably have to develop to at least 10 cages to be viable.

TABLE 2: Percentage breakdown of costs for 2 Japanese yellowtail farms in 1967

	Farm 1 (%)	Farm 2 (%)
Fishing gear	1.0	0.8
Seed collection	7.5	4.8
Material	12.3	16.2
Maintenance	1.9	1.9
Feed	49.8	49.3
Chemicals	1.9	1.3
Wages	19.6	19.9
Other	6.0	5.8
	100.0	100.0

Table 3 shows a range of costs that could apply depending on price of feed, conversion ratio, weight of fish required, and whether small natural fry or hatchery bred fish are farmed. A farm could fish for fry itself or buy from other fishermen or a hatchery (should one be established). I do not know official policy on the taking of snapper fry. Local fishermen may be worried, though there are abundant stocks of small fry in the Hauraki Gulf, a large proportion of which does not reach maturity for various reasons (L. J. Paul pers. comm.). Perhaps a quota of this fry could be made available for farming. It seems likely that such fry would vary in size and so expensive special feeds may be needed. If, on the other hand, fry has to be produced by a hatchery, it is unlikely to be any cheaper than the prevailing 50c per 10-cm fish in Japan.

Obviously the viability of snapper farming in New Zealand depends on the price of feed and the price that can be achieved for the product. As in the Japanese industry, we would have to aim at the top prices for a luxury item. There is a Japanese rule of thumb which states that all fish farming becomes a hazardous proposition when the price for feed approaches 10% of that to be made for a marketable fish. It is impossible to say yet whether the rule applies to the New Zealand situation, but it seems a useful way of providing at least a rough indication of the minimum price a farmer must achieve, given a particular food cost and a likely conversion ratio. There is considerable doubt about the profitability of farming New Zealand snapper, especially when its relatively slow growth rate is also taken into consideration.

The food costs in Table 3 are simply multiplied by 10 to arrive at a bare minimum price to the farmer. If we look at the cheapest food price of 30c per kilogram, the most favourable conversion ratio of 2:1, and feeding at 30c per kilogram over the whole life of a 1-kg fish, the price required is $6 per kilogram or $5.58 if the food cost is applied only to fish from 30 g up to 1 kg. If the lower price is taken, it is probably realistic to add 50c to the price to allow for the cost of the fry from a hatchery. If we aim at the Tokyo top price

TABLE 3: A range of estimated feed costs for a farmed snapper

Food	Price ($/kg)	Food conversion ratio	Market size of snapper (kg) 0.5 A* ($)	0.5 B† ($)	1.0 A ($)	1.0 B ($)	1.5 A ($)	1.5 B ($)
Trash fish	0.30	2:1	0.30	0.28	0.60	0.58	0.90	0.88
		3:1	0.45	0.42	0.90	0.87	1.35	1.32
		4:1	0.60	0.56	1.20	1.16	1.80	1.76
Pellet	1.20	2:1	1.20	1.13	2.40	2.33	3.60	3.53
		3:1	1.80	1.69	3.60	3.49	5.40	5.29
		4:1	2.40	2.26	4.80	4.66	7.20	7.06

*Cost A assumes feeding over the whole farmed life of the fish. This is unrealistic, as feeds more expensive than trash fish would be necessary up to about 30 g. The cost of obtaining small fry from the wild has not been assessed.
†Cost B assumes that fry of 30 g are obtained from a hatchery; a typical ex-hatchery cost of 50c per fish can be added.

chilled fish (for sashimi) market, a figure of at least $14 per kilogram c.i.f. is required. The most recent Tokyo market information indicates that the peak market price for live Japanese farmed red sea bream of 1–1.7 kg is 2,500–2,800 yen, or $13.20–$14.79, per kilogram. The highest price received so far for New Zealand chilled snapper, to the best of my knowledge, is not more than $12 per kilogram and it is difficult to visualise a chilled New Zealand farmed product consistently achieving more than $8 per kilogram. Therefore, it seems unlikely that Japanese market realisations for New Zealand farmed snapper could achieve an adequate return to a farmer, even when a highly optimistic combination of feed price and conversion ratio is assumed.

Conclusion

Snapper farming is not likely to be economic in New Zealand at present in the way that shellfish farming is. The basic reasons are:

- Distance from the Japanese market, which is likely to preclude obtaining the top prices for live or fresh snapper for sashimi.
- The high cost of feed.
- Slow growth rate of snapper. Growth to 1–1.5 kg takes at least 1–2 years and possibly longer, depending on environmental factors and feed.
- Japanese preference for the product caught at sea over the farmed product because of texture and colour differences; so the farmed product commands a lower market price.
- Uncertainty of the supply of any large quantities of snapper fry from the wild.
- The considerable cost of establishing and operating a hatchery as an alternative source of fry.

However, it is necessary to consider the possibilities of a limited scale of farming being carried out by existing fishing companies, which would be able to produce cheap feed from their own waste and would already have much of the equipment required. I understand Sanford Limited is engaged in such an exercise, and time will tell whether it is economic. Even with such low-cost farming, it still seems likely to be unprofitable if superior market prices cannot be attained in Japan.

Eventually, rising fuel costs for traditional snapper fishing may swing the balance in favour of farming, but snapper fisheries are essentially coastal and will be less affected by increasing fuel costs than many other fisheries. There is also much scope for using various less energy intensive methods of fishing and these appear to hold more promise than farming this species in the foreseeable future.

Reference

ASHENDEN ASSOCIATES. 1979: "The Japanese Market for Fisheries Products: New Zealand Species", Book 2, Part II. N.Z. Department of Trade and Industry, Wellington. 242 p.

Discussion

Mr Jarman (N.Z. Fishing Industry Board, Wellington) asked whether the cost of establishing hatchery and reseeding facilities was prohibitive, and Mr Cosh replied that it would certainly be expensive. He said it would cost $1–1½ million for a hatchery which could produce 1 million 10-cm juveniles per year. He suggested that the hatchery would have to do other work besides producing snapper fry.

Mr Sherley (Port Fisheries Limited, Whangarei) said he wanted to comment on costs in relation to a Japanese fish farm which his brother had visited recently. He said that the size of freezer needed for a 25-cage farm would cost $1½–2 million here. He also said that the Japanese market was not as big as some people believed and that as little as 4 t of fresh chilled fish from New Zealand could depress the price. He said there were already 2000 fish (about 2 t) going on the market daily, and fish farming could bring the Japanese prices down.

Mr Ritchie (Fisheries Management Division, Whangarei) said that the growth rate of farmed fish would be slower here than in Japan, where it took 2¼ years from fertilised egg to 900-g fish; the same sized fish in New Zealand was 7 years old. Mr Mace (Fisheries Management Division, Nelson) added that South Island fish grew faster and that the 1-kg size could be reached 2 years earlier. He said that snapper generally grew faster in cold water, because there was more food available.

Mr Ritchie also observed that 30c per kilogram for trash fish was too low; trash fish was becoming increasingly valuable and a minimum of 60c per kilogram was more realistic.

Mr Lockley (N.Z. Fishing Industry Board, Wellington) said he had gained the impression that the most expensive part of the process might be producing rotifers to feed the young fish, but Mr Cosh had been talking only of the cost of food for the adults. Mr Cosh explained that the cost of feeding the juveniles was reflected in the price of 50c each for 10-cm fish, where the buyer was paying for the food on which the fish had been fed. Dr Smith said that 50c each was the price quoted recently in Japan for hatchery produced fry weaned on to trash fish. He added that this might not be a realistic price economically, since the government-run hatcheries subsidised the price and a private hatchery might have to sell at higher prices.

The question of the Japanese market was raised again, and it was suggested that if 4 t of fish could depress the price, nobody would spend millions of dollars establishing a fish farm.

Mr Boyd (Fisheries Management Division, Auckland) reiterated that the whole of management, including economics, social costs, etc., needed to be looked at. The market was assumed to be there, but there was a need to look at the effects on the fishery of supplying farmed fish. Would the price of all fish drop? If reseeding were carried out, would more boats be needed to catch the extra fish? Such factors as these needed to be evaluated right at the beginning.

Mr Lynch (Fisheries Management Division, Wellington) pointed out that there would be difficulty in getting juveniles by catching wild stocks, because under present legislation a 4-in (10-cm) mesh net was the smallest allowed for catching snapper and this would not catch juveniles. Dr Smith said that in Japan a special licence could be issued for a limited time for catching juvenile stock. Mr Lynch said that this could probably be done here as well.

Mr Jarman said that the highest price received for many of our types of fish was for the sashimi market and this market was of limited size because people had to eat the fish quickly once they had bought it. He suggested that it would not take much extra fish to create a "dumping" effect. Mr Boyd suggested that there was only a certain number of dollars to be spent on fish, and even if twice as much fish were produced, we might get only the same total number of dollars. Mr Jarman reminded him that promotion was possible, which Mr Boyd accepted, but added that to market a product to get more revenue, something else might have to be displaced, and this should be considered carefully. He suggested that it might be better to supply less and get more money for it, with which Mr Jarman concurred as long as other people supplying the same market did the same thing. He added that the domestic market was crying out for snapper, but that promotion was needed to persuade people to pay more for it.

A question was asked about legislation concerning mesh sizes in purse-seine nets, as a lot of snapper had been caught in purse seines, and it was suggested that purse seiners might target fish for young snapper. Mr Boyd said that beach seines would be much more suitable for this purpose, because the water where the juveniles could be caught would probably be too shallow for effective use of purse-seine nets.

Mr Cosh observed that farmed fish seemed to be considered less desirable than wild fish. The Japanese used special foods to improve the colour of the flesh before marketing, but this seemed an expensive way to make them salable. Mr Sherley said that farmed fish did fetch quite good prices in Japan in comparison with our wild fish. Mr Jarman cautioned that, in considering prices, it was important not to confuse maximum prices with average prices.

The afternoon was devoted to discussion of 5 topics: the Marine Farming Act, environment, reseeding, diet, and marketing. Each topic was introduced by a short paper before being opened for discussion by workshop participants.

Marine Farming Act 1971

T. W. Lynch

Fisheries Management Division,
Ministry of Agriculture and Fisheries, Wellington

THE establishment of any marine farm comes under the authority of the Marine Farming Act 1971 and its amendments. Under the Act **farming** means the breeding, cultivating, and rearing of fish, shellfish, sponges, or marine vegetation. **Fish** means any species of fish, shellfish (including oysters), or sponge and includes their young or fry or spawn.

The farming of snapper is allowable, but under the present provisions of the Act all fry would have to be bred particularly for farming or reseeding either by the individual farmer or by a commercial hatchery operation for later resale to the farmer.

Leases and licences

> Under section 4A of the Act, every person commits an offence who, whether for the purposes of sale or not, farms any area that is not a leased or licensed area.

Once a source of stock is established, you will have to look carefully at what type of tenancy you will require for your farm site. The Act provides for the Minister of Agriculture and Fisheries to grant leases and licences in respect of specific areas of foreshore or sea bed (including the water column above the sea bed), within the limits of New Zealand's territorial sea and internal waters.

Lease. A lease confers on the lessee the right to carry out marine farming within the specified leased area, as well as exclusive possession of the specified area. This means that the area is tantamount to private property, and nobody may pass over, under, or through the leased area.

Licence. A licence confers on the licensee the right to carry out marine farming of nominated species within the specified licensed area, but does not give any rights of possession. This means anybody may pass over, under, or through the licensed area or fish for species in that area that are not licensed for farming.

> Under section 3 (5) (a) of the Marine Farming Act, the Minister of Agriculture and Fisheries cannot grant a marine farming lease or licence without the concurrence of the Minister of Transport.

The Ministry of Transport considers a site in terms of navigational safety and maritime public interest. Present policy of the Ministry of Transport is to concur with licences only for proposed marine farms in deep, navigable waters. The rights of navigation are therefore maintained.

In my opinion, to protect snapper farming you would need a lease, both to protect yourselves and the public from undue accident with cage culture or problems of access with netting of a particular area. With this in mind, site selection within the areas that are biologically suitable becomes extremely important if you want to avoid conflict.

Site availability and suitability

Before granting a lease or licence, the Minister **must** be satisfied that the proposed farm will not:

- interfere unduly with any existing right of navigation;
- interfere unduly with commercial fishing;
- interfere with any existing or proposed usage for recreational or scientific purposes of the foreshore or sea in the vicinity;
- otherwise be contrary to the public interest or adversely affect unduly the use by the proprietor thereof any land adjoining or in the vicinity of the area or the interests of the holder of any mining interest in such land.

Although the above criteria are statutory considerations under section 7 of the Act and are investigated in depth by MAF, they should also be taken into account by any prospective applicants. You would then have immediate knowledge of possible objections being made against the application and the likelihood of the application succeeding. The harbourmaster concerned, fishermen's association, local authority, maritime park board, and adjoining land owner are all good contacts with whom your proposals should be discussed.

The Ministry of Agriculture and Fisheries is conducting a series of planning exercises in various areas to define where marine farming should or should not take place, and in some areas this could help you with site selection. However, all these exercises have been conducted with shellfish farming in mind.

Snapper farming appears to have greater potential for conflict than other forms of farming because of the likelihood that you will need to totally alienate an area from public usage.

Similarly, under the Town and Country Planning Act 1977, planning over water can also be carried out by local authorities, harbour authorities, or maritime authorities, and it can be incorporated as part of their district and regional schemes. You may need to inquire at the appropriate MAF office at an early stage to see whether there are planning restrictions to local authority proposals.

