Assessment of the Potential for Aquaculture Development in Northland

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Executive Summary

Aquaculture directly employs around 400 people (around 320 FTE - full-time employees) and earns more than an estimated $20 million a year for the Northland Region. Economic studies indicate that aquaculture in Northland is likely to indirectly stimulate economic activity of around $20M and generate at least a further 100 jobs. The sectors of the regional economy that benefit the most from aquaculture indirectly are manufacturing, trade, property and business services.

Aquaculture in Northland is growing, doubling its total turnover in the past decade. This growth rate is slower than the growth of both the New Zealand and Australian aquaculture industries, but is similar to global aquaculture growth of about 11% per annum. The oyster farming industry in Northland is growing at a slower rate than its South Australian counterpart, which has grown at over 17% per annum in the last three years.

There is excellent potential for the development of aquaculture in the Northland Region because the area has a very good range of growing conditions, good existing infrastructure and candidate species, as well as an established local aquaculture industry. Estimates have put the potential for the Northland aquaculture industry to grow to $100 million in ten years, a growth rate of around 20% per annum. At $100 million the aquaculture industry could be expected to employ around 2,000 people directly (1600 FTE), and generate a further 700 jobs indirectly.

Currently Maori are extensively involved in aquaculture activities in Northland at many levels; employees, owners, owner-operators, and shareholders and beneficiaries of larger companies. In the past there have been extensive efforts to assist Maori to use aquaculture to further develop their economic base in Northland. That opportunity continues today, especially as Northland iwi are well placed to receive substantial seafood assets and earnings through the proposed allocation from the Treaty of Waitangi Fisheries Commission. Some of these resources could well be invested in developing the region's aquaculture. The mechanisms for encouraging this development should follow the more successful examples of economic intervention previously used for Maori aquaculture development in Northland.

Research results to date indicates that many of the negative environmental and social impacts of aquaculture activities in Northland are small and largely reversible, and become relatively trivial when compared to the positive social and economic benefits that aquaculture brings to the Region overall.

As well as economic benefits, aquaculture brings other positive benefits to the Northland Region that are often overlooked. For example, the marine shellfish farming industry is a strong environmental watchdog and advocate for maintaining water quality in sensitive harbour and coastal areas. The

water quality in many of these areas is increasingly at risk as Northland's coastal fringes continue to be urbanised and developed.

The major impediments to the growth of aquaculture in Northland are negative public attitudes toward marine farming and a long history of an unhelpful regulatory framework. These attitudes are based on perceived conflicts with public use and natural values of the marine environment. To a large extent the negative public attitudes toward aquaculture activities are due to a lack of understanding of the actual benefits and impacts of specific marine farming activities. Research on the environmental impacts of existing marine farming activities in Northland indicate they are relatively small, very localised and likely to be completely reversed once the farm is removed. Likewise, the general experience from establishing new marine farms is that they do not necessarily unduly affect the wider public use and enjoyment of the marine environment. There is a need to provide the public with better information on the positive and negative impacts of aquaculture, and for the existing aquaculture industry to more actively promote their contribution to the Northland Region.

Forthcoming changes in the regulatory regime for aquaculture has resulted in planning initiatives (establishing Aquaculture Management Areas) that are likely to set the long-term limitations on marine farm expansion in the Northland Region. Therefore, conveying the growth aspirations of the aquaculture industry in this boundary setting process is critical in determining the long-term economic potential of this industry.

Commercial aquaculture in Northland is dominated by Pacific oyster production, mostly in the Bay of Islands, Whangaroa, Kaipara, Houhora and Parengarenga Harbours. There is a relatively small scale but well-established mussel farming industry in Houhora Bay. NIWA has recently established an aquaculture research and development centre near Ruakaka, which has considerable potential to help bring new aquaculture ventures to the Region. Already several commercial enterprises have moved to site, bringing with them new aquaculture activities for the Region. This centre has excellent facilities, expert personnel and research students capable of making significant progress with aquaculture research and development for the Region. Every effort should be made to help focus this research and development capacity on rapidly building and diversifying aquaculture for Northland.

Tourism is an important part of the economy of Northland with many visitors being attracted to the region by the coastal scenery and marine activities. While there are potential conflicts with aquaculture activities that can be managed, the presence of tourists provides an excellent opportunity to promote aquaculture products and activities, and develop new and novel opportunities for tourist aquaculture ventures and outlets. These opportunities need to be explored and developed by the aquaculture, seafood and tourism industries.

A number of species with potential for the Northland Region have been identified through this study including, kingfish, Pacific oysters, mussels, scallops, crayfish, eels and kina. Some of these species will require research and development work before proceeding to commercial production. NIWA will proceed to work on more detailed reports on the potential of at least five of the best candidates for development for the Northland Region. These reports should be completed within the next month.

Recommendations

There is excellent potential for the development of aquaculture in the Northland Region, bringing with it considerable social and economic benefits. Some initiatives that will help to realise those benefits are:-

1. Improving the recognition of the development aspirations of the aquaculture industry within the regulatory regime, which is currently undergoing major revision. The identification and implementation of Aquaculture Management Areas over the next year for the Northland Region will largely determine extent and pattern of growth for Northland's aquaculture industry for the next two decades or more. Therefore, it is critical that the development aspirations of the aquaculture industry are incorporated into the planning process by the regulatory authorities. To achieve this will require better lines of communication between the regulatory agencies, especially the Northland Regional Council, and the aquaculture industry. Consideration should be given to encouraging a representative body that can articulate the needs and vision of a growing aquaculture industry in Northland, including the preparation of a strategic plan for growth in aquaculture for the Region. The existing Northland Aquaculture Development Group of Enterprise Northland would seem to be an appropriate body to undertake this role.

2. The aquaculture industry in Northland has a large number of small operators, and a few larger operators. For this reason the industry has tended to be fragmented and poorly organised as a group. If the aquaculture industry is to develop more quickly in Northland it needs to develop a regional identity, promote its common interests and develop a future vision. To achieve this the industry needs to recognise and provide for some professional coordination assistance. Consideration should be given to assisting the growth of aquaculture in Northland by establishing a professional coordinator and advocate for the industry in Northland. It would be appropriate for this professional co-ordinator to be retained by Enterprise Northland and report to the Northland Aquaculture Development Group. Assistance with establishing and funding the position should be sought from the existing Northland aquaculture industry and iwi as they will be the principal beneficiaries. NIWA would be prepared to assist in setting the goals for such a position as a logical extension of the issues arising from this report.

3. Maori are key stakeholders in the aquaculture industry in Northland and the development of the industry has enormous potential to improve their economic and social well-being. Substantial financial resources from the allocation of fisheries assets from the Treaty of Waitangi fisheries settlement ($110M in assets, and annual earnings of around $1.5M) has the potential to be directed toward aquaculture development for Maori in Northland. Consideration should be given to establishing mechanisms to provide advice and support to iwi in developing their aquaculture investments and interests in Northland. A key role for the professional Northland aquaculture industry co-ordinator would be to work closely with iwi to facilitate their investement and interests in the Northland aquaculture industry. Past examples of Maori economic intervention in Northland provide clear guidelines on the types of approaches which could be successfully repeated.

4. Poor skill development and training opportunities has frequently been identified as a key issue for improving aquaculture development in Northland. Consideration should be given to working with the existing aquaculture industry, schools, tertiary providers in Northland and the Seafood Industry Training Organisation to develop a strategic plan to improve the opportunities for skill development in Northland's aquaculture industry.

5. Public attitudes toward aquaculture in the Northland Region tend to be negative and misinformed. There is a surprising lack of freely available information on aquaculture impacts and benefits for Northland. Consideration should be given to encouraging a range of activities and information resources for Northland that provide balanced, accurate local information on aquaculture. This could include the local promotion of aquaculture products, marine farm open days, an oyster festival, a Northland aquaculture website, and school resources for Northland schools that are linked with the curriculum.

6. Diversifying the species and locations of aquaculture in the Northland will be essential to establishing long-term growth in the industry. The existing local aquaculture and seafood industry, research institutions and Maori groups are crucial to achieving this goal and need to be encouraged to attract and/or invest the resources for this much needed research and development and subsequent commercialisation. Consideration should be given to working with these key groups to help them focus on achieving this goal for the Northland Region. NIWA is completing more detailed reports on a suite of species that offer the best potential for development in Northland and this information can be used as the basis for attracting interest in developing these opportunities.

7. Increasing the value of Northland's aquaculture industry can also be achieved by integrating and promoting aquaculture with tourism and other seafood initiatives for the Region. The coastal theme is vital to the existing tourism profile of the Region and aquaculture is an important part of this. Consideration should be given to encouraging the tourism sector to link with the seafood and aquaculture sector to explore the opportunities for creating synergies.

8. Maintaining and improving coastal water quality will be vital to securing the ongoing future of this industry in many parts of Northland. Planning and enforcement agencies need to be encouraged to advocate strongly for the protection of water quality, and to work with the aquaculture industry to share water quality monitoring information and to work together to improve water quality generally. Recent events in the Bay of Islands have damaged relationships between the two groups. Consideration should be given to investigating how the common interests of regulatory agencies and the aquaculture industry can be enhanced by encouraging them to work more closely together.

9. The pastoral farming sector in Northland has recently undergone a resurgance with increased investment in dairying activity, likewise the Northland forestry industry is key stage of its development. There are important potential synergies with the pastoral and forestry industries, such as helping to address issues such as rural roading and energy supplies. Federated Farmers in Northland is already supporting oyster farmers displaced by sewage in the Bay of Islands. These potential synergies need to be encouraged by building stronger linkages between the aquaculture, pastoral and forestry industries.

Introduction

The regional economic development agency for the Northland Region, Enterprise Northland, is operated by the Northland Regional Council's Community Trust. Enterprise Northland believes that significant regional economic benefits would come from encouraging the sustainable development of aquaculture in Northland. To promote and attain these benefits, Enterprise Northland formed the Enterprise Northland Aquaculture Development Group (NADG) with the following explicit aims:-

a) Investigate and make available to appropriate interested parties information that tests and indicates possible commercial viability of potential aquaculture opportunities for the region.

b) Seek the removal of impediments that stand in the way of investors cost effectively proving (or disproving) the commercial viability of potential aquaculture opportunities for the region.

c) Where practical, assist the process for the commercial aquaculture opportunities being realised for the region.

In working toward these aims the NADG proposed a three stage process:-

Stage 1: Initiate a research project that will be structured to provide a suite of individual development opportunities, supported by appropriate scientific analyses and information, supplemented with risk analyses and reporting of economic viability where commercialisation has taken place elsewhere in New Zealand or overseas.

Stage 2: Potential investors will be identified and encouraged to individually, or in partnership with other interested parties, develop full business cases on each opportunity identified in stage one.

Stage 3: Commercialisation, through the development of private sector investment in commercial operations, or the creation of intellectual property by way of further commercially focussed research, supported where and as appropriate by Enterprise Northland and other input.

As part of the first stage of this process the NADG has contracted NIWA to investigate and report on information relevant to the potential for developing aquaculture in Northland. This involves two steps:

Step 1: By 31 January 2003 prepare a report which provides:-

- An overview of existing aquaculture in Northland, including current contribution to regional gross domestic product (expressed in total and as a percentage) and labour utilisation (expressed as FTE's).

- A review of the full range of potential aquaculture opportunities for Northland and results in the identification of a suite of potential development opportunities for further detailed investigation (Step 2).

- General information on the potential aquaculture opportunities for Northland that can be incorporated into concurrent processes for formulating Aquaculture Management Areas for Northland. This information should include information about suitable growing conditions and possible general locations in Northland.

- Exploration of what planning, regulatory, Treaty and other variables stand in the way of such development/investment and conversely explore opportunities where Northland leadership and foresight can minimise the variables and place Northland at a competitive advantage.

Step 2: By 28 February 2003 prepare reports that provide:-

- Detailed information on at least five of the suite of potential aquaculture opportunities for Northland that are self contained, and includes information about the species, potential locations for aquaculture, potential financial returns, basic risk analyses, experiences where commercialisation has occurred in New Zealand or overseas, an assessment of the regional benefit of commercial development, and an exploration of the obstacles and advantages of developing these opportunities in Northland.

This current report is the culmination of the investigations required for Step One of the above process and was funded by Enterprise Northland Trust, Industry New Zeland and Te Puni Kokiri.

In general terms, the assessment required an appraisal of the current status of aquaculture activities and the development opportunities for the Northland Region, with the aim of identifying the best opportunities for commercial aquaculture development for more detailed investigation in step two.

The information presented in this assessment of the potential for aquaculture comes from a wide variety of sources. Extensive literature reviews were conducted in selected subject areas, discussions with experts in their fields, interviews with business operators and administrative agencies, and the personal knowledge of the researcher. All published sources of information are included in the full bibliographic reference list at the back of the report. Much of the material has been summarised, however, should there be a particular interest in any further details amongst people wishing to pursue particular aquaculture options, NIWA will happily assist by providing more detailed information. In addition, more detailed information will be prepared and presented to the NADG on at least five of the most promising aquaculture opportunities for Northland identified through this overview report as part of Step 2 as outlined above.

The researcher for this project is very grateful to all those people and groups that freely provided advice and information that have gone into the preparation of this extensive report.

Northland Region

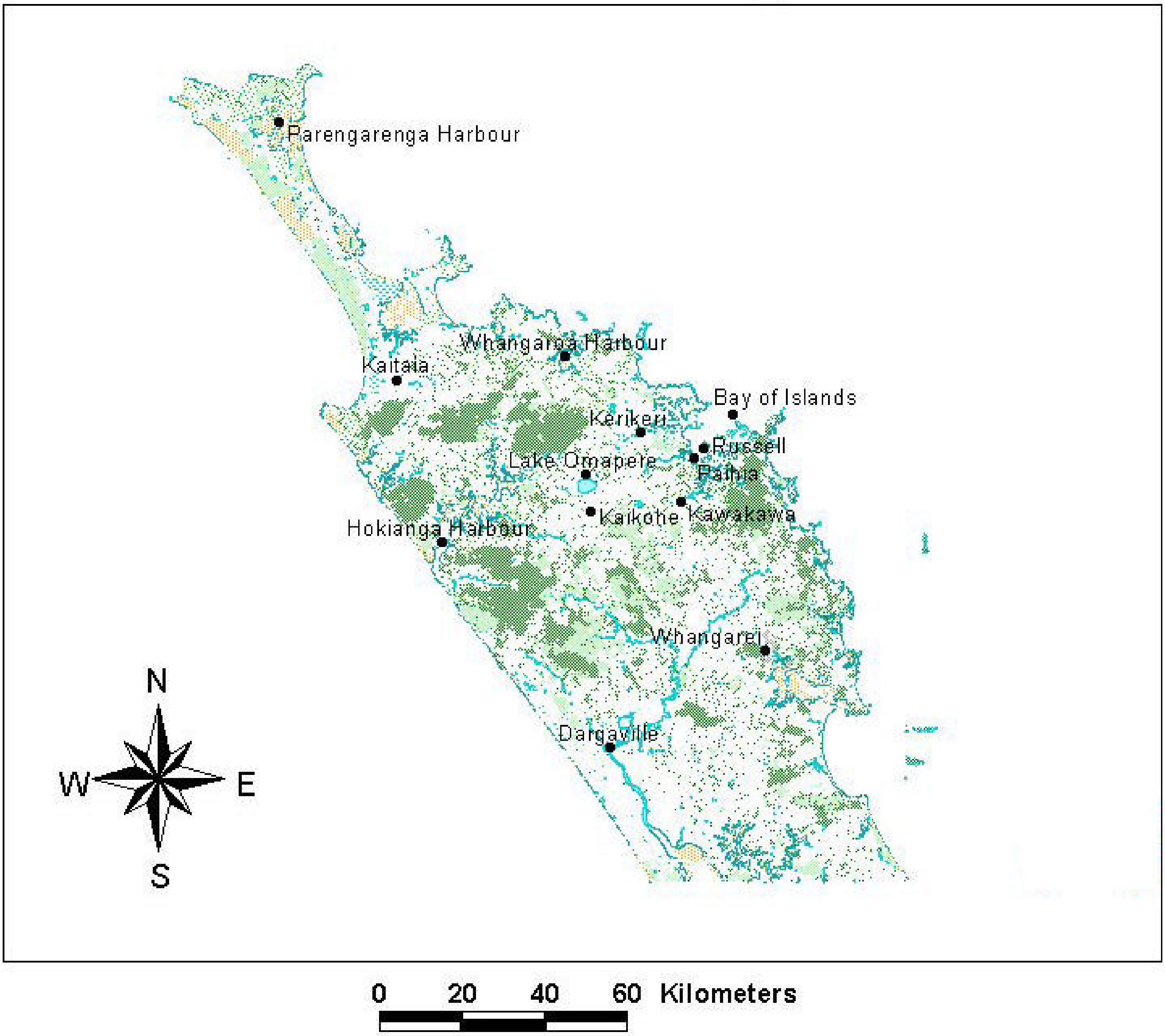

Figure 1: A map of the Northland Region.

The Global Aquaculture Scene

Aquaculture is the fastest growing sector of the world food economy. Over the past decade aquaculture output has grown at a phenomenal 11% per annum climbing from 13 million tonnes in 1990 to over 40 million tonnes by the turn of the century. This growth in production is several times that of its nearest rival food rival, poultry.

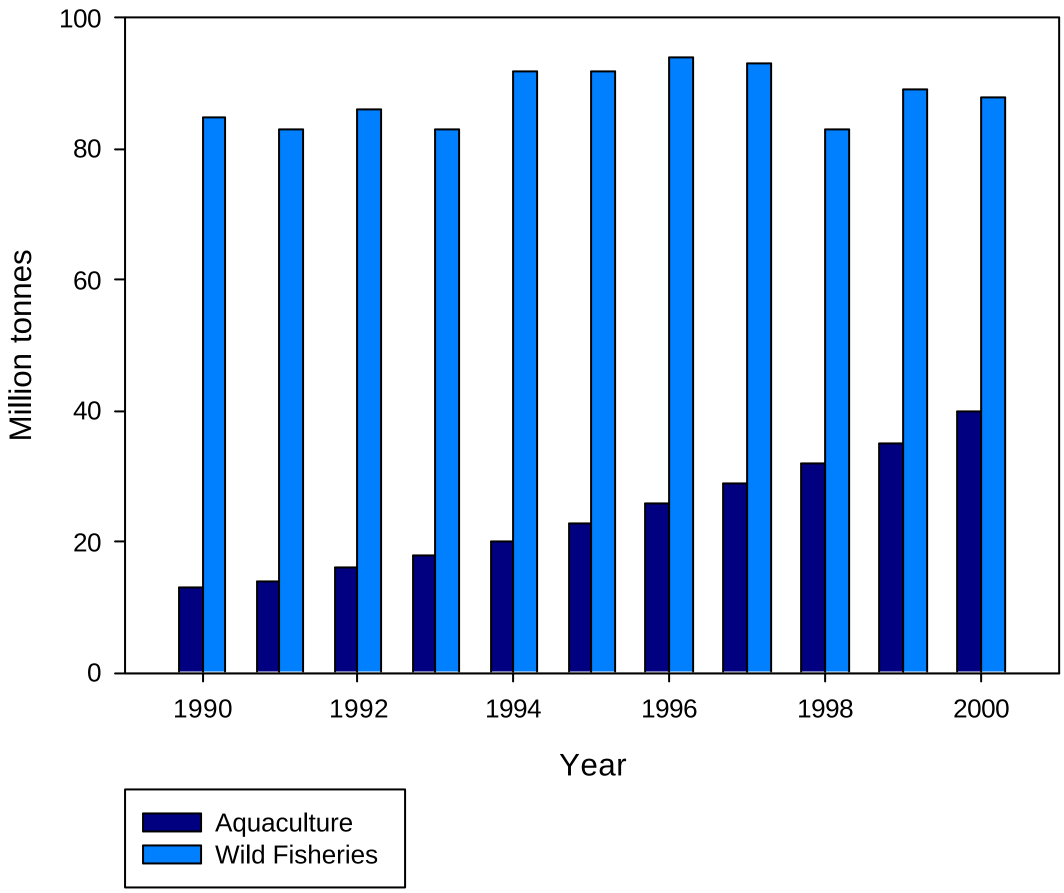

Figure 2: Changes in global production from aquaculture and wild fisheries.

By comparison, the production from wild fisheries increased steadily from the 1950's until 1989, and since then production has remained relatively static. This indicates that the global production limits of wild fisheries have been reached. Global demand for seafood is forecast to increase beyond current production levels by a further 55 million tonnes by the year 2025. Further growth in seafood production to meet this demand is expected to come from further rapid increases in aquaculture output.

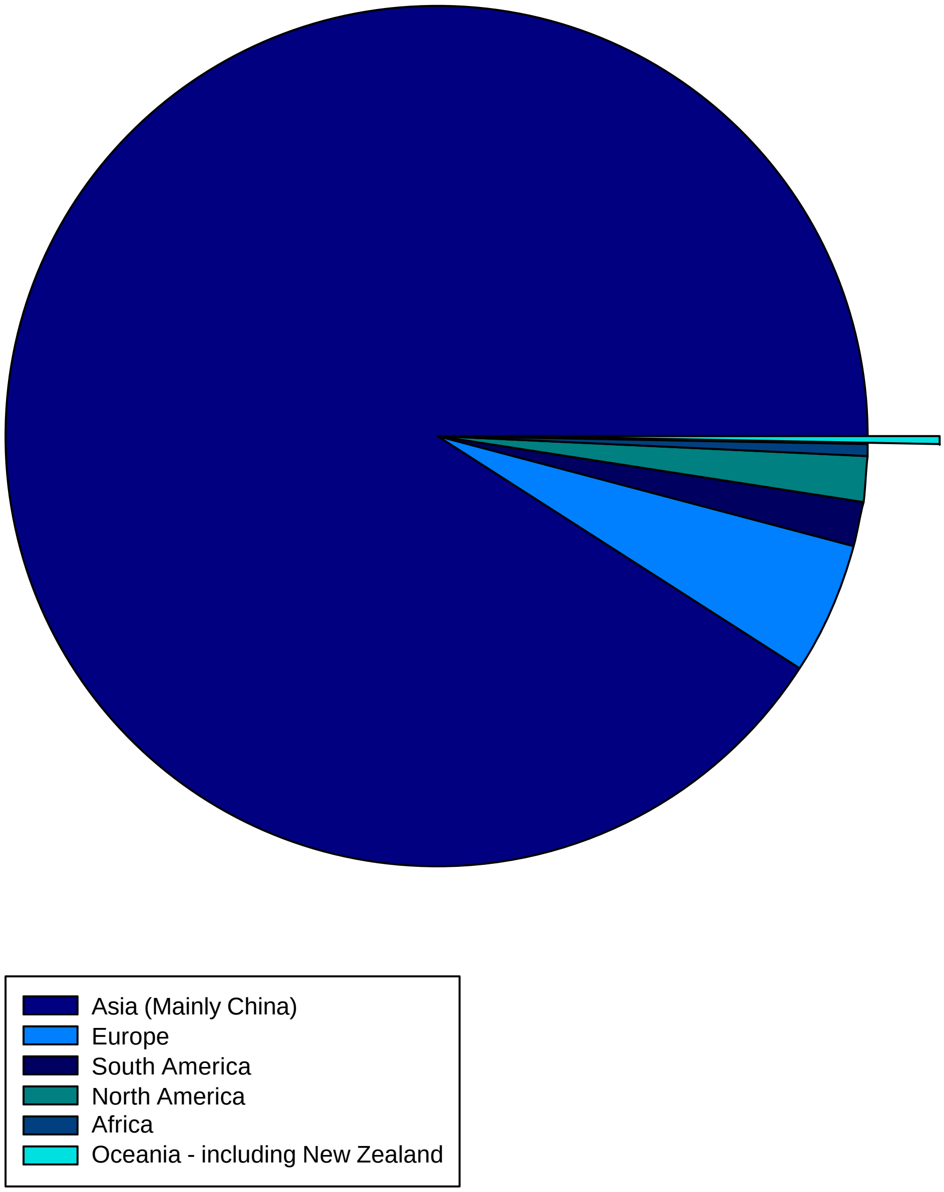

Figure 3: Global aquaculture production by global regions.

Asia, mostly China, is the world's largest aquaculture producer, accounting for over 90 % of the total world production. South America, however, is the continent, which has shown the largest average annual growth (14.5%) in aquaculture production over the last decade, followed by Oceania (13.2%), which includes New Zealand. Also, within Oceania is Australia, where the aquaculture industry has become the fastest growing rural industry with about 13% annual increase in overall value of production for the past decade, growing from A$200 million in 1990 to nearly A$700 million in 2000. Oceania currently contributes only about 0.3% of global aquaculture production, and New Zealand less than 0.2%. In terms of value, New Zealand's aquaculture production made up only 0.15% of global aquaculture production, which was valued at over US$50 billion in 2000.

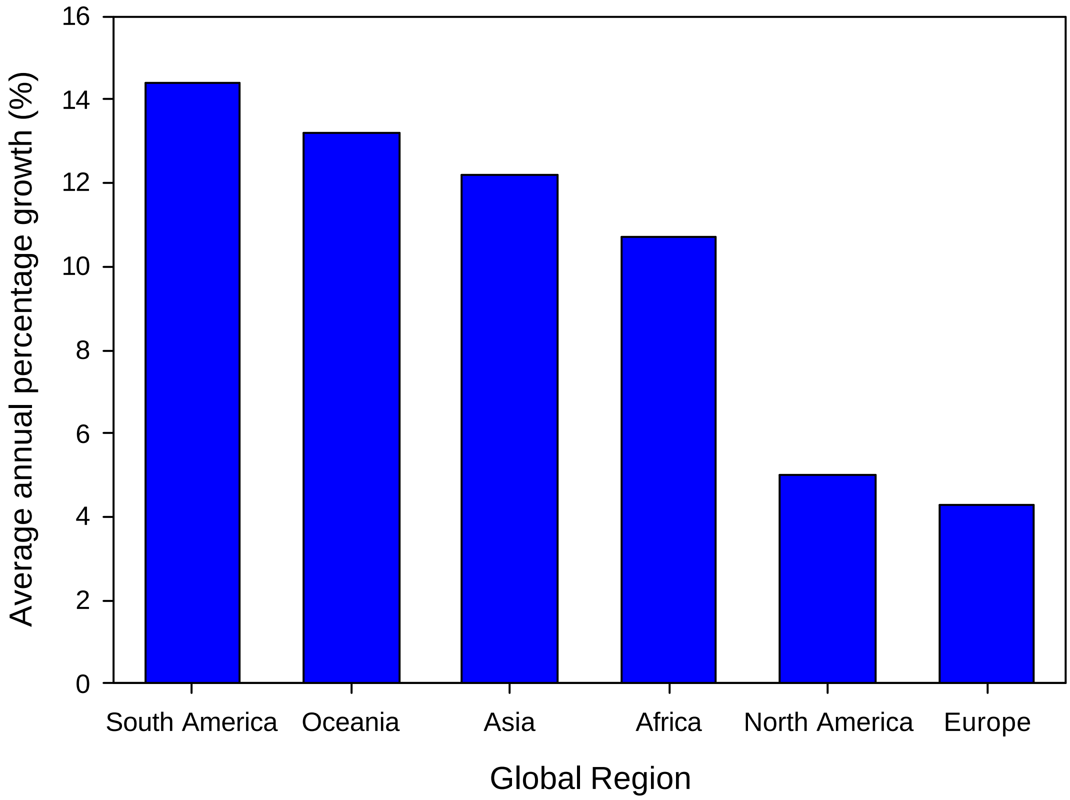

Figure 4: Average annual growth of aquaculture production volume for global regions.

The New Zealand Aquaculture Scene

Aquaculture has been growing rapidly in New Zealand mostly through the commercial production of three species; greenshell mussels, king or chinook salmon, and Pacific oysters. The artificial enhancement of commercially fished scallop beds in Tasman and Golden Bays has also become significant in recent years. In addition to these species, a number of other species are at various stages of commercial development. Foremost of these would be the aquaculture of paua (abalone), rock lobster, seahorse and kingfish. A great variety of other species are being examined for aquaculture including seahorses, eels, turbot, geoducks and freshwater crayfish.

The aquaculture of green-lipped mussels began in the mid-1960s following the collapse of dredge fisheries in the Hauraki Gulf and Tasman Bay. Today, Greenshell mussels are widely cultivated on long-lines, mainly in the Marlborough Sounds, and the Coromandel area of the Hauraki Gulf. Greenshell mussel aquaculture has grown very rapidly with production in the year 2000 exceeding 140,000 tonnes with a total value of $200M and export sales of NZ$170M to more than 60 countries. The mussel farming industry is estimated to directly involve over 1,500 FTE and contributes in excess of NZ$50M to New Zealand's gross domestic product.

The aquaculture of king or chinook salmon developed in the 1980s from fish introduced from Sacramento, California in the late 1890s for initiating a sport fishery in New Zealand. Most of the salmon production is from seacage farms located in the Marlborough Sounds, Akaroa and Stewart Island. Freshwater farms are located in a number of hydroelectric raceways and natural springs in Marlborough and Golden Bay. Sales of king salmon in the year 2000 were 6,140 tonnes, valued at NZ$65M and this production has been projected to grow to NZ$150M by 2010. However, subsequent oversupply in the global salmon market may make this sales projection somewhat optimistic.

Pacific oysters became the dominant cultivated oyster in New Zealand after they were introduced into the country in the early 1970s. Farmers switched to the Pacific oyster because it grew much faster than the native rock oyster, which is also known as the Sydney rock oyster. Oysters are mainly cultivated on racks in the intertidal in a number of northern North Island harbours, mainly Coromandel, Mahurangi, Whangaroa, and parts of the Bay of Islands. The culture of Pacific oysters using submerged long-lines is becoming more common particularly in the Marlborough Sounds. Current sales of over NZ$20M of Pacific oysters have been predicted to treble over the next decade with increases in farm efficiency and expansion of farming areas.

The aquaculture of paua, native abalone species, is developing at a steady rate with 17 farms currently in operation, predominantly as land-based facilities. The farms are scattered around the country including Stewart Island, Coromandel Peninsula, Hauraki Gulf, Kaikoura, Marlborough, Canterbury and New Plymouth. The common paua is the focus of most farming attention as it produces high value meat and half-pearls. Significant commercial development of paua farming has been predicted with sales for both pearls and meat to reach NZ$62.5M in a decade, from current sales of approximately NZ$400,000.

There is one commercial farm for the Malaysian river prawn, *Macrobrachium rosenbergii*, at Wairakei, near Taupo. The farm is economic because it can use waste heat from a geothermal source via a heat exchanger to maintain the warm water temperatures required to keep these tropical creatures alive. The farm was established in 1991 and levels of production have risen steadily to well over 12 tonnes in 1999. The farm has 18 open-air heated ponds that are each 2,000 cubic metres water capacity and are stocked at densities of 10 prawns per square metre. Most of the production is sold at the onsite tourist restaurant, with demand reportedly exceeding the present farm production.

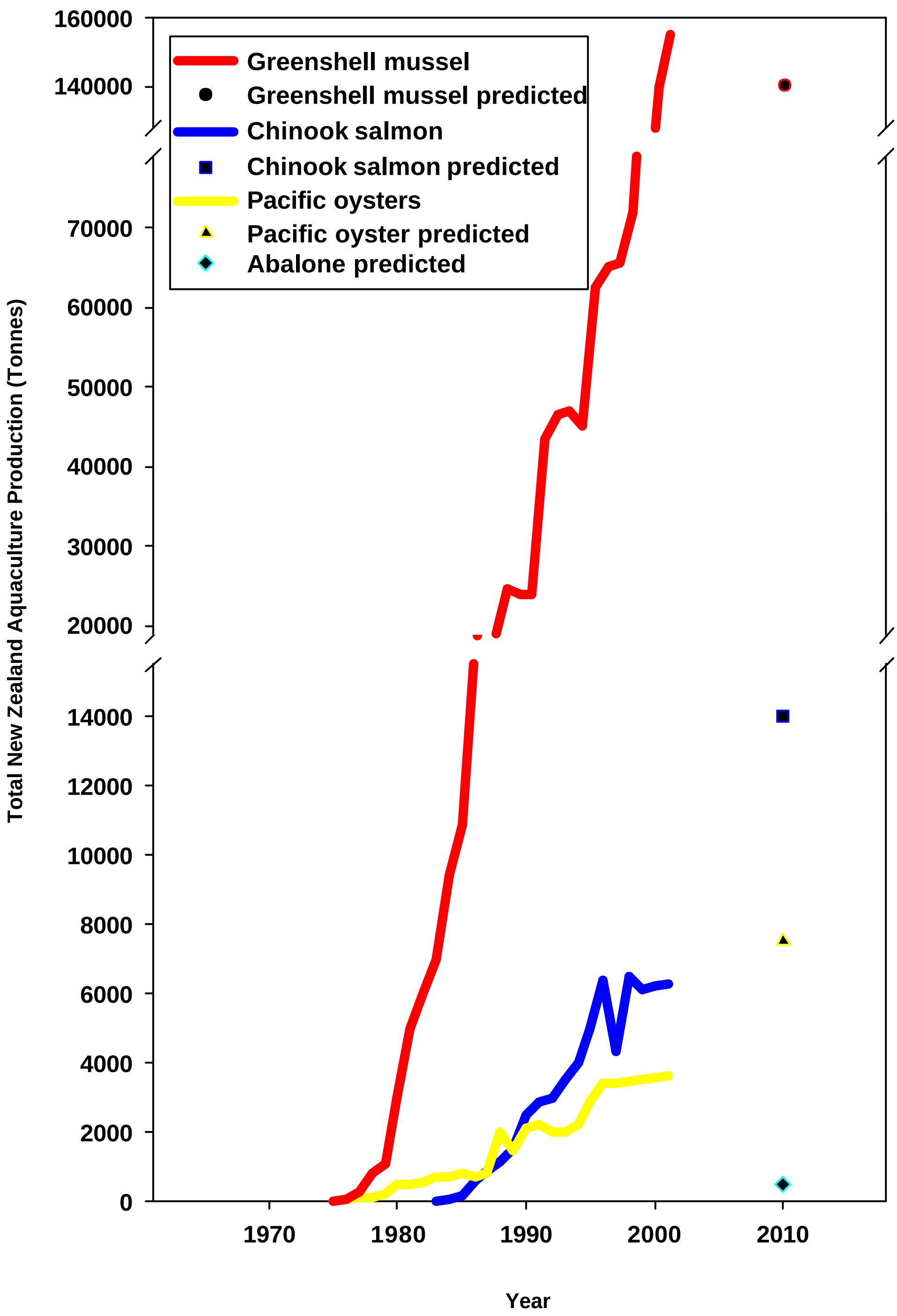

Figure 5: Total aquaculture production for New Zealand by species.

The aquaculture of rock lobster or crayfish began recently when legislative changes in 1996 permitted early juvenile lobsters to be collected from the wild for ongrowing. Two commercial scale ongrowing operations initially took advantage of the law changes. However, both operations faced difficulties obtaining sufficient seed lobsters during years of very low natural settlement. The techniques for catching the seed lobsters and ongrowing the lobsters are now well established. Pilot scale production has commenced again in the past year using a combination of early land-based rearing and novel sea cage rearing techniques which show considerable promise for providing rapid growth of lobsters with markedly reduced grow out cost.

Attempts at enhancing wild scallop fisheries in Nelson and Golden Bays begun in 1982 following the decline of the wild fishery. Today, large numbers of seed scallops are caught in plastic mesh bundles moored in areas of high natural scallop settlement. These are then used to re-seed natural scallop beds. This re-seeding has resulted in a marked increase in the available annual catch. Prior to the introduction of the enhancement programme the average annual catch was around 2,400 tonnes greenweight. However, through the development and application of re-seeding techniques the fishery has easily more than doubled its annual production and has the potential for further expansion.