Application procedure

Application forms are available from any MAF office with application procedure instructions (*Fishdex No. 12*). There is a $100 application fee when making a marine farming application. Once your application has been received, it will be checked to see that all the requirements of the Marine Farming Act 1971 have been met. You will then be advised that you may go ahead and mark the area applied for, notify certain bodies of the application by registered post, and publish the notices advertising the application.

Once the advertisements have been published, you must allow 2 months in case somebody wishes to object to your application. Anyone who does must also give you a copy of the objection. The applicant has a further 28 days in which to reply to any objections that have been received.

> The above requirements and periods of time are mandatory under section 6 of the Marine Farming Act.

Consideration of applications

After the objection and reply period has passed, your application will be investigated in terms of section 7 of the Act. This particular section sets out the criteria which the Minister must consider before granting any marine farming tenures. The time taken to carry out the investigation varies from application to application and depends on factors such as the number of objections received and their grounds, the location of the site, and the number of applications being processed at that time.

The next step is to obtain the Minister of Transport's concurrence under section 3 (5) (a) of the Act. The application is then placed before the Minister of Agriculture and Fisheries for his decision.

If your application is declined, you will be advised of this, with the reasons why it has been turned down.

Granting of lease or licence

If your application is successful, you will be advised of this in the form of an "offer". This means that you have been granted a lease or licence, and this has been offered to you subject to the submission of certified survey plans of the area to be leased or licensed. If you accept the Minister's offer, you will need to engage a registered surveyor to prepare the necessary plans. These plans identify the boundaries of the farm by survey and are recorded by the Department of Lands and Survey in much the same manner as parcels of land.

Once the plans have been received, the lease or licence documents are drawn up and sent to you to examine and sign. The documents are then signed by the Minister and entered in the appropriate register.

Note that each licence or lease is a binding contract between the Crown and the farmer and contains numerous conditions, particularly that you will commence development within 2 years and usually that development will be completed within 7 years, and that the farm will be managed in an efficient manner. If this is not done, any tenure can be forfeited back to the Crown.

Approval of gear placement

If you are granted a lease or licence, you will need to obtain approval before any gear or equipment is placed in the water. Such approvals are required under sections 30 and 31 of the Marine Farming Act and relate to the provisions of section 178 of the Harbours Act 1950, to ensure that equipment such as anchors, chain, and floats do not constitute possible navigational hazards. Such approval is usually given by the local harbourmaster or the Ministry of Transport.

> The only exception to the above requirement is for structures erected in an area leased for the purposes of rock oyster farming.

Research or pilot commercial schemes

Under section 14 (b) of the Act an applicant can also be granted a licence for research or a pilot commercial scheme. The procedure is basically the same as for an ordinary licence, but no objections are involved. However, this section was designed primarily for shellfish farming and the areas allowed to be licensed for research or pilot schemes are minimal, about 2 ha. If you wish to do experimental work, a better approach would be to request a Special Fisheries Permit under section 77 (B) of the Fisheries Act, which covers any contingency that may arise.

Discussion

Mr Ritchie (Fisheries Management Division, Whangarei) asked whether MAF promoted aquaculture in general, and water use for aquaculture, enough; and if it didn't, how this could be done. Mr Lynch replied that he didn't know. He said the Marine Farming Act was designed to promote aquaculture, but that other water uses had to be reconciled as well. He continued that the Act was to be revised next year and that submissions for change were being accepted.

Mr Ritchie responded that it seemed to him that aquaculture was not being promoted in a way that suggested that it was a best use of water. It was a non-extractive, conservationist use, and he was sure a large number of recreational fishermen would be sympathetic, but at present they regarded it as a bogey as did other members of the public.

Mr Jarman (N.Z. Fishing Industry Board, Wellington) said that the Fisheries Act was being revised and would have its first reading next year, and this would have to be done before the Marine Farming Act could be changed. He said that submissions would be invited through MAF and FIB and that would be the time to consider making the legislation reflect what could and should be happening.

Mr Begg (Sanford Limited, Auckland) asked why applications for leases and licences took so long to process. Mr Lynch replied that this was partly because of the legislation, but it was made worse by lack of facilities and the work was to be regionalised to speed things up.

Mr Mace (Fisheries Management Division, Nelson) asked whether, if someone had an existing licence for farming mussels, this could be amended for farming other species, say scallops or snapper. Mr Currie (Fisheries Management Division, Wellington) replied that all that was needed was to apply for a variation of a lease or licence. The form of tenure didn't matter; it was merely necessary to justify that you could do what you hoped to do. Another species name could be added to the licence.

Mr Boyd (Fisheries Management Division, Auckland) said he got the impression that it would be more difficult to get a licence to culture snapper, and he wondered why this would be so. Mr Lynch replied that shellfish were grown in areas which were not used by the public so much because they were not navigable areas, but snapper were more likely to be farmed in areas where passage was required.

Mr Boyd then asked what were the important things it was necessary to know in relation to snapper farming licences. Mr Lynch listed these as where it was practical to grow the fish from a biological point of view, the availability of processing facilities, fitting in with other water users, and adjacent land use. Mr Boyd said he thought the legislation should address the possible conflicts, not the technical problems. The viability of farming should be up to the applicant.

Mr Jarman pointed out that though people waiting for mussel farming licences were concerned about the delay, the inertia in licence issuing had at least led to some semblance of rational growth in mussel farming. He said that economic and technical feasibility did need to be looked at to some extent. Licences should be granted only to applicants who looked as if they would be able to make a success, and they should be made to use the licence. The public had seen the proliferation of oyster and mussel farms, some of which had been neglected, and this did not create a good image.

Mr Mace cautioned against being too selective in the issuing of licences, because some farmers had succeeded in spite of initially looking as if they would not.

Mr Boyd said he would not like to see these things built into the legislation because it would become too rigid. He felt the legislation should deal only with procedures, and only the minimum number necessary. Policy could be developed to deal with the applications, to sort out which applicants should have priority.

Mr Jarman commented that in Japan the system seemed to work because of fisheries co-operatives, which were largely controlled by the industry.

Mr Lockley (N.Z. Fishing Industry Board, Wellington) queried the distinction that had been made between a lease and a licence and wondered who decided which was granted. He observed that the mussel farmers in the Marlborough Sounds were on licences, but that leases seemed to be a better proposition. Mr Lynch explained that the lease-licence question was largely determined on the access to the farm site. The oyster farms in the north were on leases because people could get access to them and so the farmers needed protection. The Ministry of Transport did not want to grant leases for deep-water farms because they wanted to preserve navigational rights through these areas. Mr Lynch suggested that this might have to be changed and Mr Jarman added that it was important when formulating legislation to remember that we were dealing with the present, and pieces of legislation should not necessarily be perpetuated just because they had applied in the past.

Mr Lloyd (Taylors Fisheries Limited, Thames) raised the subject of mining. He said that a marine farm could be destroyed by mining on adjacent land and that priorities needed to be sorted out before marine farms were set up. Mr Jarman agreed that there was major concern in respect of town and country planning and mining legislation. He posed the question of whose legislation would prevail. He said the Minister of Fisheries should have the final say on matters relating to fisheries, and submissions had been made to this effect. Legislation to protect the economic interests of one group from the activities of another must be made, but it might be difficult in the national interest to justify a ban on, say, gold mining to save a single mussel farm. There would need to be provision to compensate marine farmers if they were affected by mining.

Mr Lynch said it was unlikely that mining activities would be curtailed for the sake of other interests.

Mr Ritchie commented on marine reserves and said he didn't see marine farming and marine reserves as being antagonistic; in fact there could be a category of marine reserves aimed at encouraging or allowing marine farming.

Mr Currie said that if the Marine Farming Act were amended, it would retain seniority over the Town and Country Planning Act, which was passed in 1977, but if a new Act were prepared, it would become subservient to the Town and Country Planning Act, and so marine farming would then be directed as to where it might or might not occur, in terms of this latter Act. This should be borne in mind in planning for marine farming.

Environment

Philip Tortell

Commission for the Environment, Wellington

AMONG the topics for discussion, this one appears to be the most open to wide interpretation. We could discuss the environmental requirements of the organisms being farmed; we could cover the potential conflicts between snapper farming and other users of the environment; we could identify the environmental impacts of fish hatcheries and fish cages; or we could talk about the process of environmental evaluation as it applies to prospective fish farmers.

I would like to address myself to the conflicts which prospective marine farmers are likely to face and suggest a mechanism by which some of these conflicts may be resolved.

Conflicts

The internal waters and territorial sea of New Zealand are vested in the Crown and have traditionally been considered common property, with the exception of some Maori owned waters of historical significance. The right of unrestricted access to and from the foreshore, the freedom to navigate on any water, the right to anchor and seek shelter, and the right (within certain conservation limits) to fish or gather shellfish for personal use are enjoyed by all New Zealanders. These rights and freedoms permit all uses of water that do not have an obvious impact on its quantity or quality. Among these uses are swimming, sunbathing, recreational fishing, rowing, sailing, power boating, water ski-ing, and scuba and skin diving. Any restriction of these rights is bound to be strongly resisted.

This attitude, however, is not realistic, since it is inevitable that the concept of land use planning must be applied to marine resources in the not too distant future. Areas of sea and sea bed are already being reserved for specific uses; for example, ports and harbours for commerce and navigation, restricted areas for national defence purposes, marinas for the mooring and servicing of pleasure craft, marine reserves for scientific study, and sewage outfall areas for the disposal of wastes.

Therefore, though access to and enjoyment of water resources are every New Zealander's inalienable right, this right has already, albeit unwittingly, been restricted. Aquaculture is a further threat to these freedoms and as such it is opposed often on principle.

Conflicts do not occur only in direct water use. Because of the inevitable impact of land use on water, there are conflicts between activities on land and the farming of fish in coastal waters.

Intensive primary production as practised in New Zealand depends on a continuous and high input of fertilisers, pesticides, and other chemicals to control the many problems that plague monocultures. A large proportion of these artificial chemicals, especially when applied by aerial spreading, sooner or later gets into watercourses. Waters that are so affected may not be suitable for aquaculture.

Sheep and cattle farms, even without the application of artificial fertilisers, are notorious non-point sources of enrichment. Within certain limits this may enhance aquaculture production. However, enriched waters tend also to encourage the growth of fouling organisms and in the long run may create more problems for the aquaculturist. Coliform counts are the traditional indicators of possible contamination. Since it may not always be possible to distinguish between coliforms of human origin, from farm animals, and from vegetation, aquaculture in the vicinity of farms may not be permitted because of high (but possibly inconsequential) coliform counts.

An established forest normally leads to an enhanced water quality within its catchment. But when the area is first cleared for planting, and later when the trees are harvested, the ground is extremely vulnerable to erosion. Vast amounts of topsoil and silt can be washed into rivers and on to estuaries with the resultant high turbidity and eventual siltation that can adversely affect some forms of aquaculture. A further potential conflict between forestry and aquaculture is to be found in areas where road access is poor and the timber must be taken out by rafting or by barge. Marine farms other than on the sea bed will create a barrier and impede the export of logs from the area.

Horticulture does not normally provide the ground cover associated with an established forest or pasture and the loose, rich soil can be carried away by rain as well as wind. Apart from this impact on water quality and the leaching of pesticides, which are used more intensively in horticulture, there is also an impact on water quantity. Fruit, vegetables, flowers, and other crops often require irrigation, normally at a time when rivers are naturally low. The abstraction of water for irrigation can have a drastic impact on the river biota and seriously impair down-stream uses. Decreased river flow volumes may also influence the physical configuration of estuaries.

Four out of 5 New Zealanders live in urban areas, most of which are on the coast; the others are usually situated on a river, not far from the coast. Residential development in urban areas, as well as in holiday resorts or for weekend accommodation, may conflict with aquaculture. The most obvious clashes are access, navigation, aesthetics, and interference through curiosity, but these are not insurmountable and can often be resolved by careful planning. More serious are the possible restrictions placed on the developer or home owner because of the presence of aquafarms. For example, some forms of waste disposal may not be permitted because of their potential impact on marine farms.

There are nearly 50 sewage outfalls into the coastal zone around New Zealand and twice as many into river systems. Most discharges are treated to some degree, but a few consist of raw, untreated effluent (Table 1). The New Zealand Department of Health is not against the disposal of effluent into rivers and coastal waters, since it is of the opinion that such discharges do not have a significant impact (Thorstensen 1980). However, in the interest of public health, the presence of a sewage outfall precludes any swimming, fishing, and marine farming. The Commission for the Environment has questioned the wisdom of relying on the sea for waste disposal (Tortell 1980).

Residential development has another impact on water quality and aquatic organisms. Neilsen and Nathan (1975) found a high concentration of lead in green-lipped mussels, *Perna canaliculus,* from areas adjacent to urban development. They could only attribute this to the input of lead from motor vehicle exhaust and from anti-corrosive roof paints, carried into the coastal zone through storm-water drains.

TABLE 1: Treatment and disposal of sewage in New Zealand

Treatment	River system	Lake	Estuary, harbour, ocean outfall	Land irrigation
Raw effluent	6	0	7	0
Screening Comminution Holding tanks	7	1	14	0
Imhoff primary treatment	19	4	11	0
Oxidation ponds Activated sludge Trickling filter	67	2	15	15

Although certain uses of water are mutually exclusive, others can be accommodated together. Similarly, there need not always be conflicts between land use and water quality. Identification of potential incompatibility and careful planning can resolve many conflicts.

Planning to prevent conflicts

Since natural waters are basically public property in New Zealand, and since the granting of a marine farming licence is, in effect, transferring ownership to a private individual, it is just that each application should be carefully scrutinised and evaluated. The existing process was outlined by Currie (1974) and is illustrated in Fig. 1. The process is long and takes a minimum of 30 months at present. It is also unsatisfactory, since it does little to mitigate public antagonism to marine farming. Aquaculture in New Zealand seems to be automatically and irrationally opposed on principle. The granting of a marine farming licence is seen by many as a capricious act by the Ministry to donate public areas for selfish exploitation by an individual. This unfortunate state of affairs is caused by the absence of an aquaculture development plan, the lack of public participation to date in the process of planning for marine farming, the denial of any right of appeal after the Minister of Fisheries has decided whether to uphold or reject an objection, and a general lack of appreciation of the food value and export potential of aquaculture products.

It is heartening to note recent moves to establish the credibility of marine farming in New Zealand (Hickman 1979, Jarman 1981). However, the case for aquaculture, in the face of competing uses of water, is at present so weak that in any planning exercise marine farming is reluctantly tolerated only in those areas which are of little use for anything else. Thus, areas made available for aquaculture are not always suitable.

It is essential that MAF undertake a comprehensive survey of the coastal zone with the object of determining which areas are suitable for marine farming. Only by taking such an initiative can MAF expect to make a strong case for marine farming when planning is undertaken for coastal zone uses. The findings of such a survey can be made public on a regional basis and public discussion encouraged.

A process similar to the environmental evaluation procedure could then be followed in which the public is invited to make submissions to a "neutral" agency. If MAF is not considered a neutral agency, the Commission for the Environment could possibly assume this role. Having received submissions from local authorities, government departments, and

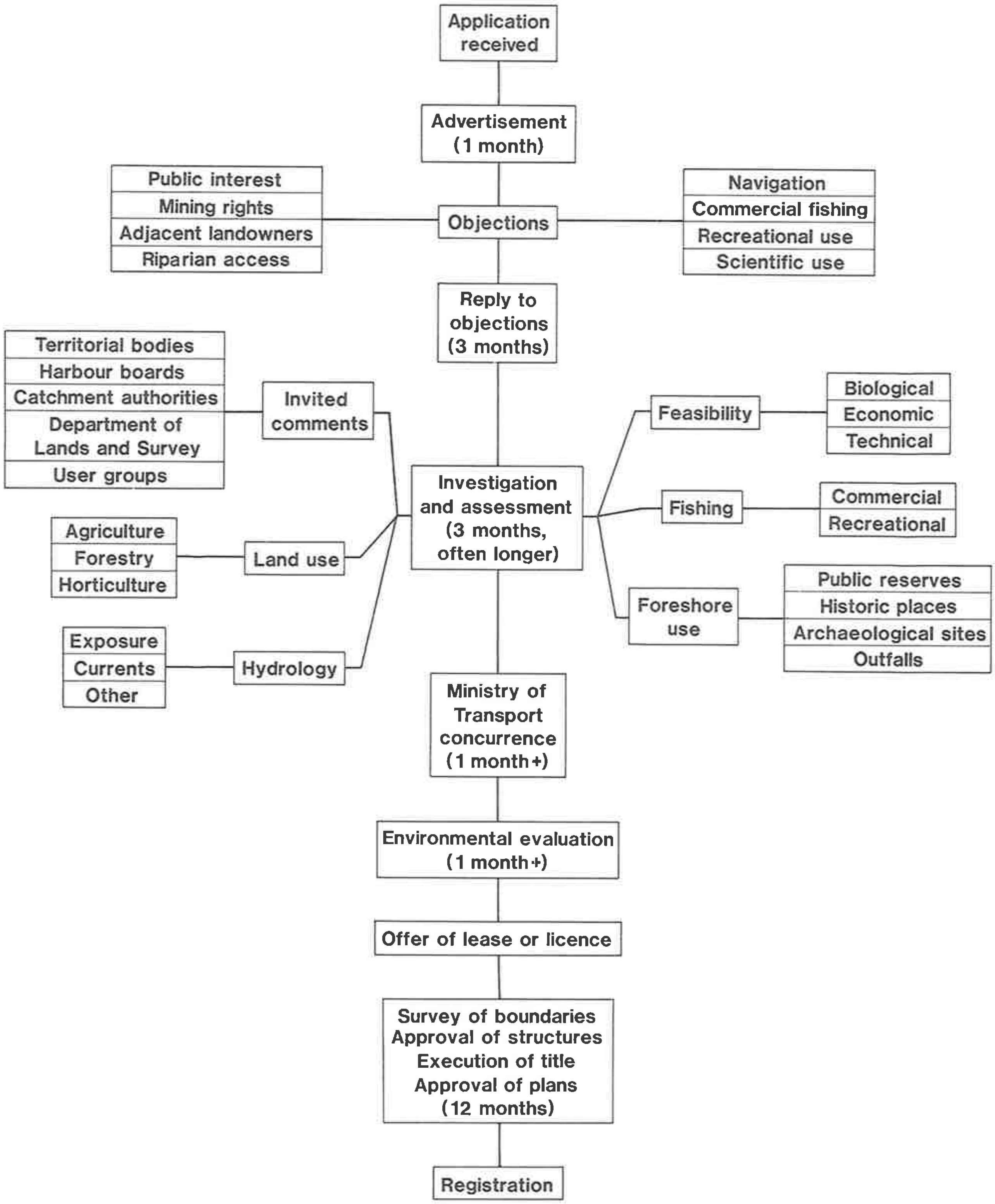

Fig. 1: Processing of an application for a marine farming lease or licence (after Currie 1974).

members of the general public, the neutral agency will make recommendations to the Minister of Fisheries. The Minister will then publish plans for the development of marine farming in particular areas. Such plans will establish the potential of the coastal zone for food production and take into account other demands. They will also provide decision makers with a more accurate idea of the value of a stretch of coast.

Conclusions

New Zealand is endowed with a long and varied coastline, rich in resources (Tortell 1981). The use of the coast has traditionally been for recreation. However, many other uses are possible and marine farming is one of them.

The antagonism directed at marine farming could be reduced if the industry made a stronger case for it as a legitimate use of coastal water capable of producing food and other products.

Such a case would rest on a thorough nationwide survey of the potential for marine farming and a plan for farming derived after public debate.

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Discussion

Mr Ritchie (Fisheries Management Division, Whangarei) suggested that if MAF, or any other body, said certain areas were suitable for marine farming, many people would apply "just in case", and areas would be taken up by people who were not using them or by big companies. Dr Tortell agreed that there probably would be some danger of this, but that at present areas were used unnecessarily for other things. He repeated that MAF should say which areas were **suitable**, not which were **available**, and then other aspects of maritime planning should also be taken into consideration to decide which areas were to be used.

Mr Mace (Fisheries Management Division, Nelson) said that a planning process had been used in the Marlborough Sounds, but he felt that it was rumours of big money to be made in mussel farming that had encouraged people to rush in, rather than statements that certain areas were available. He added that planning was now being done by the maritime planning authority under the Town and Country Planning Act and that this body was looking at areas already in use and also extending to the Golden Bay-Tasman Bay area.

Dr Tortell stressed that it was essential that MAF should plan for marine farming development before people started taking licences.

Mr Boyd (Fisheries Management Division, Auckland) said that public objections were often to the idea of a lot of marine farms, whereas 1 or 2 might be acceptable. It might not be suitable to have a lot of farms because of market possibilities, and so the market should be investigated first. The public might agree if the economic benefit to the country could be demonstrated, but at present the prevailing belief was that marine farmers made a lot of money for themselves.

Mr Jarman (N.Z. Fishing Industry Board, Wellington) said he found it difficult to see how the various areas of legislation would overlap. The Fisheries Act would allow for management areas, but it was not clear how these would affect marine farming. Individuals might meet to discuss matters and so become aware of others' requirements, but they would still be representing their own vested interests and would not necessarily reach a consensus. Someone would have to make a resolution which took into account the various views. A neutral agency would end up making value judgments. Dr Tortell answered that the role of the neutral agency would be to evaluate the information it received and make recommendations. Local or national politicians would have to make the final decisions. He added that the public elected the politicians, and the public could be educated about the recommendations by the neutral agency.

Mr Jarman said that the benefits and lack of disadvantages of marine farming needed to be promoted so that the public could make informed decisions. Dr Tortell added that it was not the image just of marine farming, but of the industry itself that needed to be promoted, so that people could see the benefit to the nation as a whole.

Mr Jarman continued that concern had been expressed about the Town and Country Planning Act. The suggestion was that, in the absence of an understanding on the part of the people making decisions, or because they were in turn reflecting the pressures that were put on them, the decision-making processes should be decentralised. He was personally in favour of greater public involvement, but not of too much power being given to the public when they didn't have all the facts. Dr Tortell responded that public participation did not necessarily mean public power and that the public would not make the decisions unless they had an overwhelming case; but nevertheless, they should be educated by marine farmers, conservationists, and so on to appreciate these areas of interest. The public could then participate in the process of informing those elected to make decisions, and this would mean local politicians, if they had power under the Town and Country Planning Act.

Mr Boyd advised that under the Town and Country Planning Act the Minister of Works and Development had the final say in approving regional schemes, and so there was ultimate central control. Mr Currie (Fisheries Management Division, Wellington) added that the Minister's approval was subject to appeal and also that a regional scheme only gathered together things to be considered in a district scheme, rather than directing what should be done.

Mr Mace pointed out that regional schemes covered land use and water use out to the limit of the 12-mile territorial sea and so this would give some protection to the water from land use.

Dr Smith (Fisheries Research Division, Wellington) said that concern had been expressed about the lack of an aquaculture policy, and Dr Colman

(Fisheries Research Division, Wellington) replied that MAF was developing one. He also commented that the power of the people should not be underestimated, if the current attitude to trout farming was considered.

Mr Lockley (N.Z. Fishing Industry Board, Wellington) said that part of the difficulty arose from the belief in some quarters, even by some of the people on maritime planning authorities, that regional bodies set up by the Town and Country Planning Act had overall control. This was not so at all; the Minister of Fisheries was the only one who could make a final decision about who was allowed to fish in which areas and where marine farming could take place.

Dr Tortell concluded that maritime planning, regional planning, etc. provided a guide for decision makers as to which areas were suitable for which pursuits.

Reseeding

L. J. Paul

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I WOULD like to look at 2 aspects of reseeding snapper, with particular reference to the Hauraki Gulf. The first is, why reseed? Is the Hauraki Gulf overfished? And the second follows on from that: if reseeding is considered desirable, how many fish should be released each year?

Why reseed?

The word reseed implies that the natural supply of seed (that is, juvenile snapper) is poor, perhaps as a consequence of overfishing, and must be boosted by the addition of hatchery reared juveniles. I do not believe this is so in the Hauraki Gulf, and I will present some information from recent studies on the Auckland commercial fishery and from annual trawling surveys of juvenile and adult snapper in the gulf (1976–80) to try to clarify the present position.

We should first define juvenile and adult snapper. The normal life history sequence of fish is: egg; larva (with yolk sac); post-larva (without yolk sac); pre-juvenile (some juvenile features not yet developed, perhaps still transparent); juvenile (fins, scales, colour pattern developed, though these may still differ from the adult, sexually immature); and mature adult. The post-larval and pre-juvenile stages are not well known in snapper. Juvenile snapper are recognisable at about 25 mm, when in shape and colour pattern they are similar to adults. They mature at the end of their third year, though they may not spawn significantly until the following year. Growth rate (and hence size at maturity) varies with locality; Figs. 1 and 2 and Table 1 provide some information on seasonal and regional variations in the growth rate of juvenile and small adult snapper. Length-weight relationships of small snapper are given in Table 2. In the Hauraki Gulf I classify fish up to 24 cm as juvenile, and fish 25 cm and over as adult.

There is now reasonably clear evidence that snapper year-class strengths are related in some way to spawning season temperatures. Warm springs produce strong year classes which a few years later increase the commercial catch rates. Cold springs are followed a few years later by poorer catches. We can use this relationship to calculate a theoretical catch rate of snapper from about 1940 to about 5 years beyond the last available temperature measurement (Fig. 3). (Predicted catch rate is an index of adult snapper abundance calculated from data on growth and mortality rates, age structure of the gulf stock, and variable recruitment from spawning season temperatures; this index is provisional only, being derived from an on-going research programme.) There was quite good agreement between this predicted catch rate and the actual catch rate until the mid 1970s, when catch rates continued to fall, or at least hold steady (the commercial catch data are unreliable) instead of rising as predicted. The years 1979–81 were predicted to produce bumper catches. I

TABLE 1: Regional variations in growth rate of snapper; values are averages and only approximate

"Age"*	Fish length (cm) Hauraki Gulf	Bay of Plenty-East Cape	West coast, North Island
1	10	10	13
2	16	16	22
3	21	21	29
4	24	26	33
5	26	29	35
6	28	31	37
7	30	33	39
8	31	35	40
9	32	36	42
10	33	37	43

*Modal sizes reached by age groups in the successive winter-spring periods (July-November) of minimum growth.