Overall, marine and freshwater fish farms, and spat catching areas in New Zealand occupy around 4,000 hectares - about the size of an average high country farm. Production from this area results in more than NZ$200M per year in export earnings. This has grown 8-fold in the last 12 years from NZ$25M in 1989 to NZ$210M in 2000. This growth rate is better than the rapid global growth in aquaculture, which is now the fastest growing primary production sector in the world. It is predicted that exports from the New Zealand aquaculture industry could exceed NZ$550M by 2010, and will top NZ$1B by 2020. Direct employment from aquaculture activity in New Zealand is currently estimated to be over 2,000 FTE and this could be expected to grow to over 9,000 FTE by 2020 should the growth potential of this industry be realised.

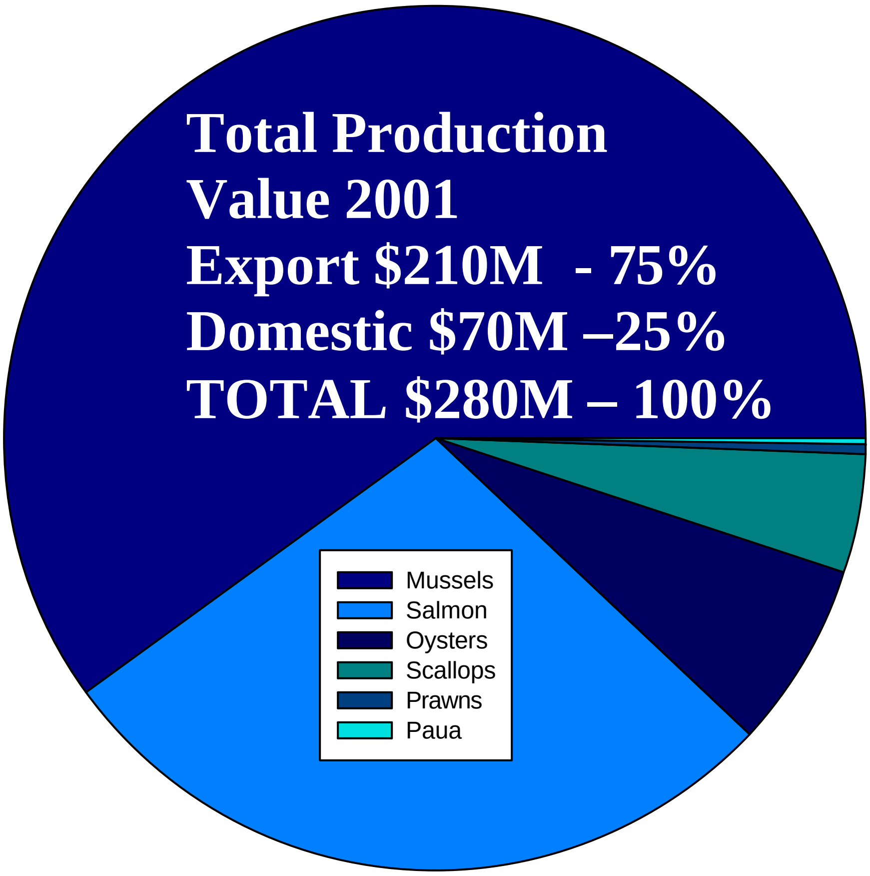

Figure 6: The value of New Zealand aquaculture production by species in 2001.

A number of key issues affect the development of the aquaculture industry in New Zealand.

The regulatory regime for aquaculture in New Zealand is widely recognised as being in need of reform and the Minister of Fisheries initiated a reform process early in 2001. Land-based aquaculture is conducted under outdated regulations stemming from the Fisheries Act and these regulations are some of the most restrictive for any land-based farming activity in New Zealand. Sea-based farming has a dual licensing system between regional government and the Ministry of Fisheries. The inadequacy of aquaculture legislation led to a commitment by the Minister of Fisheries in the 1980's to reform the existing legal framework, however, this initiative failed due to political reasons. Further attempts were made to fully integrate aquaculture activities into coastal management law reform in the early 1990s, but they were not supported by some key government agencies at the time. Over a decade later, the law reform process has been restarted and is now well advanced with draft legislation due in early 2003. A major issue for the aquaculture industry is ensuring that the new legislation provides for access and security of tenure for areas of seabed for marine farming.

The rapid growth of mussel farming activity in New Zealand has lead to a wide range of difficulties for the existing coastal management regime under the Resource Management Act. In the first wave of mussel farm developments, existing areas with mussel farms have seen the addition of further farms in the vicinity of the established farming areas, such as the Marlborough Sounds and Coromandel. This has created concerns about how well the management process is taking account of possible cumulative environmental and social impacts.

In the second wave of applications over the past few years, sheltered waters in areas previously without marine farming have attracted applications for marine farms often causing considerable anxiety, and in some cases conflict, amongst nearby residents, commercial and recreational fishers and other stakeholders. Regional government, as the principal coastal management agency, in some areas has been struggling with the proliferation of marine farm applications and in some cases has resorted to banning or severely restricting new applications for marine farms.

In the most recent wave of marine farm applications, a number of proposals were made for large marine farm areas in offshore or exposed waters, although the technology for growing mussels in these areas in New Zealand waters is yet to be developed and tested.

In late 2001 the government moved unilaterally to impose a two-year moratorium on the granting of all marine farm consents, including those already being processed. The aim of the proposed moratorium was to provide "breathing space" while the aquaculture law reform was developed and implemented. In introducing the moratorium the government indicated that it would be looking to ensure that all new aquaculture development was placed in coastal aquaculture management areas, established through the existing coastal management plans administered by regional government. The legal mechanisms for achieving this goal are integral to the aquaculture legislation reform currently.

One anomaly in the New Zealand aquaculture legal framework is a complete ban on farming trout species, which are undoubtedly one of the most widely farmed aquaculture species in the world. New Zealand is the only country in the world where trout farming is illegal, however, other salmonid species can be farmed and form an important part of New Zealand's commercial aquaculture activity. There is commercial interest and potential for trout farming in New Zealand. For example, trout farming is a A$22M industry in Australia that also provides important tourism opportunities in the form of trout ponds that are managed for tourist fishing. Previous government committees of enquiry in New Zealand have recommended lifting the ban on trout farming, which would undoubtedly result in a multimillion-dollar aquaculture industry. However, successive governments have refused to do so because of political pressure from the recreational trout fishing community.

The New Zealand aquaculture industry is heavily reliant on the culture of one species, green-lipped mussels (often known by their trade name Greenshell), which makes up over 60% of the value of the industry and is currently showing the most growth in production. In addition, the product types and markets for green-lipped mussels have also not been greatly diversified, with the majority of the product going into a few key markets in a few standard formats. This lack of diversification makes the New Zealand aquaculture industry extremely vulnerable. For example, in the year 2000 the appearance of toxic phytoplankton in northern New Zealand resulted in the main wild seed supply for the mussel industry being cut off for many months, forcing the industry to rapidly pursue other options to ensure continued seed supply. Furthermore, should the toxic phytoplankton have spread into the two key growing areas for green-lipped mussels, the Marlborough Sounds and Coromandel, the industry would have been severely affected. These two growing regions are currently responsible for over 70% of the total value of aquaculture production from New Zealand. This indicates that the aquaculture industry in New Zealand is also very poorly diversified geographically.

Another difficulty with the current range of aquaculture species currently farmed in New Zealand is their relatively low value. For example in 2001 total Australian aquaculture production was 30,000 tonnes and valued at A$680M compared to New Zealand production of 160,000 tonnes valued at $280M i.e., the value per tonne was NZ$26,400 for Australia compared to only NZ$1,750 for New Zealand. This is because Australia's aquaculture is dominated by high value species such as tuna, prawns, and pearls.

The lack of diversification in the New Zealand aquaculture industry is largely due to the approach of many aquaculture enterprises that have concentrated on increasing existing production and improving efficiency as the means to achieve business growth, rather than diversification. Consequently, aquaculture industry investment in research and development, like so many industries in New Zealand, is relatively low. Likewise, the government's investment in research and development for this fledgling industry is low given its economic growth potential. The government has tended to direct the majority of its research and development funding into the traditional primary production sector, which is very well established in New Zealand and has excellent research and development capabilities based on many years of government investment and a sound industry base. Not surprisingly, almost all of our aquaculture industries are based on imported overseas technology that has been incrementally developed under local conditions.

The current government has been re-introducing some support schemes for the development of business activity in New Zealand, with the formation of the Ministry of Economic Development. Recently, the government selected some sectors of the economy with strong growth potential for focussed assistance with development, however, aquaculture was not among them. Representatives from the Ministry of Economic Development have indicated a strong desire to assist in the continued growth of the aquaculture industry through providing assistance where they can.

As a fledgling industry, the aquaculture industry in New Zealand has lacked any national strategic focus. As sectors of the industry have matured they have developed their own representative bodies, such as the Mussel Industry Council, New Zealand Oyster Industry Association, New Zealand Marine Farmers' Association and the New Zealand Abalone Farmers' Association. Each of these bodies represents strong species-specific interests and these tend to be focused on particular regions of the country from where their members are drawn. For example, the New Zealand Marine Farmers' Association is principally interested in Nelson and Marlborough issues, which are dominated by mussel farming. All of these industry bodies have tended to become more active as their industries have grown and have a greater capacity to support wider initiatives, such as undertaking strategic development programmes. The New Zealand Aquaculture Council was formed in the 1990s as an umbrella body to represent the interests of the entire industry and consists of representatives drawn from each of the aquaculture industry groups. Due to its structure, the Aquaculture Council has very limited resources for undertaking initiatives such as national strategic planning for aquaculture. However, this body has recently become more active as the constituent member groups have developed more capability. The Aquaculture Council recently produced its first public strategic document "Vision 2020" which is focussed largely on site access issues for sea based farming associated with the reform of aquaculture laws. This is largely a consequence of the strong interest in this area due to the predominant sea-based farming membership base of the Council. Unfortunately, other key areas urgently required for aquaculture development in New Zealand, were not addressed by this strategic development document.

The formation of the industry-wide body and the initiatives for the strategic development of the industry have been undertaken with relatively little government assistance, in spite of the potential importance of the developing industry to the growth and diversification of the New Zealand economy. This contrasts with significant aquaculture developments in other parts of the world, which have involved large direct government investment during the start up phase. For example, the massive salmon aquaculture industry in Norway was a direct result of a large government investment in developing a new industry to grow and diversify the Norwegian economy. Research into the value of government investment in research and development in the aquaculture sector has shown that these investments can provide very significant levels of return to government through ongoing taxation from new production and employment capacity. For example, research on the Canadian salmon farming industry has estimated the state's return on investment in research and development was between 2:1 and 19:1 even on very large state investment in the industry's development.

Increasingly the public perception of the aquaculture industry in New Zealand is being eroded to a large degree by concerns about the environmental and social impacts of aquaculture. There is very high quality information about the nature of the environmental impacts of most current types of marine farming in New Zealand and this information is frequently used in managing and planning for new aquaculture activities by industry and planning authorities. However, there has been difficulty communicating this information more widely, especially to public interest groups, so that the debate about aquaculture impacts is well informed. For example, the environmental impacts of aquaculture production should be put in context with other forms of production, such as land-based farming practices, which can have more far reaching and long-term environmental impact on the marine environment.

Compared to many other countries, New Zealand has relatively high use of its coastal waters for commercial, recreational and customary activities partly due to the highly productive waters and the concentration of most of the country's population close to the coast. Public conflict over the use of coastal space for aquaculture is escalating rapidly in line with the swift growth of the mussel farming industry. Most of this public debate is focussed on specific sites proposed for development of new farms, rather than the wider issues of social and economic impacts and benefits.

Overall, the New Zealand aquaculture industry is at a key point in its development. It has reached a critical mass that allows it sufficient flexibility to develop new markets, products and to assert some influence over government policy, legislation and public perceptions. However, the industry as a whole remains vulnerable with low levels of government support, growing public concern and a very limited product base. The next decade will determine whether the New Zealand aquaculture industry can continue to keep pace with the rapid development in this area of economic activity around the globe. The economic and social benefits in terms of export income and employment of a well-developed and diversified aquaculture industry are significant.

Status of Aquaculture in Northland

Traditional Aquaculture

In the past, aquaculture, traditional enhancement and careful tending of shellfish, such as paua, kokota (pipi), kutai (mussels) and tuangi (cockle) was carried out by iwi throughout Northland, as it was in many parts of the country. A number of examples are outlined in the Muriwhenua Fishing Report prepared by the Waitangi Tribunal in 1988. Traditional aquaculture activities usually took the form of transplanting or thinning shellfish beds in order to extend the range or improve the growth of the shellfish. In some areas such as the Bay of Islands, large rocks were moved into intertidal areas to encourage the settlement and growth of rock oysters. Shellfish beds, such as cockles, kokota, and scallops, are still extensively exploited in Northland, especially by Maori. However, very little traditional management of these resources continues today other than some blanket rahui associated with drownings and site specific over-exploitation of resources. A number of studies have attempted to identify and record more exact details of traditional aquaculture activities, but these have generally failed through the lack of remaining knowledge and practice, as well as Maori concerns about sharing of the cultural information.

Past and Present Aquaculture

Commercial aquaculture activity has been present in the Northland Region for more than 40 years, first starting with the farming of native rock oysters in the Bay of Island in the late 1960's. The initial development of the industry in this area was helped by the Marine Department and later by the Ministry of Agriculture and Fisheries. A great deal of this support came in helping to identify and trial new farming sites, as well as developing methods to catch wild seed oysters (spat), which was a difficult task for the native rock oysters.

Later the Ministry of Agriculture and Fisheries built an oyster hatchery near Warkworth in attempt to establish a reliable artificial supply of oyster spat. In the 1970's the Pacific oyster was introduced to New Zealand. How this oyster arrived in the country is unclear, but it first turned up in northern harbours possibly after hitching a ride on Asian ships visiting New Zealand. Oyster farmers rapidly adopted the Pacific oyster over the native rock oyster because it grows faster, and the spat were easier to catch.

From the late 1970's the Northland oyster industry grew mostly by word of mouth, often with rural coastal families looking for alternative ways to make a living. This lifestyle approach to the oyster industry is reflected in the large number of licence and leaseholders often with relatively small holdings. New farmers often went through a steep learning curve of developing completely new sites and repeating many of the mistakes made by their colleagues. A large number of oyster farming sites have subsequently been abandoned because of unsuitability or business failure. During this time the demand for good quality oysters remained strong, both domestically and into export markets. However, a major difficulty was that the fragmented industry was slow to develop processing, distribution, and marketing. Due to difficulties developing new farms and new farming areas there was often poor control over the quality of product entering the market.

From the 1980's various agencies saw that oyster farming could be an effective means for rural Maori to develop an economic base in Northland. Various forms of financial and expert assistance were provided to Maori individuals and communities to establish oyster farming initiatives, especially in the Parengarenga, Kaipara and Hokianga Harbours. A good number of these initiatives have failed often due to a lack of commercial business experience. However, a small number of Maori marine farmers have become established as a result of assistance programmes.

From the 1980's a number of oyster farmers became well established and there was growing interest from corporate seafood companies in getting into the oyster industry. Together these helped to improve the quality, distribution and export of oysters, particularly to Australia, and more recently to markets in Asia.

From the 1990's the New Zealand Oyster Industry Association became more influential in bringing the fragmented industry together and initiating greater sharing of farming knowledge, and jointly tackling issues such as legislative reform. A review of aquaculture and fishing in the Northland Region in 1993 estimated that aquaculture (almost entirely oyster farming) had grown from scratch in the late 1960's to generating $9 million in total revenue, and providing $3.4 million directly into the Northland economy, as well as employing 272 people.

The New Zealand Oyster Industry Association undertook a major survey recently to ascertain current production, value, employment statistics for the whole oyster industry. Those figures were going to be used in this report, however, a poor level of survey responses by oyster industry operators has prevented this. Estimates from senior members of the industry with long experience of the industry in Northland, estimate that the region is currently producing around 70% of the 3.5 million dozen oysters which makes up New Zealand's total Pacific oyster farm production. This Northland crop is valued at around $20M of which about 85% of the returns comes from exports. The industry is estimated to employ about 400 people directly both part time and full time (around 320 FTE), in both growing and processing operations. Economic studies of intertidal farming of Pacific oysters in Australia have estimated that economic flow on effect from this aquaculture activity are high – around 1:1. On this basis the Northland oyster industry could be expected to generate indirect economic activity at an equivalent amount of its gross business turnover each year (i.e., around a further $20M in 2002). Much of this flow on effect has been shown to run to local property and business services, manufacturing, trade and transport industries. Flow on impacts on employment run at under the 1:1 ratio and on this basis the indirect employment from Northland's oyster industry is estimated to be about a further 140 jobs.

Comparisons with the 1993 estimates of oyster production indicate that the oyster industry in Northland has doubled its gross turnover in the past decade. By comparison the Pacific oyster farming in South Australia has nearly doubled its gross turnover in the past three years (2000 = A$9.4M, 2002 = A$15.2M), despite operating in sensitive marine environments, with higher operating overheads (higher labour and transport costs), and less productive waters.

Mussel farming has yet to become firmly established in Northland on a scale that it has in other parts of the country such as Marlborough and Coromandel. However, Northland has played a vital part in the phenomenal growth of the mussel farming industry elsewhere in New Zealand. Up until recently around 80% of all spat for mussel aquaculture came from large quantities that wash up intermittently on Ninety Mile Beach adhering to various species of drifting seaweed. The spat-covered seaweed is gathered from the beach and transported to mussel farms where they it is transferred and held on the cultivation dropper ropes with cotton stocking. Currently more than 200 tonnes of the spat covered seaweed is gathered and freighted from Ninety Mile Beach, and the volumes required for the industry have been increasing dramatically in recent years with the rapid growth of the mussel farming industry. The spat gathering industry currently employs around 25 people in the Far North and currently generates $1.2 -$1.5M in sales per annum and this figure has been steadily increasing.