TABLE 2: Length-weight relationship of juvenile and small adult New Zealand snapper

Length (cm)	Weight (kg)	Length (cm)	Weight (kg)
10	0.03	25	0.36
11	0.04	26	0.40
12	0.05	27	0.45
13	0.06	28	0.50
14	0.07	29	0.55
15	0.09	30	0.60
16	0.10	31	0.65
17	0.12	32	0.71
18	0.15	33	0.78
19	0.17	34	0.85
20	0.20	35	0.92
21	0.22	36	0.99
22	0.25	37	1.07
23	0.28	38	1.16
24	0.32	39	1.24

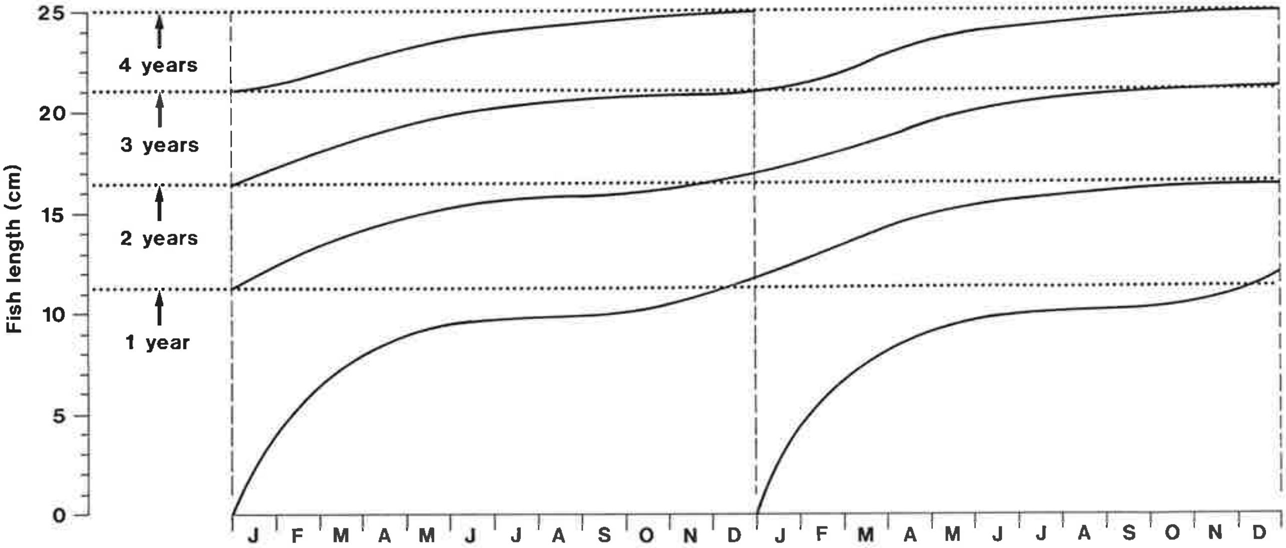

Fig. 1: Seasonal growth rate during the first 4 years of life of juvenile snapper in the south-western Hauraki Gulf (*Ikatere* data). This growth rate is among the lowest observed for naturally occurring snapper.

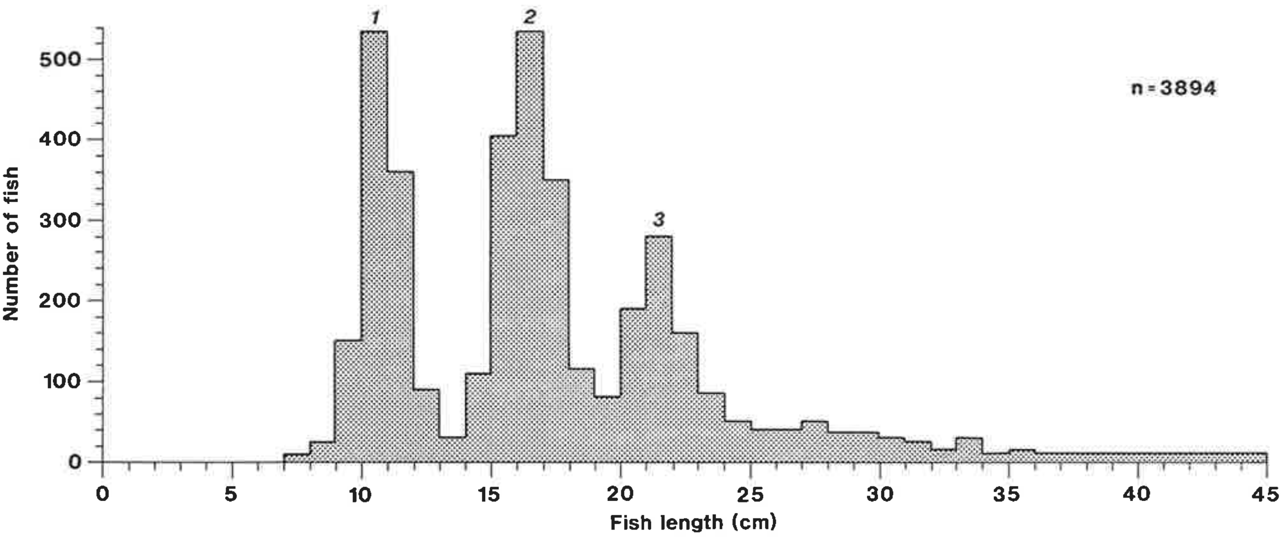

Fig. 2: Size range of a sample of snapper (combined from 5 stations) from the south-western Hauraki Gulf, showing modal sizes and degree of size overlap of the first 3 age groups (*Ikatere* data).

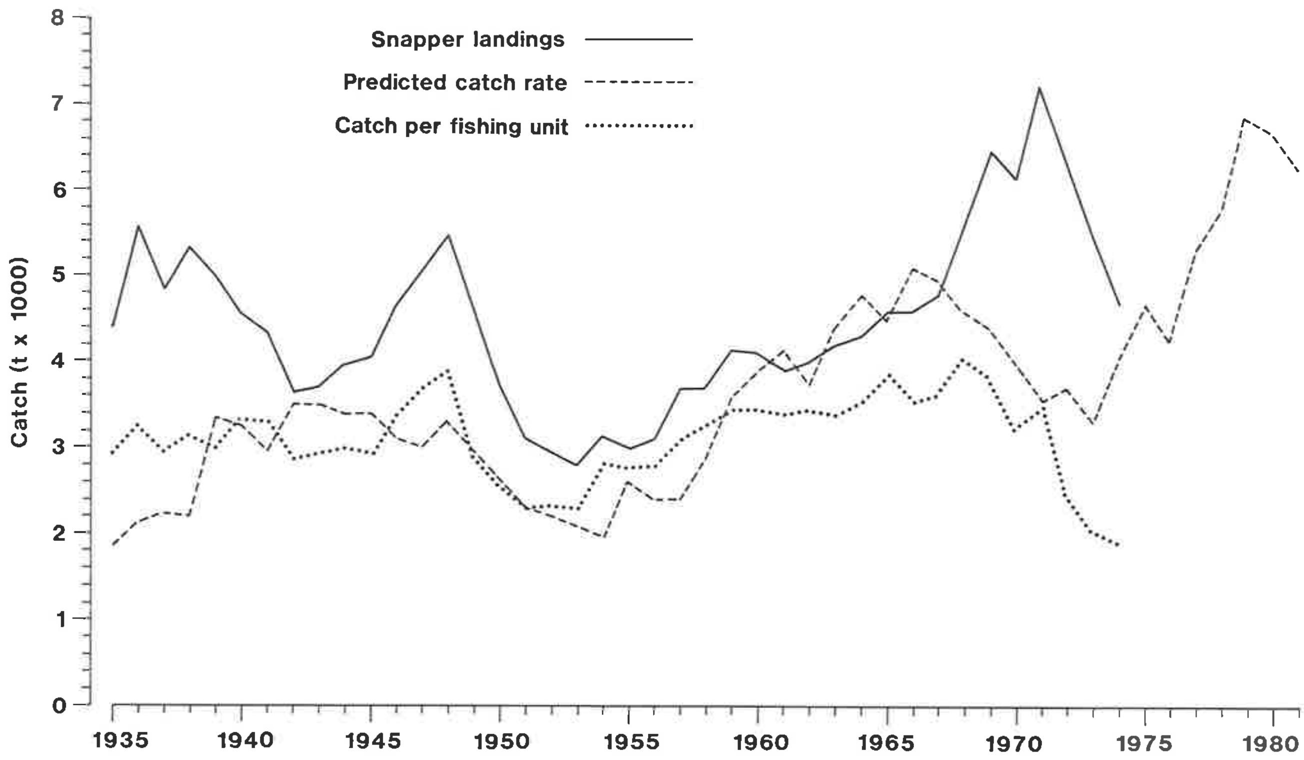

Fig. 3: Snapper catches and landings at Auckland, 1935–74. Landings are the recorded landings at Auckland. Catch per fishing unit is catch per fishing vessel registered at Auckland, with some allowance made for the different fishing power of trawlers, Danish seiners, and line and net vessels.

believe there are 2 reasons why they did not. First, the high catches centred around 1970 were taken from a declining stock, and though catch rates declined in the mid 1970s, profitability was sustained through high export prices. Second, there was a significant increase in boat numbers and fishing pressure through the 1970s, so that individual catches remained low; the resource was being shared among more people. In spite of my generalisation to the contrary above, I will concede that the central and outer gulf trawl and Danish-seine grounds (the open gulf), at least, have been overfished.

My juvenile snapper surveys in the gulf have covered the years 1975–80, that is, the period when the stock should have increased, but apparently did not (Fig. 4). A summary of catch rates is given in Fig. 5. For all 35 stations in the inner and outer gulf, **adults** appear to have increased in recent years, with a peak in 1979, which is not very different from my earlier predictions. Most of this increase, however, occurred in those parts of the gulf closed to trawling and seining; 22 localities in the central and outer gulf (that is, over half the total) showed very poor catches during this time. **Juveniles** have also increased. Recent year classes are among the strongest ever recorded in the gulf, which is not unexpected in view of recent warm years.

Differences in the catch rate of snapper during the 3 annual surveys in 1978–80 in closed and open areas of the gulf are shown in Fig. 6. Although there are some low catch rates in the closed gulf, the general trend for both juvenile and adult fish is for catch rates to be much higher in the closed gulf. The most significant feature of this is that the catch rate of adults falls off much more rapidly in the open (outer) gulf than does that of juveniles. Catches in the 5 surveys of 1976–80 show that the catch rate of juveniles in the open gulf is 22%–50% of that in the closed gulf, whereas that for adults is only 4%–9%.

Another set of observations on Hauraki Gulf juvenile snapper is relevant here. We did a trawling survey of the gulf in 1964 and repeated it with a similar net (granton trawl), and at the same time of year, in 1980. Adult snapper declined to a quarter of their earlier level, but juvenile snapper increased. A second 1980 survey was made with a modern wing trawl, which returned adult snapper catches to the 1964 level (Fig. 7). The point to be stressed is that

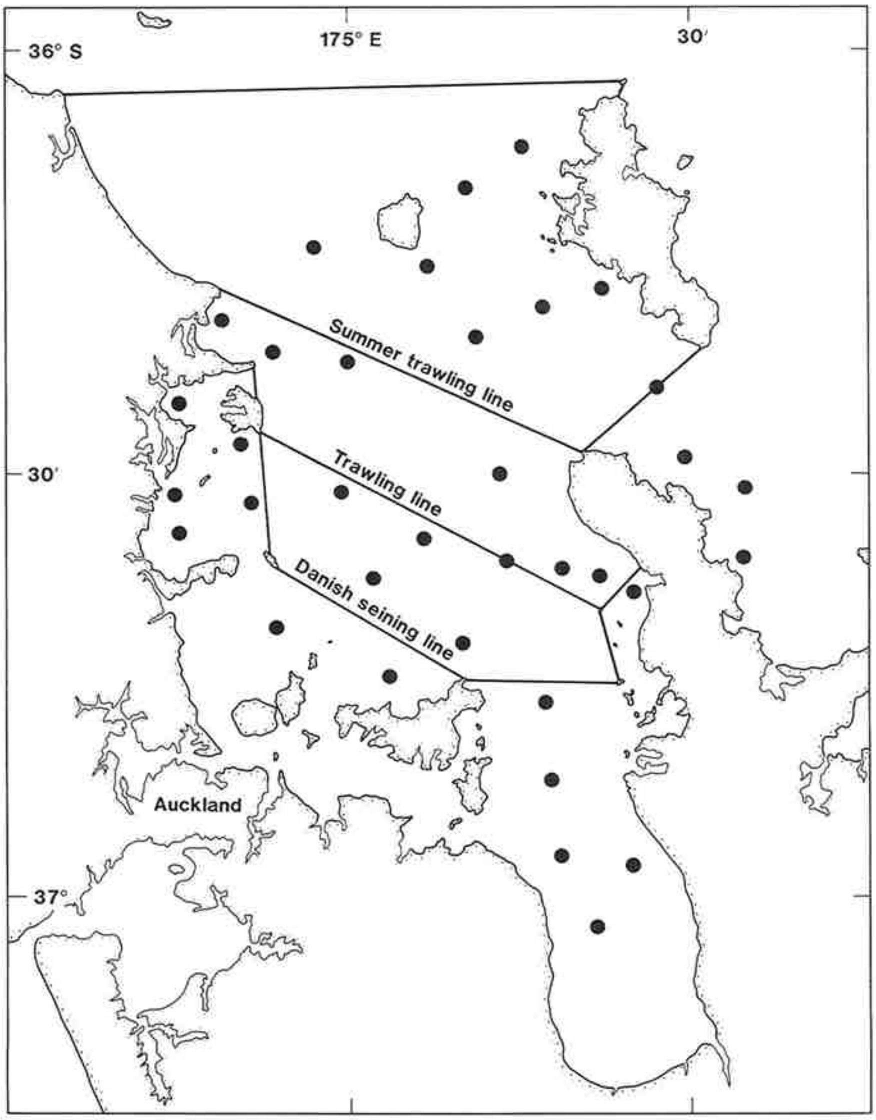

Fig. 4: The Hauraki Gulf, showing the trawling and Danish-seining lines which separate the commercial fishing areas 005, 006, and 007, and the central positions for *Ikatere* trawl stations in the 1976–80 juvenile snapper surveys. The Danish-seining line separates "closed" from "open" gulf stations.

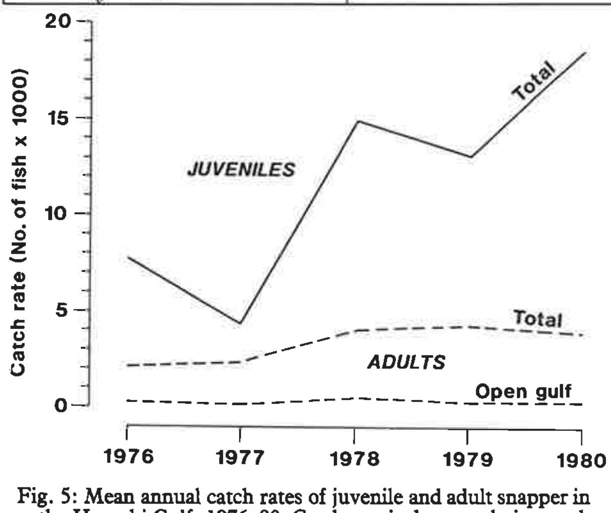

Fig. 5: Mean annual catch rates of juvenile and adult snapper in the Hauraki Gulf, 1976–80. Catch rate is the cumulative catch per hour in number of fish, at 35 stations for total juveniles and adults and 22 stations for adult open gulf snapper (*Ikatere* data).

adult snapper catches dropped from 1964 to 1980 and juvenile catches rose.

I interpret all this information as follows. The total stock of adult snapper in the gulf has dropped over the last 10–15 years, though not by as much as the recent poor catches by trawlers and seiners in the open gulf would suggest. There are still large stocks of fish on inshore grounds. Juvenile snapper numbers have at least held their own and have probably increased.

There are 2 phases of overfishing. The first is **growth overfishing,** in which the adults are reduced, but spawning, juvenile production, and recruitment are unaffected. The second is **recruitment overfishing,** in which the adult stock is reduced so low that spawning and the natural supply of juveniles are

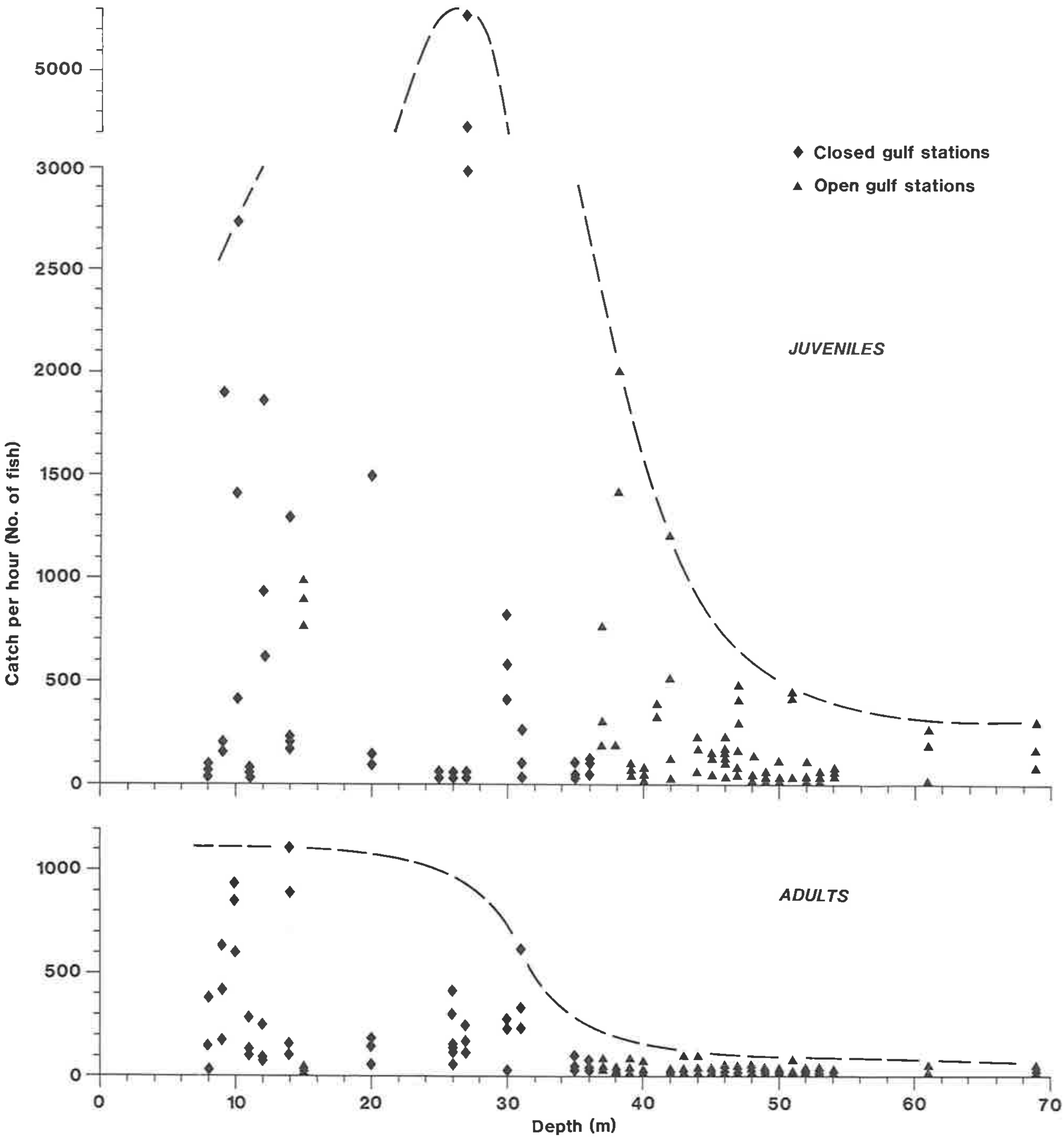

Fig. 6: Catch rates of juvenile and adult snapper at 35 stations in the Hauraki Gulf, 1978–80 cruises plotted individually (that is, 3 points for each station) at increasing depths (*Ikatere* data).

harmed; it is at this stage that enhancement by hatchery reared juveniles should be considered.

Growth overfishing may have occurred in the gulf; if so, it should be remedied by reducing the fishing pressure. There is no evidence that recruitment overfishing has occurred or is even likely, and for this reason I believe it would be inappropriate to release snapper into the gulf.

The release of juveniles into other areas where there are fewer naturally occurring juveniles, such as

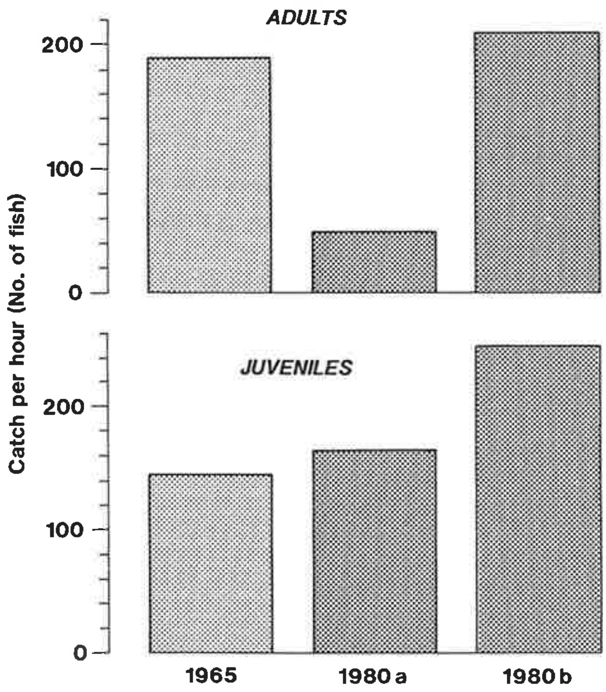

Fig. 7: Catch rates of snapper at 27 Hauraki Gulf stations in 1965 and 1980 (*Ikatere* data).

Hawke Bay and Tasman Bay, is, however, another matter. Although it seems to be more reasonable at first sight, there are other factors, such as competing fish of other species, to consider.

How many?

The second aspect of reseeding snapper to be considered is, how many? I do not claim that the following figures are accurate, but they give an idea of the sort of calculations that must be done before reseeding is considered as a reasonable proposition. We would presumably be releasing fish in their first year of life; so we need to consider how many fish of this age naturally occur in the gulf. This can be done in 2 ways:

1. From trawling surveys by *Ikatere*. Her catch rate is 50–400 0-year fish per hour, or per 0.025 square nautical miles. With an inner gulf nursery ground of about 1000 square nautical miles, we must multiply the catch rate by 40 000 to get a total count (or the standing stock). At 50 fish per hour, the standing stock is 2 million 0-year fish. At 400 fish per hour, the standing stock is 16 million fish. The outer gulf nursery grounds could add another 25% to these figures.

2. From proportional analysis of the commercial catch. Four-year-old snapper, 26 cm and 0.4 kg, make up 10% of the commercial catch by weight. The optimum yield for the gulf has been estimated at 4000 t, of which the 4-year-olds would weigh 400 t. At 0.4 kg per fish, this represents 1 million fish. If 10% of the natural population is caught, 10 million 4-year-olds must occur naturally.

It is worth noting that the calculation by Crossland (1980) of a 55 000-t biomass of snapper from planktonic egg data corresponds well with these figures. A 10% total mortality (the value currently used for snapper) would yield a catch of 5500 t, close to recent values.

To calculate back to the number of 0-year fish, we would need to know mortality rates over the first few years. These are unknown, but likely to be moderate and to result in a reduction of 2 to 5 times; this would give 20 million to 50 million 0-year fish.

To have any impact on the commercial catch, at least 10% of the existing number would have to be reared and released. Taking the central figure of 20 million natural 0-year fish obtained from the 2 methods above, some 2 million young snapper would have to be reared for release. And the cost of doing this would have to be less than the added catch value; that is, less than 10% of the natural commercial yield from the gulf.

Reference

Crossland, J. 1980: The number of snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand, based on egg surveys in 1974–75 and 1975–76. *Fisheries Research Bulletin, N.Z. Ministry of Agriculture and Fisheries, No. 22.* 38 p.

Farming and reseeding in the northern South Island

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THE only significant stocks of snapper in the South Island are found in Tasman Bay and the Marlborough Sounds. The Tasman Bay snapper are migratory, most of the catch of adult fish being taken during the October to January spawning run into the bay. The present annual catch is controlled, by quota, at about 750 t. The Marlborough Sounds also contain a significant stock of snapper, which is important to both amateur and commercial fishermen. Most of the commercial catch there is taken in the winter trawl fishery in Pelorus Sound.

Recent tagging work (Mace and Hadfield, unpublished data) suggests that there is limited intermixing of the snapper of Tasman Bay and the Marlborough Sounds. Although it is not known where Tasman Bay snapper go outside the spawning season, the lack of tag returns suggests they are not heavily exploited in their winter range.

Snapper in Nelson and Marlborough waters grow faster than those in more northern stocks and appear to have an annual natural mortality rate of less than 10% (Sullivan and Mace, unpublished data).

The size of snapper year classes varies considerably from year to year. The year class from the 1960–61 spawning is particularly noticeable, as it resulted in a large increase in trawl landings in 1965–68 and still contributed about 25% by number of schooling snapper sampled in 1978. The eventual size of a snapper year class is probably determined by the survival of juvenile snapper in their first few months of life, which in turn is probably influenced by environmental conditions, especially temperature after spawning (Paul 1976). This suggests that the size of the snapper stock could be considerably increased if the survival of young fish was improved.

Reseeding

Several features of the Tasman Bay snapper fishery would be advantageous in a trial reseeding venture:

- The fish have a faster growth rate than those in other areas.
- Most of the snapper is caught as target species in a fairly small area, over a short period, and so the fishery is potentially easily controlled.
- Almost all snapper caught in this fishery is handled by several large fish processors in Nelson and Motueka; so if it was necessary to recoup reseeding costs, these could be easily recovered.

The enhanced stock would have to be well managed, as the economic return from money invested in reseeding would need to be maximised. Management would entail controlling the size of the first exploitation of the fish and the rate of exploitation of the stock to achieve the maximum yield (by weight or value) of wild and hatchery reared fish.