The Ministry of Fisheries is currently looking at rearranging the management of this mussel spat gathering fishery, which is currently permitted through Special Permit arrangements under the Fisheries Act. The leading proposal is to place this mussel spat gathering into the Quota Management System, creating an individually owned catching right for set amounts of beach cast mussel spat. This Individual Transferable Quota (catch right) will attract a substantial capital value, as it has for other fisheries. This new capital value is likely to result in the exclusion of the current owner-operators, in much the same manner that many small commercial fishers were forced out of Northland waters with the introduction of the QMS for many finfish species. Furthermore, servicing the capital cost of the mussel spat is likely to increase the cost-structure for supplying beach cast mussel spat, making alternative sources of spat, such as hatchery raised and wild-caught on “hairy” ropes more economical. Hence, the change in management regime for mussel spat gathering in the Far North may also result in major changes to this small but important activity in Northland. The Ministry of Fisheries is currently further considering the management options for mussel spat and has called for submissions.

There is increasing interest in developing offshore mussel spat collection using spat catching materials, such as “hairy” ropes. A small pilot operation has been established just inside the entrance to the Whangape Harbour, and there is strong interest in other areas such as the Hokianga Harbour and offshore from Ahipara. Studies by NIWA and Auckland University offshore from Reef Point near Ahipara have shown that excellent levels of mussel spat can be caught on “hairy” spat catching ropes throughout much of the year. This area has the potential to be developed as an important mussel spat catching area.

The rapid growth and good financial returns from mussel farms in other parts of the country encouraged attempts in Northland from the early 1980’s. Despite several attempts, mussel farming has not become well established in Northland as it has in other parts of the country. For example, attempts at commercial scale farming of mussels in the Hokianga Harbour encountered problems with labour, currents, siltation, algal blooms, pollution and theft. The most active mussel farming area in Northland currently consists of over 20 hectares of farms at Houhora Bay. These farms started from a single farm in 1984 and have gradually expanded to their present size. Currently around 55 mussel lines are established with room for 17 more. The current farms produce around 500 tonnes a year, which are transported to Auckland for processing. The farms employ at least four people full time and two part time.

Since the early 1990's there have been further proposals for mussel farms in the Parengarenga, Whangaroa and Whangaruru Harbours and Karikari Bay, however, these proposals all failed due to concerns over issues such as navigational safety, conservation, as well as public recreation and iwi concerns. The proposal for Karikari Bay also included the farming of scallops and crayfish. Mussel farming activity in Northland is estimated to involve the employment of up to 10 people and gross returns of around $1M.

In 1987 Presbyterian Support Services (Northern) began looking for alternative employment opportunities for young people in Northland. In early 1988 they applied for a permit to import channel catfish for aquaculture development in Northland that they believed would provide the basis of a $2M venture that would generate employment for 200 people within two years. The proposal had the backing of Te Runanga o Muriwhenua. After some time they were granted permission to import channel catfish into quarantine, however, subsequent government concerns over the risks of releasing the species into the New Zealand environment resulted in the fish being destroyed and the proposals for aquaculture development stopped. A similar bureaucratic shambles was associated with the importation of marron, a freshwater crayfish species that was also touted as having considerable potential for aquaculture in Northland. In the case of marron, the contained farming of the species had begun near Warkworth, when the government recapitulated on earlier approvals for the species and arranged for the stock to be destroyed. This subsequently resulted in a substantial compensation payment by the government to the group involved in attempting to establish the marron farming activity.

A series of small freshwater ponds are used to breed grass and silver carp near Mangawhai. Fish from this operation are sold for use in clearing waterways of waterweeds and recently 4,000 fish from this farm were released in Lake Omapere to help in the control of waterweeds and small numbers of fish have been sold in the

Auckland seafood market, mainly to Asian customers. The operation attempted to on sell or lease fish for waterway clearance and then relay the ongrown fish to the Auckland seafood market. However, delays of over two years in processing permissions to move the fish between locations made this activity uneconomic.

There has been strong interest in paua farming in New Zealand for the last twenty years and at least twenty small farms now operate around the country. There has been interest in paua farming in Northland also. There was apparently an experimental Maori paua farm in the Whangaroa Harbour and proposals to establish a large farm at Mahinepua Island off Whangaroa Harbour, however, it has not been possible to find out further details about the success of these earlier investigations. Recently a paua farm has been established at NIWA's Bream Bay Aquaculture Park.

A small experimental mullet farm was established in the Kaipara Harbour but never really became established. Although there has been strong interest in developing similar mullet ventures elsewhere in Northland, such as in the Hokianga Harbour, these have never been pursued to any great extent.

A small land-based fish farm at Ruawai has been investigating the culture of eels in saltwater, and more recently has been looking at the possibility of holding live wild-caught flounder for live transport to market.

Scallop enhancement has been identified as having considerable potential for Northland for many years, and a very successful example of the value of enhancement has been established for many years in Nelson and Golden Bays. Some small-scale experimental work has been conducted at a number of locations off the east coast of Northland, which indicated that reasonable sources of spat are available. Catch levels were sufficiently high to indicate they had the potential to act as the basis of developing an enhanced scallop fishery. However, this potential has not been developed further apparently due to a lack of financial backing from the existing commercial scallop quota holders and recreational fishers that would be the primary beneficiaries of any increase in catches from enhancement.

An iwi-based proposal for enclosing Bland Bay with netting for an enclosed fish farm was dropped before it was progressed largely due to environmental concerns.

In 2002 NIWA finished the construction of a large $2.5M land-based aquaculture research and development facility at the site of the disused power stations near Ruakaka. The facility makes use of the existing seawater pipes that were previously used for the cooling system for one of the power stations. The aim of the Bream Bay Aquaculture Park is to bridge the gap between small-scale research and subsequent commercial production. Collaborative research projects at the site include kingfish, snapper, mussels, Pacific and flat oysters, paua, crayfish and eels. Moana Pacific Fisheries Ltd has space at this site with three staff working with NIWA on producing snapper and kingfish fingerlings for grow-out. Moana Pacific has also been working with Ngati Wai to develop a pilot sea-cage grow out site for these finfish at Peach Cove near Whangarei. However, their approval for a coastal consent was going to be appealed by a group of concerned local residents, which subsequently caused the applicants to withdraw the application due to the potential costs of defending the application in the Environment Court.

The Bream Bay Aquaculture Park site has more than 20 NIWA and industry staff, as well as many visitors such as University of Auckland research staff and students, and NIWA research staff from Auckland and elsewhere. The site has excellent water quality and capacity, with the state-of-the-art filtration and live feeds systems that are critical to running a successful hatchery. The quality of the site and the expertise on site is reflected in the success with spawning and rearing many species within a year of establishment, including mussels, Pacific oysters, flat oysters, snapper and kingfish.

Sealord Shellfish Ltd has developed a research scale green-lipped mussel hatchery at the Bream Bay Aquaculture Park to investigate mussel hatchery and spat nursery techniques. The Sealord operation has two staff. The results from the hatchery have been very encouraging to date. OceaNZ Blue Paua Ltd is developing one of the largest paua farms in New Zealand on site at Bream Bay. The farm aims to be producing 3 to 4 million paua, which will produce 100 tonnes of meat for export. The value of this product is high, as wild caught paua exports were valued at about $80,000 a tonne in 2001. By working with the oyster farming industry NIWA has also established a capacity to supply commercial quantities of Pacific oyster spat, and is running some preliminary trials on flat oyster (Bluff oyster) spat production.

Overall, in 2002 aquaculture in Northland is estimated to have produced over $20M in total sales, much of it from exports (around 85%). The industry is also estimated to directly employ more than 400 people (around 320 FTE). The aquaculture industry is likely to have stimulated indirect economic activity of an estimated further $20M, including generating 140 jobs.

According to the Ministry of Fisheries and Northland Regional Council records there are a total of around 130 marine farm leases of licences, and marine farming permits currently in effect in the Region. A further 5 or more marine farming licences or leases have been surrendered or have expired. A marine farm lease or licence, or a marine farming permit is a legal requirement under the Marine Farming Act 1971 or the Fisheries Act 1983 for marine farming in the sea, such as suspended mussel farm or an intertidal oyster farm.

At present there are only three valid freshwater fish farming licences for the Northland Region. A freshwater fish farm licence is a legal requirement under the Fish Farming Regulations for farming most marine or freshwater species in tanks or ponds on land. One licence is for the small-scale pond farming of silver and grass carp near Mangawhai, the second is for an experimental eel farm in Ruawai, and third is for NIWA's Bream Bay Aquaculture Park.

Many of the aquaculture activities found in the Region are run from businesses also based in the Northland Region, although two major companies involved in oyster farming have their main offices outside of Northland, Pacific Marine Farms Ltd in Coromandel and Sanford Ltd in Auckland.

Marine Farm Leases (Issued under the Marine Farming Act 1971)

#	Lease Holder	Address	Size (Ha)	Granted	Expires	Species/ Location
3	Sanford Ltd	Box 443 Auckland 1	7.1834	03/01/1983	31/10/2007	Rock Oysters
12	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	1.0931	12/01/1967	30/11/2009	Rock Oysters
14	Fleming MJ & JM	Box 115 Kaeo	1.9966	01/08/1968	31/07/2010	Rock Oysters
15	Trustees A & J L Tindall Family Trusts	Ashby St Russell	0.9821	11/01/1967	31/10/2009	Rock Oysters
16	Andelain Marine Farms Ltd	Box 98731, SAMC, 266 Roscommon Road, Auckland	1.8731	02/01/1967	31/10/2007	Rock Oysters
17	Sanford Limited	Box 443 CPO Auckland	16.2491	12/01/1968	31/10/2007	Rock Oysters
18	Sanford Limited	Box 443 CPO Auckland	7.6801	01/12/1967	30/11/2009	Rock Oysters
19	Hansen G	Box 115 Kerikeri		01/07/1982	Expired	
23	Van Veen SM	10 Taumata Close Paihia	1.3101	01/06/1979	31/05/2007	Rock Oysters
24	Robertson JC & LR	C/- Postal Agency Opua		12/07/1967	Expired	Rock Oysters
28	Brierley PJ	Box 481 Nelson	2.0001	01/04/1981	31/05/2013	Rock Oysters
29	Roadley H & K	Batley RD Maungaturoto	23.0307	01/02/1968	31/01/2010	Rock Oysters
41	Andelain Marine Farms Limited	Box 3317 Auckland 1	1.5657	01/04/1968	31/10/2007	Rock Oysters
42	Grindlay NL & DI	Box 96 Russell	4.3554	01/12/1974	30/11/2006	Rock Oysters
44	Andelain Marine Farms Limited	Box 98731 SAMC 266 Roscommon Road, Auckland	1.4513	01/06/1968	31/10/2007	Rock Oysters

47	Harwood C & R	RD 1 Russell	2.0963	01/12/1980	30/11/2008	Rock Oysters
53	Tindall Oysters Ltd	Ashby Street Russell	4.0469	01/09/1968	31/08/2010	Rock Oysters
55	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	3.4521	01/11/1968	31/10/2010	Rock Oysters
56	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	2.0234	01/12/1968	30/11/2010	Rock Oysters
57	Fleming MJ & JM	Box 115 Kaeo	2.0234	01/08/1968	31/07/2010	Rock Oysters
62	Roff MC & LM	C/- PO Maungaturoto	1.8149	01/12/1968	30/11/2011	Rock Oysters
64	Davenport C	C/- Postal Agency Opua	2.2726	01/02/1969	31/01/2011	Rock Oysters
67	Brierley PJ	Box 481 Nelson	1.9281	01/01/1970	31/10/2007	Rock Oysters
69	Kohekohe Oysters Ltd	Box 62 Russell	2.0723	01/10/1969	30/09/2011	Rock Oysters
73	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	3.9965	01/12/1969	30/11/2011	Rock Oysters
77	FB & KV Nicholson & M Sumpter	C/- M & S Box 7633142 Takapuna	4.1271	01/11/1969	31/10/2011	Rock Oysters
78	Brain AW	Box 136 Russell	2.6551	01/08/1983	31/07/2011	Rock Oysters
79	Sanford Ltd	Box 443 Auckland, 1	2.9163	01/12/1969	30/11/2007	Rock Oysters
80	Peters P & A	Box 402 Warkworth	2.0234	01/07/1969	30/07/2011	Rock Oysters
81	Sanford Ltd	Box 443 CPO Auckland 1	2.3578	01/09/1969	31/08/2011	Rock Oysters
85	Sanford Ltd	Box 443 CPO Auckland 1	15.8989	01/03/1983	31/10/2007	Rock Oysters
91	Jessop BD & CJ	RD4 Whangarei	2.8328	01/08/1969	31/07/2011	Rock Oysters
94	Colquhoun TD	271 One Tree Point Rd Ruakaka	4.047	01/08/1969	31/07/2011	Rock Oysters
95	Peters T & A	Box 402 Warkworth	2.0234	01/08/1969	30/07/2011	Rock Oysters
97	Jannock Investments Ltd	126 Western Springs Rd Auckland 3	2.2341	01/08/1969	28/11/2011	Rock Oysters
98	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	80.9383	01/06/1970	31/05/2012	Rock Oysters
100	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	23.7955	01/03/1971	28/02/2013	Rock Oysters
111	Yardley PA & CH	Maungaturoto RD Paparoa	4.0469	01/11/1969	31/10/2011	Rock Oysters
115	Roff MC & LM	C/- Post Office Maungaturoto	2.0234	01/12/1969	30/11/2011	Rock Oysters
117	Harcus I R & Spencer JM	Box 16 Paparoa	1.6187	01/10/1969	30/09/2011	Rock Oysters
119	Tindall A & J	Ashby Street Russell	2.3574	01/11/1984	31/10/2012	Rock Oysters
124	Lindauer PMF	Box 12 Russell	1.6801	01/12/1969	30/11/2011	Rock Oysters
130	Tindall A & J	Ashby Street Russell	3.2785	01/10/1970	30/09/2012	Rock Oysters
137	Tindall Oysters Ltd	Ashby Street Russell	5.2227	01/12/1969	30/11/2011	Rock Oysters
138	McInness DC & JG	C/- Postal Agency Opua	2.0234	01/08/1971	31/07/2013	Rock Oysters
139	Sanford Limited	Box 443 CPO Auckland 1	5.9329	01/12/1969	11/01/2007	Rock Oysters
140	Smith PWF	RD3 Kawakawa	4.3266	01/04/1970	31/03/2012	Rock Oysters
147	Roff MC & LM	C/- Post Office Maungaturoto	11.6471	01/10/1986	30/09/2015	Rock Oysters
152	Trustee A & JL Tindall Family Trusts	Ashby Street Russell	2.2992	01/03/1970	31/10/2007	Rock Oysters
153	Kororareka Oysters Ltd	Box 235 Russell	1.552	01/02/1986	28/02/2014	Rock Oysters
154	Kororareka Oysters Ltd	Box 235 Russell	1.0193	01/03/1986	28/02/2014	Rock Oysters
158	Warren R & S, Cairns L; Warren BT	Opito Bay RD Kerikeri	2.0722	01/08/1987	31/07/2015	Rock Oysters
159	Smith J & G	RD2 Kawakawa	5.6375	01/02/1987	31/01/2001	Rock Oysters
160	Rawlings D D Dr	93 Palmerston Road Birkenhead Auckland	7.1876	01/12/1986	31/05/2010	Rock Oysters
161	Warren R &S & L Tstee	Opito Bay R D 1 Kerikeri	4.4856	01/12/1986	31/05/2010	Rock Oysters

	Opito T & Warren BT					
162	Grindlay Properties Ltd	Box 96 Russell	2.2279	01/12/1986	31/05/2010	Rock Oysters
163	Warren R & S & L Tstee Opito T & Warren BT	Opito Bay RD 1 Kerikeri	2.3917	01/12/1986	31/05/2010	Rock Oysters
165	Cook EH	17 Netherlands Avenue Glen Eden Auckland	4.5501	01/05/1989	30/04/2003	Rock Oysters
166	Waitai B	35 Grigg Street Kaitaia	10.0001	01/01/1989	31/12/2002	Rock Oysters
167	Mitimiti Coummunity Trust	RD2 Kohukohu	5.0001	01/02/1990	31/01/2004	Rock Oysters
168	Tindall Oysters Limited	Ashby Street Russell	0.1705	01/04/1990	31/03/2004	Rock Oysters
170	Ika Marine Ltd	C/- PDC Opua	2.0001	01/10/1990	30/09/04	Rock Oysters
171	Ika Marine Ltd	C/- PDC Opua	2.8301	01/10/1990	30/09/04	Rock Oysters
172	Aronui Ko Huirau Trust Board	Box 22 518 Otahuhu	3.4785	01/10/1990	30/09/04	Rock Oysters
173	Parengarenga Fisheries Ltd	Te Kao RD4 Kaitaia (W&MH Brown)	2.0001	01/10/1970	30/09/2012	Rock Oysters
174	Aronui Ko Huirau Trust Board	Box 22 518 Otahuhu	14.5051	01/10/1990	30/09/2004	Rock Oysters
175	Trustee A & JL Tindall Family Trusts	Ashby Street Russell	1.0901	01/11/1990	31/10/04	Rock Oysters
177	Proprietors of Muriwhenua Incorp	Admin Centre Te Kao RD4 Kaitaia	36.4217	01/07/1970	31/07/2012	Rock Oysters
180	Kororareka Oysters Ltd	Box 235 Russell	1.3421	01/01/1991	31/12/2004	Rock Oysters
181	Proprietors Of Muriwhenua Incorp	Admin Centre Te Kao RD4 Kaitaia	2.0234	01/07/1970	30/06/2012	Rock Oysters
182	Leask C & D	RD1 Maungaturoto	2.3296	01/01/1992	31/12/2005	Rock Oysters
183	Sanford Ltd	Box 443 CPO Auckland 1	3.2871	01/07/1991	30/06/2005	Rock Oysters
185	Symes PL & G	Pahi RD1 Paparoa	6.0701	01/08/1970	31/07/2012	Rock Oysters
204	Sanford Ltd	Box 443 Auckland 1	23.7972	01/03/1971	31/10/2007	Rock Oysters
222	Trustee A & JL Tindall Family Trust	Ashby Street Russell	1.1758	01/01/1968	31/12/2010	Rock Oysters
223	Trustee A & JL Tindall Family Trust	Ashby Street Russell	0.9329	01/01/1968	31/12/2010	Rock Oysters
227	Parengarenga Fisheries Ltd	Te Kao RD4 Kaitaia (W&MH Brown)	2.0234	01/09/1970	31/08/2012	Rock Oysters
238	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	23.7972	01/03/1971	28/02/2013	Rock Oysters
239	Sanford Ltd	Box 443 Auckland 1001	15.8637	01/03/1971	28/02/2013	Rock Oysters
240	Leask C & D	RD1 Maungaturoto	4.7637	01/06/1979	31/05/2011	Rock Oysters
242	Leaf J & N	RD 1 Kerikeri	2.0234	01/10/1970	30/09/2012	Rock Oysters
285	Brain A	Box 136 Russell	9.1354	01/01/1976	31/12/2003	Rock Oysters
311	Pacific Marine Farms (1996) Ltd	P O Box 65 Coromandel	10.0121	01/06/1992	31/05/2006	Rock Oysters
312	Kite Moana Oysters Ltd (in liquidation)	Box 77 Kaiwaka	1.7201	01/09/1992	31/08/2006	Rock Oysters
313	Rangipapa Marine Farms Ltd (struck off)	Paparore Road, Awanui	4.9801	01/06/1993	31/05/2007	Rock Oysters
315	Pacific Marine Farms (1996) Ltd	P O Box 65 Coromandel	6.0031	01/04/1992	31/03/2006	Rock Oysters
316	Sanford Ltd	P O Box 443 CPO Auckland 1	3.9951	01/04/1992	31/03/2006	Rock Oysters
317	Sanford Ltd	P O Box 443 CPO Auckland 1	8.0271	01/05/1992	31/04/2006	Rock Oysters
318	Sanford Ltd	P O Box 443 CPO	3.9951	01/04/1992	31/03/2006	Rock Oysters