Farming

The enclosed waters of the Marlborough Sounds are ideal for marine farming. Present developments are based on the green-lipped mussel, though a commercial trial of scallop farming is being undertaken.

Cage culture. Much of the water area has been designated as not available for marine farming. An area of about 1000 ha is available, most of which has been applied for by mussel farmers. It is likely that any new developments with surface structures will be restricted to these areas. Thus the decision of any holder of a marine farming licence as to whether to grow snapper or mussels would be an economic one, though there are some areas where mussel production is depressed (probably as a result of limited water movement), and these may be more suitable for snapper than mussels.

The possibility of farming snapper and shellfish on 1 marine farm is attractive, as the shellfish could use uneaten food from the snapper farm. Separation of the 2 species would be necessary, as snapper are major predators of small mussels.

Closed bay fish farming. The Marlborough Sounds area contains many inlets suitable for this sort of farming. There would, however, be strong objections to the leasing of whole bays from existing users of the area. Two applications for the licensing of whole bays in the sounds for shellfish farming have been made, but the outcome of these is uncertain.

Reference

PAUL, L. J. 1976: A study on age, growth, and population structure of the snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand. *Fisheries Research Bulletin, N.Z. Ministry of Agriculture and Fisheries, No. 13.* 62 p.

Discussion

Mr Boyd (Fisheries Management Division, Auckland) suggested that more 0-year fish would have to be released than Mr Paul had indicated, and Mr Paul responded that his numbers had been scaled down somewhat, but certainly huge numbers of fish would be needed to get results. Mr Boyd continued that he had done some calculations and that, based on the weight of fish at the end of the first year and on published mortality rates, if 1 million fry were reared to 30 g and released, by the time they were recruited to the fishery as 5-year-olds, they would supply about 60 t of additional fish. To increase the commercial catch by 10%, about 350 t would be needed, and this would represent enormous numbers of fry.

Dr Colman (Fisheries Research Division, Wellington) inquired whether a large number of juveniles would mean a decreased growth rate, and Mr Paul agreed that it probably would. He said that in areas of the Hauraki Gulf with large numbers of juveniles, a slower growth rate had been observed. Mr Boyd confirmed that in fish stocks with variable year classes it had been found that when there was a large year class the growth rate of the individual fish was a little slower. It appeared that competition for food depressed the growth rate in very abundant year classes.

Mr Begg (Sanford Limited, Auckland) raised the subject of the line across the Hauraki Gulf, inside which fishing was not permitted. He said there were plenty of fish on the closed, inner grounds and he wondered how they could be persuaded to move to the outer grounds, where they could be caught. He asked whether, if enough fish were put into the inner grounds by reseeding, some would move out. Mr Paul said that some probably would, but of the fish now on the inner grounds, many did not move out naturally except when they moved to the spawning grounds.

He returned to what Mr Boyd had said earlier, that more effective management of existing stocks would be the best solution. He said that little was known about the juvenile mortality rate, but it was almost certainly very high, and even at the most optimistic return rates, reseeding did not seem worth while. Mr Begg said that as no one had tried it, it could not be dismissed on the grounds that it wouldn't work. Mr Boyd agreed that we would not know until we had tried it, but it was an expensive venture and there was a need to assess the prospects first. On the scale at which we could afford to do it, it would probably not be much use. The other alternative, that of managing the fishery, should be tried first because it was cheaper. The total catch in the outer gulf was not much less than it had been years ago, but there were many more boats now, which had resulted in too many boats chasing too few fish.

Mr Begg then asked about the west coast, where there was not the same problem of too many boats. Mr Paul answered that there was not much information about the west coast, but there were fewer fish in general there. Year classes were relatively stronger and relatively weaker than in the Hauraki Gulf. He suggested that perhaps reseeding could be tried in Tasman Bay, where spawning was good only in warm years. Strong year classes were separated sometimes by up to 10 years and perhaps numbers could be made up by reseeding in bad years. He cautioned that though superficially this sounded all right, there might be some biological factors that would defeat it. For instance, in colder years when snapper didn't breed so well, other fish, such as red cod, blue cod, spiny dogfish, etc. might predominate, and if snapper juveniles were released, they might have to compete with these other fish which were doing well naturally. This could lead to poor survival of the snapper.

Mr Ryan (BP Chemicals NZ Limited, Wellington) asked Mr Paul what correlation he had between juvenile and adult snapper in the Hauraki Gulf. There seemed to be a lot of guesswork, and he presumed that laymen looked to MAF to provide statistics.

Mr Jarman (N.Z. Fishing Industry Board, Wellington) said he would like to point out that accurate returns were often not available to MAF. The Hauraki Gulf was a particularly bad area for this, and researchers had to make assumptions based on known catches to try to work out actual catches. Mr Paul conceded that assumptions were made, but said the alternative was to do nothing at all. As a comment on the correlation between adult and juvenile fish, he said it was often possible to fish an adult stock down to quite a low level before juvenile production was affected. In the Hauraki Gulf there was a large stock of adults in areas where they were not available to commercial fishing, and these were providing the juveniles. There had been warmer years recently, which had resulted in good juvenile production. The juveniles moved out into the fishery at about 4 years old and then they were heavily fished by trawlers and Danish seiners.

Mr Jarman said that, despite all the uncertainties, more work had been done on the Hauraki Gulf snapper resource than on any other fishery in New Zealand. He reiterated that sound management was necessary and suggested that management should be from an economic viewpoint rather than a biological one. He maintained that if management ensured that individual operators were all right economically, biological management would take care of itself. Mr Boyd said that as a basic premise it must be accepted that the fish came first and the economics second. There was no point in developing economic policy if the fish were not there to catch. Mr Jarman agreed, but maintained that if the catch rate of the individual unit were economic—not necessarily making large profits—the resource would automatically be preserved.

Mr Mace wondered whether reseeding would be done on a user-pays basis. He suggested that if fishermen had to pay 50c per fish in licence fees to cover the cost of releasing the juveniles, and if only 10% of the juveniles released (at a cost of 50c each) were eventually caught, the economics did not look good.

Mr Boyd said reseeding should be considered and not just ruled out on economic grounds, because there might be investment potential in increasing production. Snapper provided 25% or more of the total value of wetfish caught in New Zealand and for that reason alone it was worth trying to see whether production could be increased. However, he said that one concern from a management point of view was that if a reseeding programme were undertaken, we might think we were doing some good, but we could not afford to take risks with the natural stocks. The aim of reseeding was to increase the total production, not just keep it at the same level.

Dr Colman said that attention seemed to have been concentrated on the Hauraki Gulf, which might be the worst place to start, because there were plenty of juveniles there already. Would it not be better to look at some other area for reseeding; for example, the west coast of the North Island, where the growth rate was known to be better, or Tasman Bay, where recruitment was uncertain and erratic. Mr Mace agreed that it would be better to undertake reseeding where it could be monitored, where there was a limited number of boats and fishermen. He said no one would know what was happening in the Hauraki Gulf because there were too many boats there. Mr Boyd concurred that this was a further reason to work elsewhere. He said it would be preferable to use a small, fairly discrete stock of fish and there would be a better opportunity to measure results somewhere like Tasman Bay or Hawke Bay.

Dr Smith (Fisheries Research Division, Wellington) said it should also be considered that a multispecies hatchery would be preferable, and in Tasman Bay this would tie in with paua reseeding. Paua spawned in winter and snapper in summer. Mr Paul added that if an aquaculture facility were developed somewhere like Tasman Bay, it should cover a variety of species. It would probably not be worth while for snapper alone, but in conjunction with other species it might be more reasonable. Snapper reseeding could be done for some year classes, but in intervening years other species would be more important.

Dr Smith said he had given a depressing picture of returns in Japan, but the figures were based on a 3-year experiment in which fish had been tagged. He suggested that when more was understood about the ecology of the release sites, returns could probably be increased.

Mr Mace asked if there was any better figure than 50c for producing fish of releasable size. Dr Smith said that about $200,000 per year would be required to produce large numbers of juveniles for release programmes. Salaries were the most expensive item for established hatcheries; even in commercial hatcheries expert staff were needed because certain skills were necessary to rear the fish.

Mr Lockey (N.Z. Fishing Industry Board, Wellington) said he thought that reseeding should not be a thing in its own right, but rather a part of fishery management. Plenty of arguments had been advanced to support the view that the overall management situation suggested that reseeding was not necessary.

Mr Paul suggested that there might be public goodwill towards establishing a reseeding facility; properly promoted, it could become a public asset. Perhaps it could eventually give rise to something like the marine equivalent of an acclimatisation society, to look after the sports fishery.

Mr Lockley wondered whether young snapper could be planted in an area where there had never been a snapper fishery before. He thought it was highly improbable, but perhaps not entirely impossible. Mr Paul said that, for example, there were very few juvenile snapper in the Firth of Thames and perhaps reseeding could be tried there.

Mr Ritchie (Fisheries Management Division, Whangarei) asked where the juveniles were. He said that in many years of diving on the north-east coast and doing harbour fish survey work he had seen very few juveniles, but the adults were ubiquitous. Mr Paul agreed that the juveniles were not often seen, but he thought they were in deeper and dirtier water than that in which divers usually swam. He said they were out at 20-odd fathoms in the Hauraki Gulf.

Mr Cosh (MAF Economics Division, Wellington) asked whether there was any possibility of gathering small juveniles, rearing them to a larger size, and then releasing them, rather than having a hatchery to produce the juveniles. Mr Paul said this could be done, but if juveniles were caught, it would be better to fatten them on than to release them again. Catching 1-year-old fish, growing them for about 18 months, and selling them as pan-size, prime fish would make good sense biologically, if the economics were right. There was a surplus of juveniles, but it would be difficult to convince the public that this should be done. Mr Boyd agreed that it would be a sensible thing to do, but if there were just 1 bad year of fishing, this activity would be blamed for it.

Diet

K. J. O'Sullivan

BP Chemicals NZ Limited, Wellington

OUR occupation, as present or potential aquaculturists, is the conversion of cheap protein into expensive protein. Commercially it is most important to obtain a ready supply of palatable feed which the fish will utilise fully and fatten on quickly, without hazard to fish health or pollution to the environment.

It is as true for fish as for any other organisms that they are what they eat. If we feed our fish any old rubbish, we run the risk of producing rubbish fish with off flavours; and nobody will buy them. I present the following anecdotes to illustrate the attention we must pay to diet:

- I visited several dozen trout farms in France recently with a fish veterinarian and on each farm the fish exhibited a wide range of symptoms, of viral diseases, bacterial diseases, ectoparasites, and gut parasites. On most farms the standard of fish husbandry was very high and the likely cause of these problems appeared to be the particle size of the feed used for the young fry. This was slightly too large and had produced gut irritation, which in turn led to a halt in feeding. This was followed by general debilitation, which allowed disease organisms to cause further problems and finally death.

- In Europe 1 or 2 years ago there were fish kills in a number of trout farms. The cause was traced to toxins present in the feed originating from 1 supplier (fortunately not BP Nutrition). Within their factory the problem was found to be an employee who had urinated in a corner of the raw materials silo. This caused an increase in bacterial action which led to toxins in the feed, which in turn killed the fish.

I propose, in this paper, to examine briefly the feed types we are likely to use when growing snapper in New Zealand. I shall not be concerned here with the early larval stages in hatcheries, for which a complex of food must be established: algae as feed for rotifers, which are fed to the very small fish, or *Artemia*, which are fed to the fish when they are a little larger. This area of diet is naturally extremely important, but I prefer here to discuss the feeding of older fish with prepared diets in contained culture farms.

The basic feeds in use today are fresh fish (minced or whole), dried concentrates (generally fishmeal based), and the fairly recently introduced fish silage (also known as liquid fish protein).

Fresh feed

The simplest method of feeding carnivorous fish is to use fresh feed. If the farm is near a supply of readily obtainable, cheap fish and has good frozen storage facilities, this feed type is often preferred. If the feed fish are small, they may be thrown whole to the stock in the cages. Mincing whole fish provides a feed more acceptable to the stock and a further refinement is the addition of binders and vitamin premixes to achieve a stable, uniform, soft, moist pellet.

However, there are drawbacks to using fresh feed:

- Frozen storage is generally required, as a daily supply of freshly caught feed is unlikely to be available.
- The distribution of fresh food is not uniform; the stronger fish eat at the expense of the weaker.
- Disease introduction from uncooked minced or whole feed can be a severe problem.
- The water is rapidly polluted, as all of the feed is not used and large quantities may drop through the cages to the sea floor.

Dry feed

Many of the drawbacks mentioned above have been solved by the use of dried feeds:

- Storage is easier. The feed must be kept cool and dry, but has a shelf life of several months if stored away from sunlight.
- Distribution of dry feed can be by way of automatic feeders delivering an optimum quantity of feed at preset intervals. The growth of fish can be closely monitored and tied in with the amount of feed used to provide accurate conversion ratio data.
- Dry feed is sterilised to remove all chances of disease introduction from the feed. Medicated dry feed is also a convenient way of administering accurate quantities of drugs for disease control.
- There is little water pollution, as all the feed is used. (If a buildup of feed under cages is observed, too much feed is being offered.)