		Auckland 1				
319	Andelain Marine Farms Ltd	Box 98721 AMC Manukau	1.7006	01/04/1993	31/03/2007	Rock Oysters
320	Kororareka Oysters Ltd	Box 235 Russell	0.518	01/05/1993	30/04/2007	Rock Oysters
321	Kororareka Oysters Ltd	Box 235 Russell	0.867	01/05/1993	30/04/2007	Rock Oysters
322	Trustee A & JL Tindall Family Trust	Ashby Street Russell	0.8381	01/04/1993	31/03/2007	Rock Oysters
323	Trustee A & JL Tindall Family Trust	Ashby Street Russell	0.5981	01/04/1993	31/03/2007	Rock Oysters
324	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	0.6191	01/04/1993	31/03/2007	Rock Oysters
325	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	0.9321	01/04/1993	31/03/2007	Rock Oysters
326	Trustees Waihaua Trust	Box 22518 Otahuhu	4.0044	01/12/1992	30/11/2006	Rock Oysters
327	Waitai S T and P C	Box 151 Awanui	10.0001	01/02/1993	31/01/2007	Rock Oysters
330	Olsen D & Murray S	Inland Road RD 4 Kaitaia	5.0021	01/05/1993	30/04/2007	Rock Oysters
331	Kapa A	Box 22 Awanui	7.4551	01/05/1993	30/04/2007	Rock Oysters
337	Andelain Marine Farms Ltd	Box 98731 SAMC 266 Roscommon Rd Auckland	0.8701	01/02/1994	28/02/2014	Rock Oysters
338	Andelain Marine Farms Ltd	Box 98731 SAMC 266 Roscommon Rd Auckland	0.5675	01/05/1993	31/12/2007	Rock Oysters
339	Harwood C & R	Main Road Russell	0.6464	01/04/1993	31/03/2007	Rock Oysters
344	Herbert IR & PMF (1996) Ltd	1600 Long Bay Road Coromandel	4.0468	12/08/1998	28/02/2013	Rock Oysters
345	Lindauer PWF & Lindauer SM	P O Box 12 Russell	1.6801	07/11/1998	28/11/2011	Rock Oysters
348	Hearn C & Hearn M	7 Galliard Way Kamo	1.3901	03/11/1998	31/12/2006	Rock Oysters
349	Hearn MJ	7 Galliard Way Kamo	1.2261	03/11/1998	31/12/2006	Rock Oysters
350	Playle KR	C/- PO Russell	0.5948	01/09/1999	28/02/2014	Rock Oysters

Total number of current valid licences is 106, for a total area of 578.2785 hectares, which is all in oysters. The most significant holders of marine farm licences are Pacific Marine Farms Ltd with a holding of 156.6625 hectares, and Sanford Ltd with a holding of 117.1838 hectares.

Marine Farm Licences (Issued under the Marine Farming Act 1971)

#	Licence Holder	Address	Size (Ha)	Granted	Expires	Species/ Location
277	Weber Bros Ltd	Box 20 Matakohe	2.0365	08/01/1983	31/07/2012	Mussels
284	Sea Hatcheries Ltd	Box 6219 Wellesley Street	-	02/01/1984	Surrendered	Mussels
302	Houhora Bay Marine Farms Ltd	RD4 Kaitaia	4.5001	10/01/1984	30/09/2012	Mussels
398	Westpac Mussel Distributors Ltd	19 Railside Ave Henderson	3.0001	01/01/1988	31/12/2001	Mussels
414	Hokianga Mussel Venture Ltd	Box 447 Whangarei	-	12/01/1991	Surrendered	Mussels
470	Ngapera P and Thompson F	RD1 Kohukohu	-	05/01/1992	Surrendered	Mussels
533	Matiu M and Busby	C/- Ngati Kahu T.B. Box 383 Kaitaia	4.0001	12/01/1993	Surrendered	Mussels

Total number of current valid licences is two, for a total area of 6.5366 hectares for farming mussels.

Marine Farming Permits (Issued under the Fisheries Act 1983)

#	Permit Holder	Address	Size (Ha)	Granted	Expires	Species
27	Waitai Ben	Box 618 Kaitaia	4.0001	31/07/1993	30/07/2008	Pacific Oysters
28	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	2.0001	24/11/1992	23/11/2006	Pacific Oysters
29	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	5.4011	04/01/1992	31/03/2006	Pacific Oysters
44	Sanford Limited	Box 443 CPO Auckland, 1	3.4001	24/11/1992	23/11/2017	Pacific Oysters
46	Sanford Limited	Box 443 CPO Auckland 1	1.8901	24/11/1992	23/11/2017	Pacific Oysters
48	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	1.8901	14/12/1992	13/12/2017	Pacific Oysters
50	Sanford Limited	Box 443 CPO Auckland 1	6.0001	04/01/1992	31/03/2006	Pacific Oysters
76	Houhora Bay Marine Farms Ltd	Lambs Road RD4 Kaitaia	4.5001	30/06/1994	29/06/2009	Mussels
83	New Zealand Native Fisheries Ltd	73 Inland Road RD3 Kaitaia	9.0001	31/07/1992	30/07/2017	Pacific Oysters
103	Kauanga Fisheries Ltd	C/- J S Everitt Everitts Rd RD4 Kaitaia	7.8001	30/09/1993	29/09/2008	Pacific Oysters
116	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	6.0001	06/11/1992	05/11/2017	Pacific Oysters
118	Westpac Mussel Distributors Ltd	19 Corbans Ave Henderson	2.5501	30/06/1994	29/06/2009	Mussels
139	D Olsen, T Houkamau, T Edwards	Imms Road RD1 Awanui Northland	4.0001	28/11/1994	27/11/2009	Pacific Oysters
140	Ross Walker Whanau	Tanoa Rd RD1 Maungaturoto	0.9901	19/12/1994	18/12/2009	Pacific Oysters
142	D Olsen, T Houkamau, T Edwards	Imms Road RD1 Awanui Northland	4.0001	28/11/1994	27/11/2009	Pacific Oysters
148	Brown Waina	Te Hapua RD4 Kaitaia	4.0001	28/11/1994	27/11/2009	Pacific Oysters
190	Pacific Marine Farms (1996) Ltd	Box 65 Coromandel	4.0001	28/11/1994	27/11/2009	Pacific Oysters
214	Kite Moana Whanau Trust (Tstees)	Box 27 Kaiwaka	2.3101	19/12/1994	18/12/2009	Pacific Oysters
216	Otamatea Aquaculture Ltd	Box 27 Kaiwaka	9.5212	01/06/1996	03/10/2009	Pacific Oysters
238	Te Pokere Oysters Ltd	C/- M Rata Ngataki RD4 Kaitaia	4.0001	28/11/1994	27/11/2009	Pacific Oysters
242	Wipatene Brown & EK Waenga	Te Hapua RD4 Kaitaia	4.0001	28/11/1994	27/11/2009	Pacific Oysters
288	Kaiawa Marine Ltd	Batley Rd RD1 Maungaturoto	1.4301	Surrendered	12/09/2000	Pacific Oysters
362	Rata Le Lievre Whanau Co-op	C/- J Le Lievre Pukenui RD4 Kaitaia	2.0001	01/05/1998	31/05/2009	Pacific Oysters
363	Le Lievre Ronda Lee	Te Hapua RD4 Kaitaia	4.0001	01/05/1998	31/05/2009	Pacific Oysters
387	Aquatic World BOI Ltd	Marsden Road Paihia	-	21/10/1999	02/06/2013	Seahorses
646	Biomarine Ltd	Box 183 Warkworth	1.4401	26/11/2001	31/08/2016	Pacific Oysters
647	Shane Colquohn	Whakapirau RD Maungaturoto	1.4401	26/11/2001	31/08/2016	Pacific Oysters
CPT	Petera E	P O Box 110 Awanui	5.0001	17/07/1995	31/07/2010	Mussels
CPT	Aupouri Fishing	P O Box 260 Kaitaia	8.0001	17/08/1995	31/07/2010	Mussels

	Company Ltd					
CPT	Nicholson F & B	Ota Point RD Kaeo	2.3001	18/04/1997	31/10/2011	Pacific Oysters
CPT	Koti H, Thrush A, Puru N	RD1 Maungaturoto	2.1001	21/11/1996	31/10/2011	Pacific Oysters
CPT	Aromia Seafoods Ltd	Box 22518 Otahuhu	3.2501	21/11/1996	31/10/2011	Pacific Oysters
CPT	Paparoa Whakatu Whanau	P O Box 147 Leigh	0.9201	19/12/1994	18/12/2009	Pacific Oysters
CPT	Waiaotea Oyster Ltd	C/- Mikaera Miru Private Bag Tinopai	2.0001	05/12/1997	30/11/2012	Pacific Oysters

Total number of permits is 32, for a total area of 123.7053 hectares. Four permits are for mussels covering an area of 20.0504 hectares and 28 permits are for oysters covering an area of 103.6549. A further permit is for a seahorse farm, which is a bureaucratic anomaly due to the tourist aquarium at Pahia being located over the sea on a pier. The two permit holders with the largest area are Pacific Marine Farms Ltd with 19.2915 hectares of oyster permits, and Sanford Ltd with 11.2903 hectares of oyster permits.

Freshwater Fish Farm Licences (Issued under the Freshwater Fish Farming Regulations)

The total number of freshwater fish farm licences for Northland is two.

#	Licence Holder	Address	Species
6	LaBonte, Andre William	PO Box 60, Waipu, Northland 0254	Grass & silver carp
82	Hollenberg, Theodore Johannes	Raupo, RD2, Ruawai, Northland	Eels & Flounder
?	NIWA	PO Box 109-695, Auckland	Kingfish, snapper, eels, paua

According to the records of the Northland Regional Council marine farms in Northland breakdown into the following locations.

HARBOUR LOCATION	Species	MAF Licence/ Lease	CPT Permit	Total Permits	MAF Area (ha)	CPT Area (ha)	Total Area (ha)
Parengarenga							**84.3**
North	Oysters	5	4+7	16	52.50	22.0	
South	Oysters	1	1	2	2.0	7.8	
Houhora							**50.95**
Jacksons Bay	Oysters	5	6	11	32.03	18.92	
Houhora Bay							
Kowhai Bay	Mussels	2	1+3	6	7.5	4.5	**12**
Karikari Bay	Mussels	1		1	4		**4**
Rangaunu							**31.46**
Pukewhau Channel	Oysters	3	1	4	22.46	9	
Whangaroa							**114.24**
Waitapu Bay	Oysters	3	+1?	4	11.20		
Touwai Bay	Oysters	1		1	4.93		
Pumanawa Bay	Oysters	1		1	2.92		
St. Peters	Oysters	5		5	95.19		
Bay of Islands							**182.43**
Te Puna Inlet	Oysters	5		5	23.40		
Kerikeri Inlet	Oysters	7		7	41.43		
Parekura Bay	Oysters	1		1	2.5		
Paroa Bay	Oysters	1		1	2.1		
Orongo Bay	Oysters	18		18	29.08		
Waikare Inlet	Oysters	23		23	72.72		
Waikino Inlet	Oysters	2		2	11.21		
Whangarei							**2.83**
Parua Bay	Oysters	1		1	2.83		
Kaipara			5+4	9			**193.11**
Pahi River	Oysters	5		5	13.17		
Paparoa Creek	Oysters	3		3	19.34		
Arapaoa River	Oysters	6		6	39.39		
	Mussels	1		1	2.31		
Otamatea River	Mussels	1		1	7.3		
Whakaki River	Oysters	2		2	6.7		
Kirikiri Inlet	Oysters	1		1	4.0		
Hargreaves Basin	Oysters	4		4	100.9		
Hokianga							**36.12**
Te Karaka	Oysters	3		3	22.92		
	Mussels	2		2	13.2		
TOTALS	Oysters	106	12(+20?)	32	585.14	87.52	**672.66**
	Mussels	7	1	8	34.31	4.5	**38.81**
GRAND TOTAL		**113**	**13**	**126**	**619.45**	**92.02**	**711.47**

The figures from the two different government agencies are slightly different but both record a total of just over 700 hectares of marine farm space allocated in Northland, with the majority in intertidal Pacific oyster farms (around 670 hectares) and the balance in subtidal mussel farms (around 40 hectares). The major locations for oyster farms are throughout the Bay of Islands and the Kaipara Harbour (both around 180 hectares). It is unclear what proportion of this farm space is fully developed, however, it is clear from discussions with a number of Northland marine farmers that a significant proportion of the farm space has not yet been developed. For example, both the Kaipara and Hokianga Harbours have significant areas of undeveloped marine farm space. A survey by the Ministry of Agriculture and Fisheries in 1993 found that over 40% of farm space was undeveloped in Northland. There are a wide variety of reasons why marine farm space is not fully developed including, unsuitability of the site, or part of the site for farming, delays in acquiring the capital or capacity to develop the farm sites, business failure, or recent pollution events.

The Bay of Islands and Whangaroa Harbour are currently the strongest suppliers of good quality Pacific oysters. Although the Kaipara Harbour has significant growing areas, it has never prospered for oyster farming in the same manner as parts of the Bay of Islands because growing oysters in the Kaipara Harbour is generally more difficult. This is because of the siltier conditions, "overcatch" or smothering of ongrown oysters with settling oyster spat, fouling with other marine creatures, and problems with predatory flat worms in some locations. In more recent years interest in using the Kaipara Harbour for expansion of the oyster farming has been rekindled following the development of new oyster farming methods that better suit the conditions in this harbour. The Kaipara Harbour has always been a popular location for collecting oyster spat and a very large proportion of the spat gathered for oyster farms throughout the North Island comes from this harbour. However, in the last few years there has been growing interest in using hatchery raised spat among many oyster farmers, as this can provide greater control over the product quality. Hatchery spat is the predominant seed source for most of the world's Pacific oyster farming industry which produces in excess of 3 million tonnes a year.

Aquaculture has long been identified as having significant potential for economic development in Northland. A great number of regional planning and economic development initiatives have identified this potential starting in the late 1960's when the Marine Department very actively promoted the development of the intertidal farming of native rock oysters in the Northland. Subsequent regional economic development initiatives in the 1970's (Northland Regional Development Council), 1980's (Development Finance Corporation of New Zealand, and North Ventures) and 1990's and early 2000's (The James Henare Maori Research Centre, and the Northland Regional Council Community Trust) have repeatedly identified the considerable potential for aquaculture in the region.

In the 1970's the Northland Regional Development Council undertook an extensive survey of resources in Northland that could be developed for the regional economy. This review included fisheries and aquaculture potential. The work identified the potential for the farming of snapper, kingfish, scallops, oysters and mussels and recommended support to expand shellfish farming activities, and research to aid finfish farming development. Improved arrangements for managing the placement of marine farms were also recommended.

In the mid-1980's the Development Finance Corporation of New Zealand reviewed the economic development opportunities in the Northland and concluded that aquaculture of a variety of species, including those identified a decade previously, had considerable potential. At this time (1986) the Northland oyster industry had grown to producing over $3M of oysters a year with the majority exported. Like the previous work by the Northland Regional Development Council, the Development Finance Corporation also recommended improvements in the institutional arrangements for establishing marine farms. This followed failed attempts at establishing mussel farms in Whangaroa Harbour and the Bay of Islands during this period. They criticised the short-term tenure available for marine farm sites under the legislation of the time. In addition, they identified a lack of marketing and business skills among the oyster farming industry, and the need to consolidate the industry in order to make gains.

In the late 1980's a private consultancy, North Ventures Ltd, was hired by the Northland Regional Council to report on development options for Northland. The work identified a similar suite of resource development opportunities to the Development Finance Corporation a few years earlier and this included aquaculture opportunities. North Ventures identified that decreasing water quality in harbour areas would continue to cause difficulties for shellfish aquaculture development and needed to be addressed with better monitoring and controls of pollution. Like their predecessors they also recommended improvements in the institutional arrangements for establishing and operating marine farms.

In the late 1980's the Ministry of Agriculture and Fisheries (MAF) attempted to redress the ongoing difficulties with the institutional arrangements for establishing and operating marine farms, by way of proposing a complete reform of aquaculture legislation. However, the legislative reform was dragged into the process for reforming environmental law, which later emerged as the Resource Management Act (RMA). During the formation of the RMA there were also efforts to fully integrate the laws for establishing and operating marine farms into the new legislation, however, strong political lobbying from the MAF, prevented this from taking place.