Figure 1 indicates the range of pelleted feed available for rainbow trout in Europe. Dry feeds, if

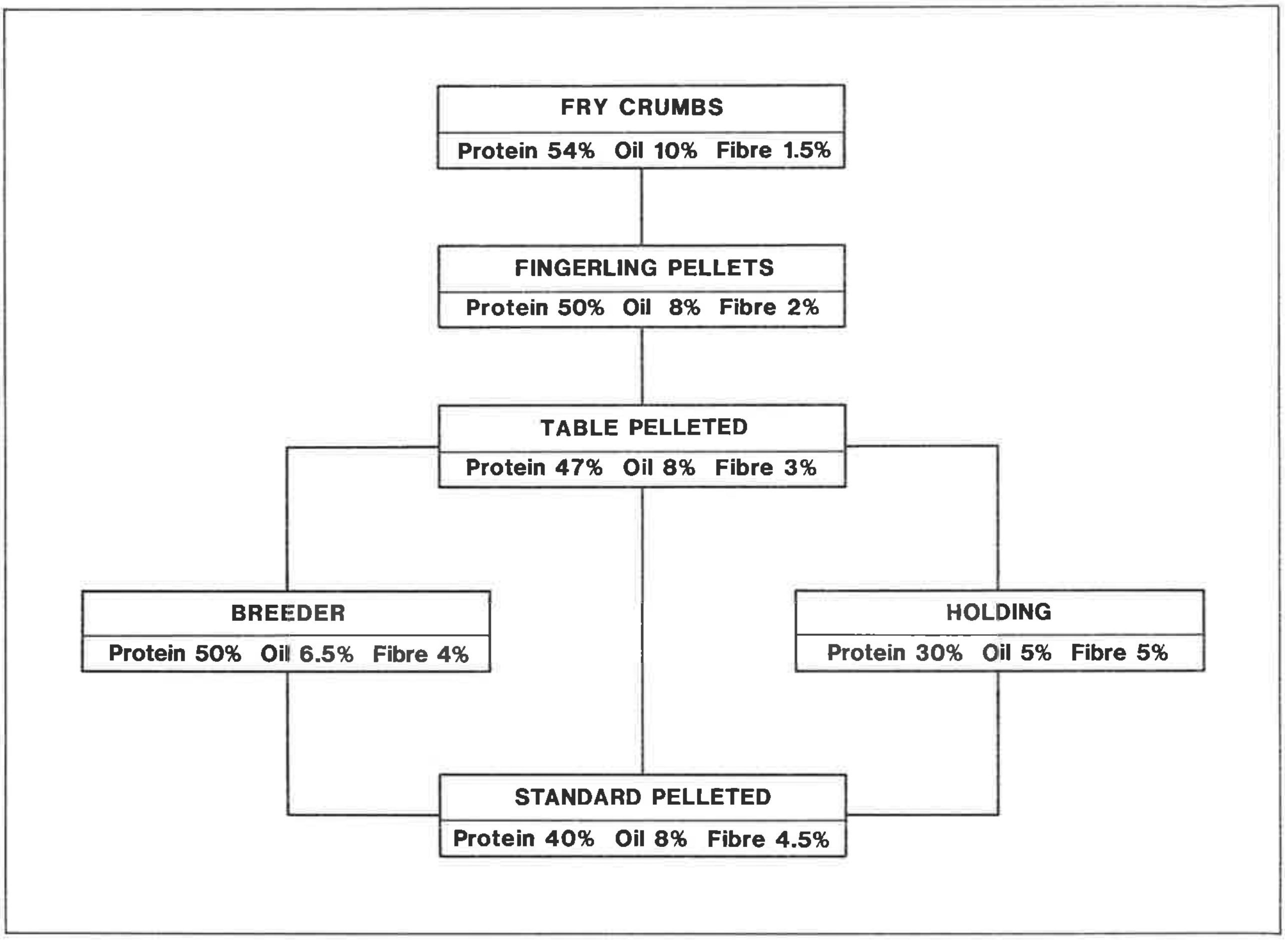

Fig. 1: Types of feed pellet available.

they are to be compounded in New Zealand for snapper, would also have to be produced in a similar variety of sizes and types.

The main thrust in the development of fish feeds in Europe is towards maximising the growth efficiency of each constituent of the hard pellets used in fish farming. Figure 2 shows what researchers are aiming for in achieving the goal of a perfect fish food.

Liquid fish protein (fish silage)

Fish silage is a feed which, in energy terms and usefulness, lies between dry feeds and fresh feeds. It is described by Torry Research Station as "a liquid product made from whole fish, or parts of fish, that are liquefied by the action of enzymes in the fish in the presence of an added acid. The enzymes break down fish proteins into smaller soluble units, and the acid helps to speed up their activity while preventing bacterial spoilage".

There are some advantages in using fish silage:

- The feed may be produced at the fish farm by use of simple equipment (Figs. 3 and 4). The raw material—whole fish frames and guts—is minced and "Bio-Add" (3.5% of 85% formic acid) is added and mixed in thoroughly. The acidity is checked and should be pH4 or lower to prevent bacterial action. The ensilage action takes about 2 days at 20 °C, but the time is increased considerably at lower temperatures.
- A further advantage is that the silage can be kept for up to 2 years.

Liquid fish protein is predominantly used as a substitute for fishmeal in rainbow trout, cattle, pig, and chicken feeds. At present 25 000 t is used in Denmark and about 10 000 t in Poland, but very little elsewhere.

This type of feed also has drawbacks:

- It is a liquid and therefore more difficult to transport and store than fishmeal.

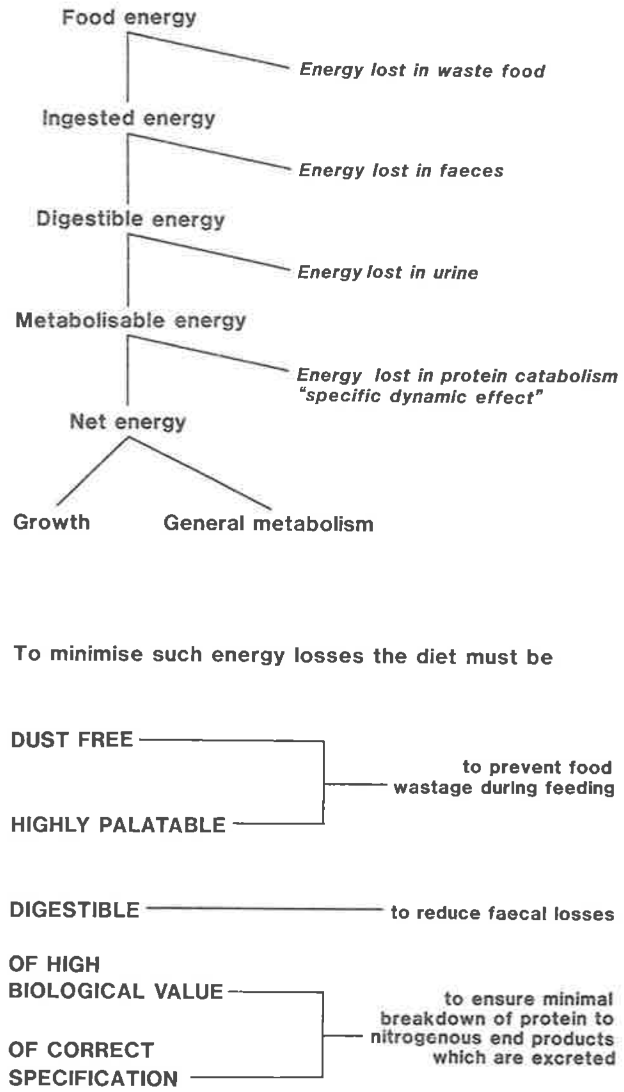

Fig. 2: Energy needs in fish diets.

- It contains only 25% of the amount of protein in fishmeal, though the silage could be condensed.
- If oily fish is used, the oil must be centrifuged off, as it speeds putrefaction.
- Formic acid may not be the most appropriate acid to use, as it may remove lycine from the silage. Studies are being done in Norway on the use of other organic acids, and these may conclude in the production of a more satisfactory silage.

Feed and economics

The cost of the feed and the efficiency of the fish feed conversion to salable weight are most important considerations in determining whether growing snapper will be economic. Experimental work on saithe, cod, and turbot in Norway and Scotland indicates that these marine fish have similar conversion ratios. The conversion of wet feed to salable wetfish is about 8:1 to 10:1. (The conversion for fish silage is about 5:1 to 8:1.) So if wet fish feed is used, 8 to 10 kg of fish would be needed as feed for every kilogram of salable fish.

Dry feed to wet weight conversion ratios are generally 1.5:1 to 2:1, which means that 1.5 to 2 kg of dry feed are needed to produce a kilogram of salable whole fish. Dry feed prices in New Zealand are about $1,200 to $1,500 per tonne. So a price of up to $3,000 would be needed at the fish farm gate just to pay for the feed.

A prime requisite before going into snapper farming in New Zealand should be the formulation of a suitable feed. This would be used as a base diet if its ability to supply adequate snapper nutrition could be demonstrated, and it could be altered in known ways to produce faster weight gain.

Having decided how sophisticated we wished to become in snapper rearing, we could:

- aim for fast-growth feeds (which would be very expensive);
- maintain growth at acceptable levels;
- use the cheapest possible fish feed which snapper would accept.

Each farmer must produce a feed cost-benefit analysis before determining feeding practice.

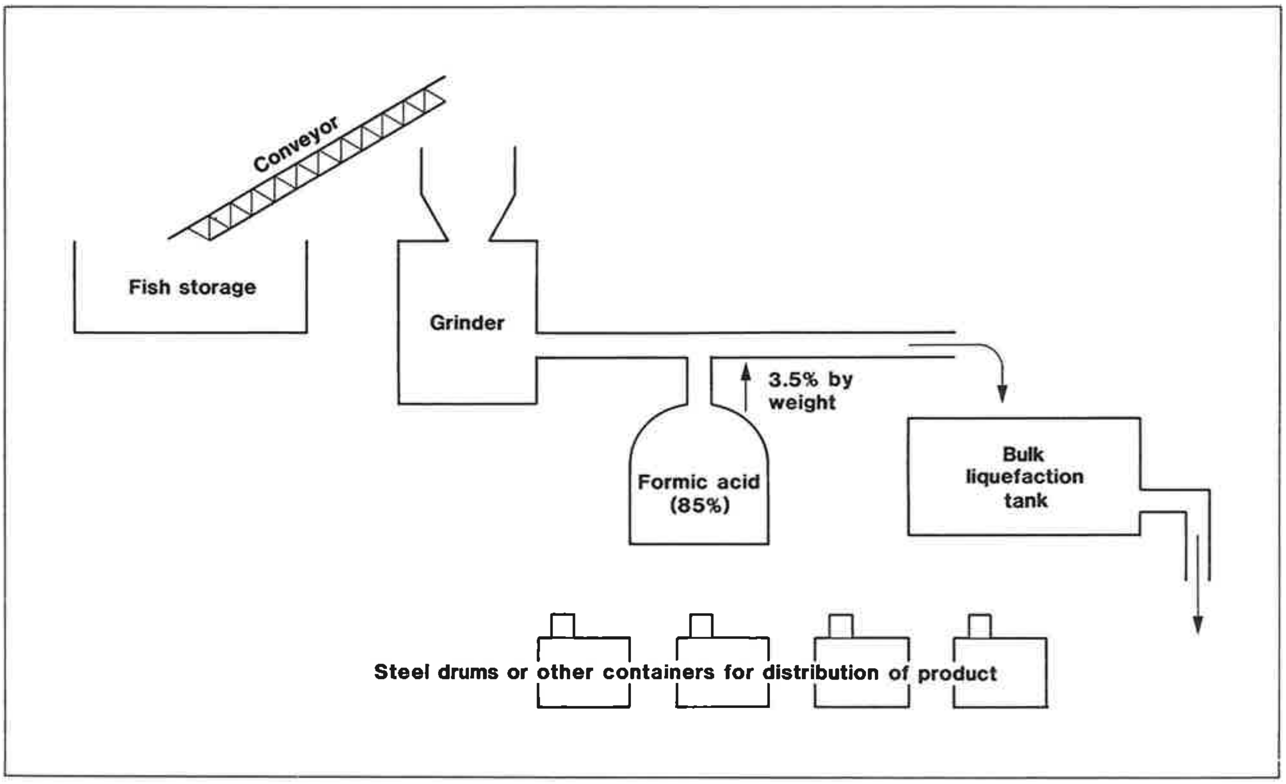

Fig. 3: Fish silage manufacture.

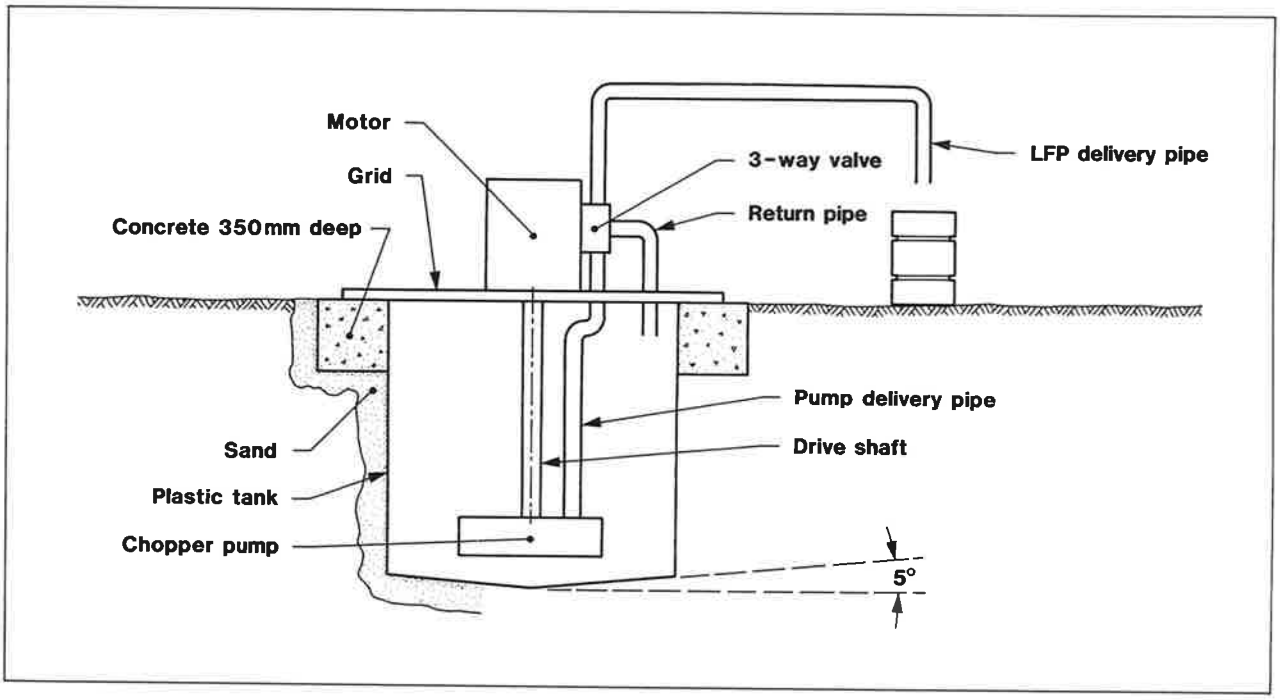

Fig. 4: BPN LFP 300 fish silage plant.

Discussion

In answer to a query about whether feeding of dry feed to marine fish would cause stress, Mr O'Sullivan said that stress was caused by changing the diet. If fish were accustomed to 1 type of feed, any change should be made gradually.

Dr Tortell (Commission for the Environment, Wellington) asked whether any other sources of protein had been considered, such as meatworks or oxidation ponds. Mr O'Sullivan replied that most data he had were based on European practices, and fishmeal was more readily available than other forms of protein in Europe, though some study had been done on milk wastes. More work was needed on nutritional requirements before other animal protein was used to formulate feeds.

Dr Smith (Fisheries Research Division, Wellington) inquired whether any pellet feeds were likely to be manufactured in New Zealand or whether they would have to be imported. Mr O'Sullivan said that general, all-purpose feeds were already being made, and more specific ones could probably be made if these were requested. Mr Lockley (N.Z. Fishing Industry Board, Wellington) added that quite a lot of work was done in the eel-farming days, and at one time soya beans were being considered as a food source.

In response to a query about how fish silage was fed to the fish, Mr O'Sullivan replied that it was pumped into the cages through plastic pipes. This led to some wastage and it was difficult to assess when too much was being fed.

Some discussion followed about the possibility of using mussels as food for snapper. Mr Mace (Fisheries Management Division, Nelson) suggested that blue mussels could be used, as they were not being used for anything else, but were just thrown back into the sea. Dr Tortell added that freshwater mussels could be grown in oxidation ponds and used for snapper food. Mr Jarman (N.Z. Fishing Industry Board, Wellington) said the mussels would need some processing before they could be fed to young snapper, and this would add to the cost. Mr O'Sullivan said that some form of storage would be required, and this would further add to the cost.

Dr Smith said that in Japan a range of pellets was available for feeding red sea bream, but the farmers did not use them; they used the cheapest trash fish available and added multivitamins and minerals, because the pellets were too expensive.

After more discussion about the various possible feeds, Dr Smith stressed that 1 food source needed to be elected, as fish growth rate slowed when the feed was changed, because the fish stopped eating. He agreed that pellets made of a mixture of foods could be used, and Mr Lockley pointed out that something similar to this was being done for feeding salmon and trout at MAF's Silverstream hatchery.

Mr Boyd (Fisheries Management Division, Auckland) asked if there was likely to be a problem with heavy metal contamination in concentrated feed. He said he had heard of this happening in Europe. Mr O'Sullivan replied that the Europeans tended to live with higher levels of pollutants than we would be prepared to consider, but if the concentration became too great, the manufacturer would go out of business.

Mr Paul (Fisheries Research Division, Wellington) asked Mr O'Sullivan if the fish he had seen were being fed different amounts of food in different seasons, because snapper in the wild had a natural feeding season in summer. Mr O'Sullivan replied that the fish were not fed in winter because their metabolism slowed down in cold water. Dr Smith said the Japanese snapper were fed once a day in summer and once a week in winter. The juveniles were fed 4 times a day when first put into the sea cages, to maintain a high growth rate. Mr O'Sullivan said that the fish he had seen were fed at dawn and at dusk in summer.

Marketing

Introduced by C. Begg, *Sanford Limited, Auckland*

Mr Begg prefaced his comments on marketing with a brief explanation of the reasons for Sanfords' interest in snapper farming. He said that increases in fuel costs were creating a situation where fishing companies could not afford to go looking for fish, and Sanfords saw snapper farming as the only viable alternative. Accordingly, they had set up tanks in an enclosed system, caught juvenile snapper (0–1-year-olds), and put them into the system to do feeding trials. However, problems such as pollution and stress had made it difficult to keep the fish alive. The plan now was to try growing fish in sea cages.

As for marketing, Mr Begg offered the opinion that farmed fish would be substituted for what was now caught, because in future companies would not be able to afford to catch fish because of fuel and running costs. He added, though, that there would always be a market for chilled, long-line-caught fish, as these were of premium quality. He said the main market was Japan, with larger fish going to Europe and smaller ones to the Pacific Islands and America. The demand would always be there, and the quality being put on to the market with farmed fish would be a lot higher.

Mr Boyd (Fisheries Management Division, Auckland) wondered whether MAF could do more to promote better productivity of individual fishing vessels. He said that fish tended to be in certain places because of environmental or other factors (he cited as a simple example the knowledge of where fish congregated for spawning), and fishermen had to find them. Perhaps MAF should try to give more assistance with finding fish, as this might be more cost-effective than fish farming. Mr Begg agreed that this was a good idea, but said it didn't work because fish were not in the same place even when conditions seemed to be the same. Mr Boyd suggested that subtle things in the environment might determine where the fish could be found; perhaps things that no one had looked for yet.

Mr Paul (Fisheries Research Division, Wellington) agreed that something needed to be done because of increasing energy costs, but he could not see why it was necessary to continue with current regulations. He felt that it was not sensible to enforce fishing by an unlimited fleet out on the worst fishing grounds. Strictly controlled fishing in the inner gulf would be better than fish farming. The public might not like it, but they might have to accept it because of energy costs.

Mr Begg pointed out that there were other advantages of getting into snapper farming. There was more certainty in processing with farmed fish; the quantity and size of fish were known, whereas you didn't know what the boats would bring back. Processing plant was very expensive and it was an advantage to know how many staff were needed, what equipment would be required, and how much fish there would be to be marketed.

Mr Jarman (N.Z. Fishing Industry Board, Wellington) said that farming could be done in addition to other things, and that management controls needed to be looked at to ensure that they were not outdated. Fishing methods which used less energy needed to be investigated too. He also drew attention to the differences in catching ability of different skippers. He said that some fishing boat skippers were not using equipment such as sonar and echo-sounders as well as Japanese skippers, who had had more experience. He felt that these things needed attention whether or not reseeding or full-scale farming were to be carried out.

Mr Cosh (MAF Economics Division, Wellington) said he could appreciate the future energy problem, but that snapper fishing might be less affected by it than other fisheries, since it was closer inshore.

Mr Ritchie (Fisheries Management Division, Whangarei) drew attention to the fact that a radical change in management might make a fishery more readily open to abuse and that a mistake could be disastrous. Mr Boyd rejoined that if enough were known about the stock, there would be no problem. However, politically it was not possible to open the inner gulf to trawlers at present. In other areas, though, if the fish were present, we should try to catch them, but there was no point in going looking for them if they were not there.

After some discussion of how much it cost to catch a snapper commercially, the point was made that even if snapper farming were undertaken, the costs for that would rise too, since boats would be necessary for servicing the cages and catching trash fish, and food processing costs would rise. However, aquaculture should be less energy dependent than fishing. It was stressed that fishing—particularly trawling—was very seriously affected by fuel price increases, more so than any other industry. Trap nets were fuel savers, and if all fish were used from a trap net, it would be more economical still. Trash fish from the net would be used to feed farmed fish.

Mr Boyd suggested that though fish farming might not seem very economical, it could save imported fuel and so there might be an argument for subsidising it, especially at first, in the national interest. Eventually it might become economical as energy costs rose. Mr Begg pointed out that if industry were to be involved financially, an enterprise must be profit orientated and show a return in 5 years.

Mr Lockley (N.Z. Fishing Industry Board, Wellington) said it was apparent that a lot of basic information still needed to be acquired, but 1 of the most important factors seemed to be growth rate, and our snapper took longer to grow than the Japanese species. Mr Paul said it took 3–4 years for snapper to reach maturity at 25 cm and 2–3 years more for them to grow to a decent marketable size, but if catching them at age 2 and fattening-on, it might be necessary to grow them for only another 2 years to obtain a reasonable size. The smaller you could sell the fish, the more reasonable were the prospects for farming them.

Another possible problem associated with marketing fish in a fresh state was raised; namely, that they had to be air freighted, and the cost of this might increase so much that it became too expensive. Mr Jarman said that, on the other hand, if cultivated snapper were being marketed, they would not be processed so much because they would be sold whole. This would tend to reduce costs. He added that a ground for optimism was that FAO had predicted better markets for fish in the mid 1980s.

Summary by Dr Colman, Fisheries Research Division, Wellington

Dr Colman, in summing up the day's discussions, said that he was left with mixed feelings; the meeting had resolved some issues, but not others.

Economics seemed to be the prime consideration. The whole question of farming anything depended on having a stable market, and in the case of snapper farming a high-priced market was necessary, which appeared to mean Japan. The market was apparently delicate and vulnerable to oversupply; so the rearing of snapper for the fresh, chilled market seemed risky. This applied to rearing through to market size. Other options were rearing for reseeding and catching juveniles for on-growing.

The costs of rearing for reseeding were uncertain, as they were not comparable with those in Japan. Private companies would be unlikely to become involved because they would not want to let their fish go for others to catch, but government might try it. Success would depend on the choice of site. The Hauraki Gulf already had plenty of juveniles, but west coast North Island, Hawke Bay, and Tasman Bay were possibilities. The west coast growth rate was higher, and there was erratic recruitment in Tasman Bay, which could perhaps be smoothed out by a reseeding programme.

As for on-growing juveniles, plenty were available in the Hauraki Gulf, but catching them—and adults with them—would not please commercial or recreational fishermen. The capital costs of setting up an on-growing establishment were lower than those for a whole hatchery. Cage culture appeared to be the best farming option, but there were legislative and public relations problems.

The disease aspect was apparently not very serious if management was sound and preventive treatment was given.

Food and labour costs accounted for a substantial proportion of running costs, about two-thirds of the total.

Some equipment, for example, refrigeration plant, might already be available and therefore capital cost would be less to an already established concern.

A multi-species hatchery, perhaps including paua and scallops, would be more economic.

Dr Colman concluded by saying that many facts still had to be found out. Some work might be able to be done by MAF, possibly for no return. The progress of Sanfords' experiment would be watched with interest.

Summary by Mr Jarman, N.Z. Fishing Industry Board, Wellington

Mr Jarman began his summing up by referring back to points made earlier by Mr Boyd: that irrespective of steps taken in farming or reseeding, management of present stocks was necessary. Appropriate, sound, forward-looking fisheries management and an appropriate attitude from the industry were essential.

Promotion of the concept of aquaculture to the public needed to be looked at and this should probably be done by a combination of MAF, FIB, and industry, working as a group.

On the subject of legislation, he repeated that if the Marine Farming Act should be totally rewritten, it would lose its priority over other acts. The emphasis should not be on restraints but on a balanced use of the environment; in other words, emphasis should be on positive aspects rather than saying "Thou shalt not . . .".

In fisheries management, even if more equable distribution among fishermen could be achieved, fuel costs would change the situation day by day, and because of its dependence on energy costs, the industry was very vulnerable.

Greater understanding was required so that the present snapper resource could be used. More work needed to be done on the snapper themselves, and industry needed to look at more efficient methods, to use passive fishing where possible, to find ways to improve quality, and to improve marketing aspects. These things needed to be done as well as looking at augmentation and farming.

There was a need for industry, FIB, and MAF to work together and a need for a national aquaculture development plan to determine which species could be cultivated and to direct regional planning.

A great amount of work needed to be done and there were not enough resources in terms of manpower or money, and so it was necessary to make sure effort was spent on the right thing. There was potential in biological terms, even if not in economic ones, and so there was a need to look closely at which areas to develop so that a profit might be realised.

Mr Jarman concluded by thanking Dr Smith in particular and Fisheries Research Division in general for arranging the workshop.

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