As a result the responsibilities for the establishment and administration of marine farms were split between several government agencies (mainly Department of Conservation (DoC) and MAF) as well as regional councils. Furthermore, existing marine farm leases and licenses were retained while introducing a new system under the RMA that further complicated the administrative system for marine farms. This unsatisfactory outcome probably had the greatest impact in Northland and Waikato where the three lead agencies, DoC, MAF and the Northland Regional Council became entangled in debates over their roles and general approaches to managing marine farming activity. This was partly due to strong coastal conservation attitude adopted by DoC, increasing iwi concerns and clout over coastal issues, and frustration from would-be marine farmers, some who had been waiting in excess of three years for their applications for new farm sites to be processed.

In 1993 the New Zealand Fishing Industry Board commissioned a report into the potential for the Northland seafood industry as a region that the Board considered had good growth potential. As expected the study identified strong potential for growth in the seafood sector for Northland, especially from improved quality and marketing, and the development of specific aquaculture initiatives such as scallop enhancement and fish farming.

From 1995 until mid-2003 the James Henare Maori Research Centre of the University of Auckland was funded for over $367,000 a year to research and assist Maori with the sustainable development of their cultural and physical resources in Northland. These extensive studies, undertaken in successive tribal regions, also included investigation of aquaculture development opportunities and capacity among Maori communities. Overall, these studies found that Maori were significant owners of natural resources in many parts of Northland, especially land. However, Maori were consistently found to have a poor socio-economic profile measured as low levels of employment, motivation, entrepreneurship and educational achievement, and high social welfare benefit dependency, as well as limited income and access to potential sources of capital reserves. These factors were thought to have greatly limited the opportunity for economic development in these communities. Poor infrastructure identified in many of the rural areas that were studied were thought to have further compounded these development constraints. Maori were also found to have concerns about environmental and cultural damage resulting from developing economic opportunities. A number of mechanisms for Maori communities to deal with these many issues by preparing and implementing their own business development strategies were proposed by the researchers.

A range of specific aquaculture development opportunities were identified through the University of Auckland research for different parts of Northland, however, increased oyster farming and processing was a common recommendation for many of the areas that were studied. Other opportunities that were identified included scallop enhancement, as well as snapper and kingfish farming.

In 2001 the Northland Regional Council Community Trust funded the preparation of a strategy for the sustainable economic development of Northland. The study identified many of the issues related to the poor economic development of Maori in Northland, many of which have been identified through previous investigations. The study also identified the potential for aquaculture as an economic development initiative in Northland. The resulting strategy from the study identified similar issues to those that had been raised previously relating to aquaculture. Improvements in the institutional arrangements for establishing and operating marine farms was a key priority, as was improving aquaculture research, education, infrastructure and information availability for the Northland region. Attracting aquaculture investment to the region by promoting the benefits of Northland was also identified as a priority for action. Following on from this strategy project, the NADG has commissioned this current report.

In reviewing this history of economic development initiatives for the Northland region, it is very likely that some material has been missed. However, what is clear from reviewing this material is that although the issues have repeatedly been identified in the successive investigations over the past 30 years there has been a failure to adequately address some of the fundamental issues, in particular improving the institutional arrangements for establishing and operating marine farms.

As a consequence these issues remain today, and the regional economy of Northland has suffered from a tremendous lost opportunity. In the last decade aquaculture globally has grown by around 130% in total value, Australia well over 300%, New Zealand at almost 750% and Northland only around 70 - 80%. This lower growth rate in Northland is despite the region being one of the first in the country to develop commercial aquaculture and also possessing some of the best natural conditions for aquaculture of any region in New Zealand. Achieving regional aquaculture growth at the national average would have provided Northland with a $50M a year industry by 2000 and providing direct employment for as many as 2000 people (around 1600 FTE).

Many millions of financial support from regional and central government sources, as well as other sources, have been used to actively plan and promote aquaculture development in Northland in the past thirty years. This began in the late 1960's with the Marine Department giving hands-on and technical support to the establishment of oyster farms in Northland. In particular, large amounts of direct and indirect financial assistance have been given to establishing Maori run aquaculture enterprises in Northland over many years, including support from Department of Trade and Industry, Ministry of Agriculture and Fisheries, Department of Maori Affairs, Foundation for Research, Science and Technology, Technology New Zealand, University of Auckland, Te Ohu Kai Moana (Maori Fisheries Commission) and its seafood companies, Te Puni Kokiri, Te Runanga o Muriwhenua, Regional Business Development Agency, Northland Regional Council, as well as various regional development agencies.

Overall, the scale of aquaculture production and activity in Northland resulting from these extensive and expensive efforts to promote aquaculture growth has been limited. It is clear that the early initiatives by the Marine Department and later the Ministry of Fisheries, were instrumental in establishing the oyster industry in Northland. However, subsequent agency economic intervention have only resulted in the establishment of a limited number of additional farms in northern harbours, a number of which are still struggling financially.

Identifying the reasons for the failure of this economic intervention is particularly important in the case of Northland, as clearly traditional approaches are not as effective as they might be.

An interesting parallel with Northland can be drawn from the extensive efforts to promote aquaculture development by international aid agencies in poor parts of Africa since the 1950's. These programmes, which have cost tens of millions of dollars, also have a long history of very limited success. Recent research into the reasons for the failure of this intervention in Africa indicate that it is related to the delivery mechanisms, which have consistently failed to identify and empower effective entrepreneurs in local communities. More recent assistance programmes that have attempted to do this by adopting an alternative approach have achieved much better outcomes. These programmes have begun by identifying suitable existing entrepreneurs and business people in the community and encouraging them to move to develop aquaculture with the help of expert technical support, carefully structured commercial loans to raise capital, and developing more effective private sector, community and government partnerships. This approach has been criticised for not providing the direct financial and food benefits back to those most at need. However, the selection of effective entrepreneurs to lead the developments has resulted in more enduring aquaculture developments, and greater downstream benefits in terms of a reliable food supply and employment opportunities.

The lack of effective business and entrepreneurial skills for start up aquaculture enterprises has also been a problem in rural parts of Australia, which like Northland have excellent aquaculture development opportunities. In remoter parts of Australia this has been a significant issue for the aquaculture industry as highly skilled business managers and entrepreneurs capable of making a success of aquaculture start up ventures are attracted to urban centres and other industries where the opportunities and rewards are greater. Efforts have been made to up-skill and support local aquaculture entrepreneurs and to encourage local industry support networks.

The lack of capital to put at risk for starting new aquaculture ventures has also been an issue in Northland, as it is in many parts of the world. In the case of Northland, more capital intensive aquaculture ventures that require longer lead in times and further research and development (e.g. finfish aquaculture) are less attractive for investors, although the long term prospects may be good. In Australia, these difficulties have been addressed in a number of ways. There are a large number of government assistance schemes that are targeted at helping to raise capital, and to ease the financial pressures during the start up phase of significant ventures. These forms of assistance include generous tax relief for research and development, government grants for improving infrastructure such as roading or power supply to key sites, and a variety of assistance schemes for business planning through to finding export markets. South Australia runs a series of Regional Development Boards, which have more recently been involved in developing aquaculture. The boards are independent and have extensive input from community business leaders and are actively involved in bringing investors with capital together to support new ventures. Independent reviews of the effectiveness of the Regional Development Boards in South Australia has found that they have produced excellent results in terms of creating employment and investment in regional areas.

Australian government agencies have also been very active in seeking offshore capital investment and technical and business expertise in growing the aquaculture industry. For example, South Australia's Department of Industry and Trade has succeeded in attracting around A$15M of foreign investment into new aquaculture ventures in 2001. Partly, as a consequence of these kinds of initiatives the total value of aquaculture production in South Australia has grown massively from A$650,000 in

1989 to A$286M in 2000. The phenomenal growth in aquaculture activity in this Australian state has transformed the depressed regional economy and is rumoured to have created the highest density of millionaires in Australia, in the coastal town of Port Lincoln.

Much of the focus of economic intervention in aquaculture in Northland has focussed on Maori and has been of limited success in producing either strong economic outcomes or sustainable sources of kaimoana for local consumption. Similar experiences with indigenous people have been found in Australia and this appears to be related to the limited capacity of indigenous communities to develop entrepreneurial business ventures due to their socio-economic profile. Also, there are often significant conflicts with cultural and environmental views. Australia has recently developed a national strategy for engaging indigenous people in aquaculture development and much of this strategy focuses on providing support in many of the fundamental areas, such as aquaculture and business skill development. Studies and experience in New Zealand indicate that Maori communities will require similar support to succeed well with aquaculture developments in regions such as Northland. The involvement of Maori in aquaculture development and seafood enterprises is of particular significance in Northland, as statistics indicate they are socially and economically disadvantaged in the Region. Under the proposed allocation of assets from the Treaty of Waitangi Fisheries Commission, iwi in the Northland region will be allocated around $110M in assets and receive earnings from assets retained in Aotearoa Fisheries Ltd of around $1.5M. These existing seafood resources have considerable potential to help fund the realisation of further economic development opportunities through aquaculture.

Physical and Human Resources for Aquaculture in the Northland Region

Northland consists of a relatively narrow peninsula of land extending along a northwest-southeast axis for about 200km, with a total land area of 1.25M hectares. The region abuts the Auckland region to the south at just below the Mangawhai Harbour and midway across the Kaipara Harbour. The Region is divided into three administrative districts, Far North, Kaipara and Whangarei. The economy is largely agricultural with over half the land area of the region in dairy, beef and sheep. The agricultural sector contributes around $1billion annually to the regional economy, with more than half of this coming from dairying. Forestry and horticulture activities are becoming increasingly important to the economy of the region. Tourism contributes an estimated $230-$500M to the Northland economy and employs around 10% of the entire Northland workforce either directly or indirectly. The unemployment rate in Northland has fallen in recent years, staying below 10% for more than a year.

Northland is the most rural region of New Zealand with nearly half of the population of 140,133 living in rural areas. There are some 30 townships with populations of more than 500 people. The largest centre is the city of Whangarei with a population of over 45,000. Other provincial centres include (in order of decreasing population size) Kaitaia, Dargaville, Kaikohe, Paihia, Kerikeri, Taipa-Mangonui, Kawakawa. The population is generally concentrated along the region's east coast, particularly in the Whangarei and Bay of Islands areas. The coastal and river margins of Northland, were also home to extensive populations of Maori in the past. For this reason there are numerous archaeological sites throughout these areas.

The population is growing at just over 2%, which is slightly slower than the national average of 3.3%. However, much of Northland’s population is young with 25.1% under 15 years of age. The region has 52,086 occupied dwellings and 10,475 businesses (only 3% of the national total). Only 23.6% of Northland’s population earn over $30,000 a year while the national average is 30.7%. A number of surveys have shown high levels of social welfare support in Northland and generally low levels of tertiary training and recognised industry skills development.

Northland has few mountain ranges or even isolated peaks that rise more than 850m above sea level. Most of the rivers are short and tend to be slow flowing and heavily silt laden. The countryside can best be described as “rolling hill country.” The climate is subtropical – temperate with a mean annual rainfall that ranges from about 1000-1300mm in low-lying coastal districts to over 2500mm on some of the higher country. About a third of the rainfall occurs in winter.

The region has around 6,500 kilometres of roads with just over 700 kilometres in state highways. Highway One is the major route that runs most of the length of the centre of the region, while highways 10 and 12 reach to the east and west respectively. Airports served by commercial services are at Kaitaia, Kerikeri, Kaikohe, and Whangarei. A rail line runs from Auckland to Dargaville and Whangarei, and then onwards further north. Whangarei Harbour and Opua provide the two main shipping centres. The Port of Opua is mainly used for stopovers of tourist cruise ships, while Whangarei handles shipments of oil, logs and general goods.

The coastal environment is a major feature of the Northland Region. The west coast of Northland is exposed to the prevailing onshore oceanic swells mostly from the southwest that cause turbulence, turbidity and sediment movement in shallow marine and intertidal habitats. Consequently, the coastline consists of many miles of well-sorted sand beaches interrupted by rocky headlands and harbour entrances. These harbours (Kaipara, Hokianga, Herekino and Whangape) are mostly shallow, heavily silted and fringed with mangroves and salt marshes. The Kaipara Harbour is New Zealand's largest estuarine system and provides an important habitat for many coastal marine species, including birds and fish. The harbour has an extensive coast due to its convoluted coastline, which forms a series of inlets running inland. The harbour is a mixture of very extensive intertidal flats and deeper channels. Sands dominate the main body of the harbour, while more muddy environments are present where river influences become stronger due to the high sediment loading they carry. The Kaipara Harbour is used commercially for sand extraction near the entrance and commercial fishing for fish, mostly rig, schoolshark, flounder and mullet. There is some oyster and mussel faming within the harbour. The harbour is used extensively for cultural and recreational use, especially fishing, as are most harbours in Northland. Offshore from the west coast the seabed slopes gradually and it consists of fine sands grading into muds some considerable distance offshore. Two offshore ocean currents influence this coastline, the warm West Auckland Current at times flows southwards from the Tasman Sea, while from the south the Westland Current brings cooler waters up the coast and usually predominates, although weakly.

The eastern coastline of Northland is irregular , with promontories of rock interspersed with a great variety of harbours, bays and inlets, that have a full range of sediments such as mud, sand, shingle and gravel. This coast has low to moderate wave energy unlike the more exposed west coast of Northland. Harbours and estuaries within drowned river valleys are a common feature along the east coast of Northland. Most are ecologically similar to those on the west coast, but Parengarenga, Houhora and Rangaunu Harbours differ in having large intertidal sand flats and shell banks. The east coast of Northland is strongly influenced by the intermittent flow of the warm East Auckland Current coming down from subtropical south-eastern Australia. This warm current and diversity of habitats provides the basis for great diversity of marine life in this area, which consists of a mix of sub-tropical and temperate biota. Besides the intermittent East Auckland Current the water circulation in this area is strongly influenced by weather patterns, especially patterns of wind movement. The whole of the eastern coast of Northland is used extensively for cultural and recreational activities, especially fishing and boating. The area is also a very popular holiday destination with numerous holiday homes, especially around beaches and harbours. The eastern coast of Northland is extensively used commercially for fishing for fish, mostly snapper, crayfish, trevally, tarakihi, scallops and hapuku. As already outlined there is extensive oyster faming within a number of shallow intertidal areas. These extensively seafood operations have developed a good network of processing and distribution. Most seafood products leave the region by road, usually for Auckland where they are often processed or prepared for export. Substantial seafood processing plants are also present in Whangarei, Kaeo and near Kaitaia.

The Northland coastal and marine environment is widely thought to retain a high level of natural character and amenity value and therefore deserves a high level of protection. This is reflected in the high level of public and institutional concern over the impact that aquaculture might have on these values. Unfortunately, there are more significant and ongoing threats to the marine environment in Northland that attract far less vociferious public and institutional concern.

The early habitation of Northland by Maori using fire clearance of land resulted in significant erosion of land in many parts of Northland that date back at least 700 years. Subsequent European colonisation and their love of pastoral farming greatly speeded this process. Consequently most Northland harbours and shallow coastal areas have experienced a massive influx of silt and soils since human arrival, which continues in most parts of Northland today. The influx of soil material has radically altered most Northland harbour systems, with sensitive shallow intertidal habitats being obliterated and mangrove communities spreading from harbour margins as they thrive on the rich soil material. These permanent changes to the marine environment from soil erosion probably also extend well out into the coastal environment but have not yet been examined and described in detail. Shallow harbour ecosystems are well known to be important nursery and feeding areas of many coastal fish species, so the relatively dramatic ecological changes in Northland's harbours would have very likely had a knock on effect on coastal fisheries. Farming activities have also reclaimed large areas of harbour margins. For example, one study in the Hokianga Harbour found that almost half of the original mangrove and saltmarsh habitats had been destroyed. As well as permanently altering the marine environment, land-based activities also have an ongoing polluting impact. Faecal coliforms from livestock are now a common feature of Northland's harbours, and with increasing coastal development, human sewage pollution is becoming increasingly common. Soil nutrients and fertilisers washed into the marine environment also greatly alter the productivity and nutrient cycling of coastal waters. It is clear from numerous historical accounts that fish resources in Northland were extremely abundant at the time of European colonisation. Fishing activities in Northland have greatly reduced the natural populations of many of our coastal fish species, and again this would have undoubtedly created ecological knock on effects. Many offshore areas of Northland have been fished by trawlers and dredges over long periods and these activities are known to create significant and sometimes permanent change to the seafloor habitats. Any possible environmental impacts of aquaculture in the region needs to be carefully placed in context of the existing level of widespread degredation of the region's natural marine environment.

Most of the rivers and streams in Northland, with the exception of the Northern Wairoa, are relatively short with small catchments. While river flows vary considerably, Northland's rivers are generally characterised as being slow flowing and silt-laden.

The Northland region has a large number of small and generally shallow lakes. They were formed either by dune activity, volcanic activity or are artificially made. Small dune lakes and associated freshwater wetlands are numerous on the coastal sands of the region. The dune lakes are in four main groups situated on the Aupouri Peninsula, Karikari Peninsula, Kai Iwi lakes and Pouto Peninsula. They generally range in size between 5 and 35 hectares and are usually less than 15 metres deep. Lake Taharoa of the Kai Iwi group is one of the largest and deepest in the country, covering an area of 237 hectares and being 37 metres deep. These lakes usually have little or no continuous surface inflows or outflows being fed primarily by direct rainfall or from surrounding wetlands. As a result, water levels fluctuate considerably with climatic patterns. Because the lakes are relatively small and shallow they have limited capacity to assimilate any contaminants. They are prone to nutrient enrichment from stock and fertiliser particularly where lakeside vegetation has been grazed or removed and where there is direct stock access to the lake. Lakes Omapere and Owhareiti near Kaikohe were formed by lava flows damming the valleys. The largest lake in Northland is the shallow lake, Omapere, which has experienced ongoing water quality problems for many years. Further to the north are two large artificially made lakes associated with the Kerikeri irrigation scheme, which are a major water resource for that area.

- There is some geothermal water extracted near Kaikohe, including the operation of a deep well geothermal power station by Top Energy Ltd.

Controls on Aquaculture in the Region

The legal controls over aquaculture in New Zealand are complex and involve a number of local and central government agencies all with different roles. Furthermore, major changes in aquaculture legislation are currently underway that will have a major effect on both land based aquaculture and marine farming at sea. The current Minister of Fisheries had previously indicated that he would like to see new aquaculture legislation in place by the end of 2002, however, this target date has now been missed. It is possible the new aquaculture law might now be operational by the end of 2003.

The Ministry of Fisheries administers the Freshwater Fish Farming Regulations 1983 and the Fisheries Act 1983. Despite their name the Freshwater Fish Farming Regulations are used to control the farming of most marine or freshwater plants and animals in tanks, ponds or similar, on land above high water mark. The main purpose of these regulations is to control the movement of farm stock, particularly in relation to the potential poaching of wild fish resources and the possible spread of diseases. The regulations also provide some control over environmental effects such as the disposal of fish offal and farm effluent.

Part IVA of the Fisheries Act 1983 is used to control the farming of marine plants and animals below high water mark. Like the freshwater fish farming regulations, the main purpose of these laws are to control the movement of farm stock particularly in relation to the potential poaching of wild fish resources and the possible spread of diseases.

Occupying space on the seabed out to 12 nautical miles offshore or in the intertidal area for an oyster or mussel farm or any other marine farming activity that requires a structure or exclusive occupation of space requires a resource consent or coastal permit under the Resource Management Act 1991 (RMA) which is administered by the Northland Regional Council, the regional authority for the study area. Likewise the uptake and discharge of seawater from the coast requires similar consents. These types of activities and others that are allowed in the coastal environment are controlled through a regional coastal plan, in this area it is the Proposed Regional Coastal Plan for Northland. A regional coastal plan is established through the processes outlined in the Resource Management Act 1991, and in the case of the Northland Region the Regional Coastal Plan has been under preparation since the empowering legislation was passed and is not yet complete until various legal appeals on its content can be finalised.

The majority of the existing marine farms in Northland (around 600 hectares of the total of more than 700 hectares) were established prior to the introduction of the Resource Management Act as marine farming leases or licences granted by the Ministry of Fisheries under the Marine Farming Act 1971, which prior to the Resource Management Act was the principal legislation controlling marine farming activity. Subsequent to the RMA being introduced a number of marine farm sites have been approved (around 100 hectares).

The proposed Regional Coastal Plan for Northland specifically mentions aquaculture, especially in relation to marine farming structures in the coastal and marine environment. The plan makes provision for existing conventional oyster or mussel farms holding a current lease or licence under the earlier Marine Farming Act to continue their activities by obtaining a coastal permit when their lease or licence finally expires. The proposed plan also allows aquaculture as a discretionary activity throughout most of the coastal region of Northland, but currently prohibits aquaculture in any Marine 1 (Protection) Management Areas – these are areas thought to have high conservation significance. An additional set of smaller areas outside Marine 1 (Protection) Management Areas, where new marine farms are prohibited are also included in the plan. These are generally areas directly in front of existing coastal settlements..

A discretionary activity means that a marine farming activity requires a resource consent before being allowed to proceed, and would be required to demonstrate that it would not unduly effect the environment or the use of the area by existing users or nearby residents. For much of the Northland Region, especially on the eastern seaboard, the development of visible marine farms in inshore areas is likely to be a contentious because of the extensive recreational water activities, strong iwi interests, and in some areas, valuable coastal properties.

Late in 2001 the Government moved unilaterally to declare a national moratorium on issuing coastal permits for new marine farms for a period of two years while local government was given an opportunity to implement Aquaculture Management Areas (AMA) in the coastal and marine environment. This moratorium was subsequently established in the Resource Management (Aquaculture Moratorium) Amendment Act 2002. The framework for establishing AMAs will be included in the aquaculture law reform process that was already underway and due for completion by the end of 2002, but has been delayed. This new legislation will provide a longer term and more detailed framework for the operation of the AMAs that will be put into place during the moratorium, as well as revising the entire legal framework for aquaculture management in New Zealand. The Government's intention of introducing an AMA process into coastal planning in New Zealand was to attempt to provide some area-based planning for aquaculture expansion, rather than allow the expansion to happen on what was perceived as a continuing ad hoc basis.

From 2002 the Northland Regional Council began to prepare a variation to the Proposed Coastal Plan in anticipation of the new AMA empowering legislation. This has included public consultation and the preparation of constraint maps, whereby areas of the coast where there could be a conflict between aquaculture activities and other potential coastal users were mapped for the region. The next step of the process will be to formulate some AMA proposals for the region and to notify them publicly as a variation to the proposed Regional Coastal Plan for Northland. The location and extent of these AMAs are critical, as they will provide the basis for the future expansion of aquaculture activities in Northland, while making provision for existing aquaculture activities. Completing the formal process of establishing the AMAs in Northland is likely to take until the moratorium on new marine farms is lifted. Without the AMAs in place, proposals for new marine farms cannot be processed, unless provisions for an exemption are exercised by the Government.

The basis for excluding new marine farms from the Marine Management One areas of Northland under the proposed Regional Coastal Plan for Northland are mainly related to conservation concerns. However, the basis for this blanket ban from Marine 1 (Protection) Management Areas for Northland has been under appeal from the New Zealand Oyster Industry Association, which argues that ban is unjustified in some areas, especially areas such as the Kaipara, Houhora, and Parengarenga Harbours where oyster farming is already well established.

Interestingly, the studies that have been undertaken on the impacts of oyster farms in Northland have found that they tend to have very localised impact on the seabed and its biota. For example, the diversity of the macrofauna (creatures big enough to be seen) was found to increase under oyster farms, although this varied with the type of oyster farming activity (bag versus stick oyster farming methods). This highly localised impact is likely to be naturally reversible with the removal of the farm. In one student study there was an indication that wading birds might be affected by the presence of an oyster farm, but the study was not very comprehensive or well designed. An independent survey of harbour side residents in the Whangaroa Harbour found that their greatest concern over new oyster farms were not the visual or amenity impact, but their potential impact on harbour hydraulics. Research suggests that oyster farms do decrease water movements in the immediate vicinity of the farm. Taken overall, however, the scientific evidence suggests that the environmental impacts of oyster farms in Northland are relatively trivial and likely to be reversible with their removal.

Under the Resource Management Act 1991, district councils are responsible for preparing district plans and the consideration of resource consents for most land uses and subdivision. The Whangarei District has a transitional district plan that does not specifically mention aquaculture, however, it has been interpreted to be included within the definition of "agriculture." Agriculture as an activity is permitted in rural zones, which include most of the district. The district has an amended district plan which is coming into force and which also has not specifically dealt with aquaculture as an activity. However, under this new district plan aquaculture is likely to be included with "factory farming" (high intensity animal farming, such as pig and poultry farming), which is a discretionary activity for the rural zones, but is a permitted activity in the Business 4 zone (heavy industrial). This will mean that in the rural zones proposals for land-based aquaculture would require a resource consent from the district council that would be assessed against a set of general and discretionary criteria, the main aims of which are to prevent adverse effects on the environment, and protect adjacent land-owners from effects arising from the activity. Interestingly other types of land-based farming activities such as dairying and sheep farming generally do not require a land use consent in rural zones. For other district councils in New Zealand it is common that should an aquaculture activity comply with the zone standards outlined in the plan then the aquaculture development can proceed without the need to obtain a resource consent.

The Kaipara District Plan allows for aquaculture as a permitted activity in the Rural, Coastal and Maori Purposes Zones which include most of the district. For the Commercial and Residential Zones, aquaculture activity is not mentioned and is therefore non-complying.

The Far North District Plan has a proposed district plan for which final decisions on amendments are expected in the middle of this year. This proposed plan does not include activity classifications, but has performance criteria, which allows an activity to be permitted without a resource consent provide it meets the performance criteria specified for a planning zone. The most likely performance criteria that would affect aquaculture development would be a requirement for buildings to be set back at least 40 metres from Mean High Water Springs.

The discharge of any fish farm effluent water into seawater follows criteria within the Proposed Coastal Plan and would normally require a resource consent. The main concern for the Regional Council in assessing a proposal is to ensure that the discharge will not result in more than minor adverse effects to the receiving waters or to other users of the water. Likewise, the discharge of any fish farm effluent water into freshwater would also be required to meet appropriate standards. The diversion of natural waterways and any structures in the beds of rivers and streams (such as intake structures and dams etc) will typically require a resource consent.

The controls on the extraction of groundwater and surface fresh waters for aquaculture in Northland are relatively complex. Generally taking small amounts of freshwater from surface waters is possible from most areas without a resource consent. However, in most situations an aquaculture operator wanting to take larger amounts of freshwater from surface waters or a bore will require a resource consent that takes into account the availability of the water source, and the effects on the environment and other users. The extraction of seawater is covered by the Proposed Regional Coastal Plan and is generally permitted provided it does not change or damage the marine environment from where it is taken. Likewise, the discharge of fish farm effluent into the sea is generally allowed provided the discharged water complies with a set of quality standards.

Potential Aquaculture Activities for the Northland Region

As mentioned in the previous sections, the study area has some major physical and logistic advantages and disadvantages for aquaculture development.

Advantages for Aquaculture

The key advantages for aquaculture development in the Northland Region are an abundance of good quality and warm seawater over much of the Region that is entirely suitable for culturing many different species. Likewise, there is a remarkable range of different types of potential sites for aquaculture, especially on the eastern seaboard. These include the protected waters of the Bay of Islands and the many other harbours found throughout the region. In many areas the limited amount of human development have resulted in relatively little pollution from terrestrial or human inputs which is important for most aquaculture. In many coastal areas the waters are readily accessible through some facilities such as wharves, jetties, boat ramps and mooring areas. Whangarei also has a good maritime service industry that provides support to the extensive fishing industry, which is an important part of the economy of Northland.

There are areas of low-lying land adjacent to the coast suitable for land-based marine aquaculture development in both the eastern and western parts of the Region. Land use planning provisions in the three Northland sub-districts are generally supportive of aquaculture development provided natural values are safeguarded.

There appear to be some sites with sufficient freshwater sources to allow small-scale freshwater aquaculture activities, and this is already happening at one location near Mangawhai.

The Regional Council, District Councils, and other agencies such as Te Puni Kokiri, iwi organisations, and Te Ohu Kaimoana appear to be keen to encourage new enterprises, especially those that may provide local employment opportunities.

The Northland Region has a long history of commercial aquaculture activity, as it was one of the first oyster farming locations in the country. Oyster farming in Northland is now a well-established and accepted activity in many of the harbours and there are good opportunities to build on this local goodwill to increase public support for aquaculture in the region. Associated with the oyster industry are facilities such as licensed shellfish processing plants, refrigerated transport systems, which have the capacity to be expanded to handle other aquaculture species. Likewise, there are other well established seafood processing and export approved facilities within the region that could be used to handle aquaculture products. The existing aquaculture industry in Northland is continuing to expand and has a forward outlook. This has mainly focussed on accessing new sites to expand their existing operations. There is considerable potential for further expansion of existing oyster farming activities within the sheltered harbour areas of Northland, although in a number of harbours this is currently prevented by the Proposed Regional Coastal Plan for Northland.

The region has excellent arterial road links through to Auckland and Whangarei, as well as a rail link. In addition, the area is relatively close to Auckland city an urban centre with a population with a large disposable income, and an increasing market for seafood, especially among recent Asian immigrants. Many of the regular visitors to the region are from Auckland as they have holiday homes or boats in the region. This is also likely to make it easier to attract economic investment to the aquaculture industry among people familiar with the region than in more remote parts of the country.

There are good opportunities for developing aquaculture tourism ventures in the region given that the coast and marine activities already appears to attract many of the visitors to the area. A seahorse farm, public display aquarium and café complex at Pahia attracts considerable number of tourists each year.

The Northland Region has a polytechnic, which is currently providing some maritime and business training and skills courses. The polytechnic also has connections with universities outside the region offering more extensive degree courses in subjects related to aquaculture.

NIWA has a large aquaculture research and development facility near Whangarei, which includes aquaculture researchers and a large land-based seawater research facility that is largely focussed on developing aquaculture production for the Northland Region. The facility also provides training opportunities for post-graduate students in aquaculture undertaking research that also has the potential to increase aquaculture opportunities and human capacity for the region.

Figure 7: NIWA's Bream Bay Aquaculture Park is aimed at bridging the gap between research and commercialisation of aquaculture. The site now has a number of commercial partners working on site to commercialise new aquaculture opportunities.

There is some good information on tourism numbers and their visitor profile for the Northland Region, and maritime activities and coastal activities feature prominently as a draw card for visitors. The recent successful promotion of the Twin Coast Discovery Highway has further served to emphasise the coastal qualities that Northland has to offer, and of which aquaculture is an important part. Overall, this provides good opportunities to develop new and effective tourism opportunities based around aquaculture or aquaculture products in Northland.

Disadvantages for Aquaculture

A recent strategic regional development initiative for Northland identified a range of issues that impacted on regional development, including aquaculture, which had been identified as having considerable economic development potential for the region. This included the need to:-

- Improve the attitudes and aspirations of Northland people
- Improve education and skills, especially for aquaculture
- Provide better sector advice, and information, especially for aquaculture
- Improve industry co-ordination, especially for aquaculture
- Improve regional infrastructure
- Provide a more supportive regulatory environment, especially for aquaculture
- Strengthen Maori economic development.

The key disadvantages of the Northland Region for aquaculture development is the continuing competition for the coastal and marine space, between aquaculture development and other public uses, including recreation, conservation and tourism. Managing this competition has been an ongoing source of frustration for Northland aquaculture industry and regulators alike.

Public attitudes in the Region and among some regulatory agencies often tend to overemphasise the conflict with possible public use and conservation values of any specific space in the marine environment identified for marine farming use. However, experience from new farm sites established in the Northland Region and elsewhere in New Zealand would suggest that once new marine farms are established they are generally accepted by the community and generally do not have a significant direct impact on marine activities or the marine environment. The contentious nature of aquaculture activities has resulted in the development of the industry in Northland being faced with very costly and inefficient regulatory processes for accessing farming space for expansion. This has been the principal reason why applicants for a short-term consent to experimentally farm snapper and kingfish at Peach Cove have recently abandoned their proposals despite being granted approval from the Northland Regional Council. Unfortunately, this withdrawal is likely to signal to other antiaquaculture groups in Northland that they have considerable influence over new aquaculture proposals, especially fish farming. There has also been an ongoing problem with untidy and abandoned oyster farms in Northland for many years and these have also helped to produce a negative public image of the viability of the industry in the region.

Although the aquaculture industry is well established in Northland it has not been greatly proactive in the past, in areas such as marketing, industry promotion, diversification and development. In most other areas of the country with an aquaculture industry, various participants have been actively involved in testing and developing a range of new species for aquaculture and novel farming techniques. However, there are relatively few examples of this kind of activity that could be found in Northland. Recently marine farmers from Northland formed a group to engage in the process for formulating Aquaculture Management Areas for Northland. In the future this group may emerge as an important co-ordinating group for aquaculture in Northland.

Remote coastal land in Northland is becoming increasingly sought after for holiday properties and investment. Consequently, access to coastal land for potential aquaculture development is facing increasingly high land prices.

There are some natural limitations on aquaculture in the Northland Region. The open west coast of the region is generally too exposed for marine farming activities involving farming structures. On the eastern seaboard marine recreational activities are popular and there are a number of coastal land areas with conservation values. Experience in Northland from proposals for marine farm activities near these areas indicate that there are strong concerns about their proximity.

Increasing urbanisation on coastal margins is affecting water quality due to contamination from terrestrial or human inputs, especially from septic tank systems. Decreased water quality will effect the quality of cultured shellfish, and hence the efficiency of the industry into the future. The recent suspension of oyster farming activities from part of the Bay of Islands due to suspected sewage pollution is an indication of the effectiveness of standards placed on existing sewage disposal systems and the monitoring of these standards. The inability to quickly address these failings could be seen as a reflection of the current environmental priorities held by the community as a whole.

While there are some large natural freshwater supplies in Northland, most of these are affected by agricultural runoff and silt. Furthermore, the opportunities for the farming of freshwater aquatic species in Northland appear to be relatively limited.

Rural infrastructure in more remote areas is frequently limited. For example, rurual roads are frequently unsealedand often corrugated, and access to three phase power is limited in some more remote areas.

Therefore, given the constraints of the region the most promising areas for further investigation of aquaculture development are; expansion of shellfish farming (especially oysters), seabed enhancement, land-based freshwater and seawater aquaculture (especially combined with tourism). For these reasons the remainder of this investigative report focuses on those species with potential within these categories.

Land-Based Freshwater Aquaculture

Eels - long and short-finned eels, tuna (*Anguilla dieffenbachii* & *A. australis*)

Background

There are two main species of eels or tuna in New Zealand, the shortfin eel (*Anguilla australis*) and the longfin eel (*A. dieffenbachii*). Both tuna species are native to New Zealand, and are widely distributed throughout the country. The shortfin eel is more commonly found in coastal lagoons, lowland lakes, and slow flowing rivers and streams, while the longfin eel appears to prefer stonier faster flowing rivers and can be found well inland in high country lakes. The longfin eel, which is the top predator in New Zealand freshwaters, is endemic to New Zealand and is not found anywhere else. The shortfin eel is also found in south-east Australia, Tasmania, New Caledonia and some South Pacific Islands. The longfin eel grows to be the larger out of the two species, reaching up to 180 centimetres in length and up to 20 kilogrammes in weight, while the shortfin eel can attain a length of 100 centimetres, and weigh up to 2 kilogrammes.

Both species contribute to an important commercial, recreational, and traditional fishery. Eels are held in extremely high regard by Maori, who value them for historical, cultural and spiritual reasons. The New Zealand commercial eel fishery, which is based entirely on wild stocks, produces approximately 1,200 tonnes of eel per year (Ministry of Fisheries Statistics). The principal markets for these eels are in Europe and parts of Asia, with small quantities also exported to Australia and America. Approximately 60% of eel product is whole frozen eels, while other frozen and chilled eel products amount to 15% and a further 20% are sold as live eels.

New Zealand's exclusively wild-caught eel production differs remarkably from the global scene, where 90% of the 120,000 tonnes of eel produced each year is produced through aquaculture. There is, however, increasing interest in the commercial culture of both shortfin and longfin eels in New Zealand. Heavily exploited eel populations, combined with a worldwide decline in eel stocks and an associated increase in world demand and price, have resulted in a desire to better utilise the available eel resource. Eel culture is seen as one of the most suitable methods by which to manage our remaining stocks, and both our native species appear to have considerable potential for commercial farming using modern culture techniques.

Eel aquaculture is well established in Asia and Europe. The bulk of eel production occurs in Asia, where China and Japan produce approximately 50,000 and 35,000 tonnes, respectively, while Europe produces up to 10,000 tonnes each year. A variety of intensive culturing techniques have been described from around the world, and intensive freshwater re-circulation systems have been adopted in Western counties as the principal means of culturing eels. Some of these existing farming techniques have the potential to be adapted to New Zealand species.

Eel aquaculture in New Zealand - a historical perspective

Intensive eel farming is not a new idea in New Zealand, however, initial attempts were not particularly successful. The first eel farm in New Zealand was established at Kerikeri and began operation in 1971. During the next three years, five more eel farms opened around the country in Brookby, Meremere, Pakuranga, Te Kaha and Dunedin. The farms ranged from traditional Japanese pond culture systems to indoor systems with recirculating warm water. Unfortunately a variety of production problems were encountered, and by 1975 all of these ventures had failed for a variety of reasons including, escalating food costs, depressed export prices, irregular supplies of glass eels, unfamiliarity with the culture requirements of the New Zealand species and some instances of disease. Despite these initial problems, the government decided that resources should be invested in a more detailed study of eel farming, and subsequently the eel farm near Te Kaha was purchased by the Ministry of Agriculture and Fisheries and reopened for research in 1977. This farm remained operating for another five years, while resources were invested into a detailed study of the problems and prospects of eel farming. Although improvements were made to eel farming technology along the way, closure of the research station was finally due to the perceived poor economics of eel farming at the time.

Since these earlier attempts at eel aquaculture, there have been considerable advances in eel culture technology and techniques around the world. Overseas research has revealed optimal rearing temperatures and optimal feeding regimes for a number of eel species, and studies have resulted in improved artificial feeds and advanced technology that has reduced labour costs, and improved water quality. In addition, grading systems have become more effective, and there is much greater control of diseases and parasites. In addition, the New Zealand eel species have become more acceptable in a wider range of overseas markets, and it has been found that both native species can produce very good growth rates if given optimal growing conditions. These advances greatly improve the prospects of establishing commercially viable eel farming operations in New Zealand, however, the applicability of the overseas studies to New Zealand species and commercial farm settings in New Zealand would need to be carefully assessed.

In the late 1970's, some emphasis was also placed on the fattening of market-sized eels that were in poor condition when captured from the wild fishery. At the time, this sort of venture could not compete with the wild fishery in New Zealand, as there was insufficient value added to product. However, research is required to establish whether eel fattening can be done economically under the present circumstances, as the reduced supply from the wild eel fishery may have improved the competitive price of the 'fattened' eel.

Biology and implications for culture

The lifecycle of the eel is remarkably complex. Sexually mature *A. Anguilla* and *A. dieffenbachii* adults migrate from freshwater to somewhere in the tropical Pacific to spawn. The eggs hatch, and the small larval eels (or leptocephali) are carried back to New Zealand in ocean currents. Once reaching the continental shelf, the larval eel metamorphose into the transparent glass eel, which has the normal cylindrical eel shape but is less than 50 millimetres in length. It is the glass eel stage that swims up the rivers during winter and spring each year, after being carried into estuaries and river mouths from the continental shelf by tides. Further upstream migration from these areas is temporarily delayed for a few weeks, while the small glass eels adjust to the change from seawater to freshwater. The glass eels then undergo a second migration upstream. Over a period of one year, these eels grow and develop pigmentation to become elvers (less than 120 millimeteres in length). Elvers look like adult eels in everyway except in their smaller size. The elvers move further up the rivers in mass migrations during the summer and autumn months, until they reach their feeding grounds in the upper reaches of rivers. The eels continue to grow and eventually become the sexually maturing eels, which are seen migrating out of the river during autumn months to commence their extensive journey to spawn, after which they probably die.

Although maturing eels can be artificially induced to spawn, and larvae can be produced through artificial fertilisation of eggs, research efforts have not managed to produce glass eels, due to the very delicate nature of the larvae. Consequently, eel culture is highly dependent on the young eel stages being harvested from the wild. Large numbers of glass eels and elvers are taken in many parts of the world, with young eels being collected by dip nets and set nets in estuaries and rivers, and by trawling with fine meshed nets. Glass eels, in particular, are the seedstock of choice for the Asian and European commercial eel aquaculture industry, and as many as 350-500 tonnes of *A. anguilla* glass eels were taken from European waters during 1993 and 1994, while 100-150 tonnes of glass eels were caught from waters in Taiwan, China and Japan. High demand for seedstock means that fishers can demand very high prices for the supply of glass eels. In 1999, UK fishers received over $600 for a kilogramme of glass eels, and in 1987 glass eels of *A. japonica*, the preferred species in Japan, fetched up to $7,000 per kilogramme.

In New Zealand there are opportunities to collect commercial quantities of glass eels and elvers for subsequent culture on eel farms. Considerable effort went into capturing glass eels from 1970 to 1974 in the Waikato River to stock local eel farms, and also to export to Japan for use in the Japanese eel farming industry. More than six tonnes of glass eels were caught from the Waikato River during 1973, for subsequent export to Japan. However, glass eel exports from New Zealand are now prohibited. Elvers are also taken easily in New Zealand waterways and large collections of elvers can be made during summer periods, when this stage of the lifecycle migrates upstream. Research is currently being conducted by NIWA to determine the timing and location of significant glass eel migrations at a range of alternative sites in New Zealand. Such research is considered pertinent to a successful eel farming industry, as the lack of reliable glass eel supplies in Australia has resulted in continuous problems for prospective eel farmers. Research is also required on the best methods for handling and rearing these fragile glass eels once they have been collected, as little has been documented on the effects of temperature, feeding, growth, density and disease of our longfin eel species.

The legal obstacles to collecting these young eels for culture must also be considered. At present it is illegal to collect any eel under 220 grams, as they are classified as undersized fish under fisheries regulations. It is possible that provisions of the Fishery Act could be invoked to allow the commercial harvest of small eels for aquaculture. Similar measures have recently been introduced to allow the harvesting of seed crayfish for ongrowing in aquaculture operations. Convincing biological arguments (the apparently large natural mortality of glass eels due to cannibalism) could be put up to support such a case, although there is likely to be considerable concern for the main users of the resource, such as commercial fishers and Maori.

Culture techniques

Current eel farming practices around the world use a variety of well-established systems that have been described in many publications. The existing technologies thought to be most adaptable for New Zealand species include:

- Outdoor pond culture
- Japanese greenhouse culture (indoors)
- Thermal effluent systems
- European recirculating water systems

Outdoor pond culture is used throughout Asia, and also in parts of Europe, and has already been attempted in New Zealand. Although these initial attempts were found to be uneconomical, it is suspected that improvements in technology over the last 20 years have improved the possibility of making a success of this technique under New Zealand conditions. The Japanese greenhouse system (indoor pond culture) is a derivative of this outdoor pond culture, and is also likely to be feasible in New Zealand. The main advantages of pond systems (both indoor and outdoor) are that they are cheap to establish and operate. The main disadvantage is that pond culture requires large quantities of clean water. Although this requirement is not a significant issue for New Zealand conditions, an added disadvantage of this system is an increased risk of diseases via natural source water. Some of the first eel farms in New Zealand had considerable problems caused by diseases entering the farmed stock.

The European intensive water recirculation system is considered to be technologically advanced and extremely reliable, and has the benefit of being readily available from companies specialising in eel production systems. This system certainly has the potential to work under New Zealand conditions, with both the shortfin eel and probably the longfin, although some adjustments for our local conditions and species are very likely to be required. The introduction of a European intensive water recirculation system for eel aquaculture in New Zealand is likely to involve very high initial investment because of its reliance on sophisticated technology and the associated requirements for trained staff to operate the system. Once installed, the system has the potential to produce high growth rates, as ideal temperatures of 26° Celsius can be maintained by retaining heated water. This system also provides the eel farmer with increased control over the quality of water discharge, and with a well run system efficiencies can be obtained through reduced staffing levels and improved feed conversion. A major benefit of recirculation systems is the improved ability to prevent diseases. The common eel diseases can be controlled through regular preventative treatments, and in-line ultraviolet light water treatments can deal with common pathogens, while biofilters can be used to help minimise bacterial infections. Good quarantine procedures can also prevent pathogens and parasites from entering the farming system.

The use of flow-through effluent systems for eel aquaculture may be suitable for New Zealand conditions. This type of aquaculture system takes advantage of available heated water either from a natural ground source or as an industrial by-product, and thus reduces the high investment of the intensive water recirculation techniques. This option does, however, require a suitable water source to be located nearby, and the construction of a settling pond that is capable of handling the outflow associated with the flow-through. A flow-through thermal effluent farm was established at the

Meremere coal-fired power station in the 1970's by Wattie Industries Ltd. Although this trial was abandoned after extremely high temperatures resulted in thermal stress and high disease amongst the farmed eels, the chance of success would have been increased if the farm had greater capacity to control water temperatures by mixing with cooler river water.

Additional issues for eel farmers

Feed is consistently the single largest ongoing cost in all of the available culture systems. One of the major reasons for the failure of eel farms in New Zealand in the past has been the high cost of food that has not been recouped through other farm efficiencies. The main disadvantage for eel farmers in New Zealand is that high performance eel foods are not produced in New Zealand, and although artificial eel feeds are available in Asia and Europe, they remain very costly to import to New Zealand. An additional issue is that the artificial feeds that are available have been specially formulated for different ages and stages of overseas species and may require some adjustment in their composition to suit the New Zealand species. Adaptation of salmon feeds that are manufactured in New Zealand may be practical, but they are unlikely to produce the most efficient growth in farmed eels. There is potential for the development of artificial feeds locally, but species-specific formulation of diets for New Zealand eels may require considerable research and development.

The presence of an assured export market will also remarkably increase any chance of success for future large-scale eel farming in New Zealand. Although New Zealand currently supplies a strong European eel market and there are also indications that the domestic and Australia markets for eel products are increasing, the future markets for cultured eels from New Zealand will probably be in Asia. The Japanese market, in particular, is expected to have the greatest potential for supplying cultured eels, with the best returns likely to come from exporting live eels of around 150 grams. Cultured eels may also be used to supply the European market, although the market would require the supply of larger eels of 500 grams to 1 kilogram.

Cultured product currently occupies a highly competitive position in the market place, and the recent expansion of intensive aquaculture in China and Europe is likely to increase the competition even further. There is some concern, however, that New Zealand's cultured eels will not be readily accepted in parts of Asia, because they are lighter in colour than eels currently preferred by the market, and they lack the distinctive "wild" taste of the eels we harvest and export at present. The failure of efforts to develop a market for New Zealand eels in Japan in the 1970's is often attributed to the lack of acceptance of cultured species in the market place. Considerable market research and acceptability trials would be required to confirm the potential of the eel markets in Asia and Europe for cultured eels from New Zealand. To market a successful product, farmers must be aware that they may have to supply high quality flesh that has been adapted to market (e.g. taste and colour). It is feasible to adjust flavour of eels through their diet, but the techniques for doing so in the New Zealand species would need to be established. The timing of supply to the market will also be an issue for eel farmers. Better prices are likely to be achieved if New Zealand eels are produced mainly during the Japanese off-season and during poor production years.

The Study Area

There is very little known about the availability of glass eels in Northland, although what is known indicates that only small and unpredictable catches of glass eels are likely in the region. However, there is an assured supply of glass eels from the nearby Waikato River, which features large numbers of glass eels arriving regularly in spring each year.

The general lack of naturally large and very high quality freshwater supplies in Northland could make it difficult to develop an eel farm with a year round supply of high quality fresh water sufficient to meet the anticipated needs of an eel farm capable of producing 10-15 tonnes of eel per hectare. A closed water eel farming system may be feasible, however, the operation of these kinds of technology in New Zealand remains unproven.

The Te Kaha eel farm was closed in 1982 largely because of high food costs, low export prices, and an overall lack of information about culture requirements of the New Zealand eel species, especially their diseases. While significant advances in our knowledge of eel culture have been made since 1982, there are a number of major concerns that still need to be addressed before substantial investments into eel farming could be justified. Good quality aquaculture feeds specifically for New Zealand longfin and shortfin eels need to be developed. Optimal feeding regimes, stocking densities and temperatures that have been identified for overseas species need to be established for New Zealand species and under commercial scale farm conditions.

Also, suitable markets for New Zealand aquacultured eel species must be identified and assessed for their potential.

A small pilot scale eel farm has operated near Ruawai since the 1990's using saltwater for raising glass eels experimentally with some good results. Likewise, NIWA has recently reared glass eels in saltwater filled tanks at the Bream Bay Aquaculture Park with good survival and growth rates.

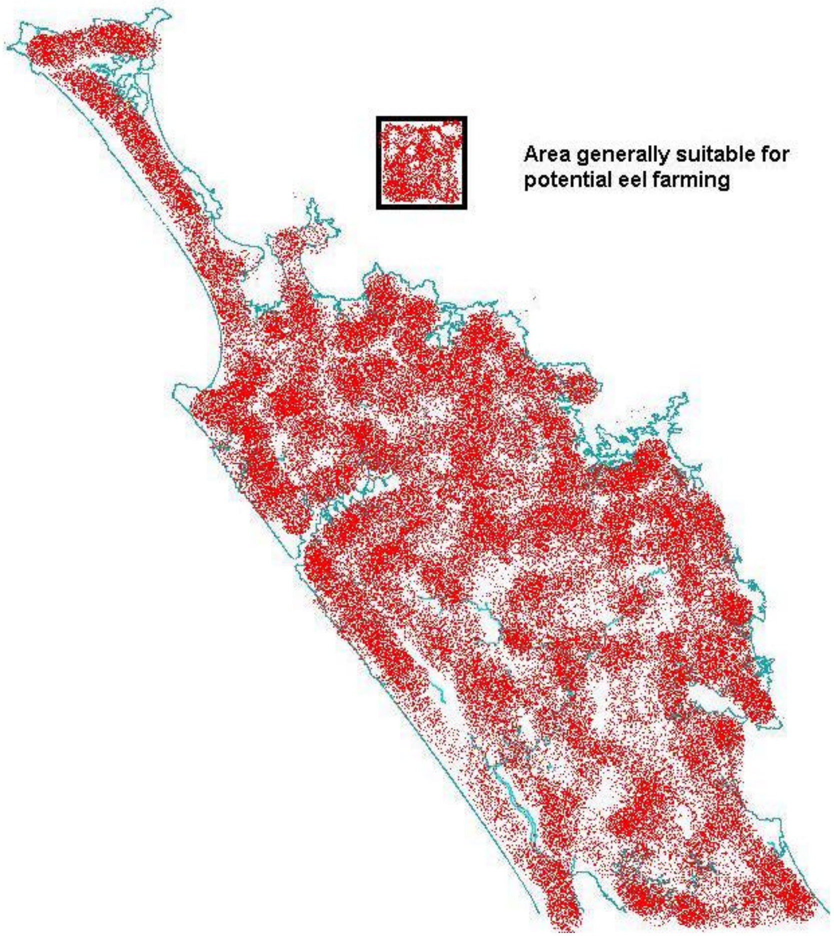

Figure 8: Map of Northland showing areas that may generally be suitable for eel aquaculture.

Conclusion

There is good potential for commercial eel aquaculture in New Zealand. Both species of eels found in this country are suitable for aquaculture, and indoor and outdoor pond culture systems, warm water effluent systems and sophisticated recirculation systems may be used if they are adapted to suit New Zealand conditions and species. There are good natural sources of glass eels, which could provide the seed stock for aquaculture development in New Zealand. There are likely to be some legal obstacles to overcome before permission to harvest commercial quantities of glass eels will be granted. Northland is unlikely to have commercial quantities of glass eels present in the river systems, but a good source is available from the not too distant Waikato River. Northland does not have widely available supplies of high quality freshwater which would be entirely suitable for flow through eel aquaculture techniques, such as pond culture. High technology European farming systems that are capable of recirculating water may be more feasible for Northland, but this technology is unproven for the New Zealand species of eels. At the Bream Bay Aquaculture Park NIWA is currently investigating methods for ongrowing native glass eels in seawater and brackish water, which has some potential advantages, including reducing the requirement for large volumes of freshwater for some farming systems. If successful, this approach to eel farming may have considerable merit for Northland, which because of its extensive areas of estuaries has good access to brackish waters and high quality saltwater for a land-based farming operation.

Overall, there are a number of technical uncertainties that would need to be assessed before the economic viability of glass eel culture systems could be adequately determined, and small-scale pilot studies on the preferred culture techniques are recommended. Also, the Japanese and European markets require significant evaluation to assess the likely acceptance and value of New Zealand cultured eels. These technical developments and assessments need to be conducted as part of, or prior to, any major development of eel aquaculture activity in Northland. Overall, eel aquaculture has some potential for Northland and warrants close consideration in the longer term.

Giant freshwater prawns - Malaysian river prawn (*Macrobrachium rosenbergii*)

Background

The Malaysian river prawn is a tropical species of prawn that is native to parts of Asia where it is also cultivated extensively in warm freshwater of around 28° Celsius.

There is one commercial operation growing these Malaysian river prawns in New Zealand at Wairakei, near Taupo, where waste heat from a geothermal source is used via a heat exchanger to heat water in the prawn-rearing ponds. The farm was established in 1991 and levels of production have risen steadily to reach 12 tonnes for the first half of 1999. The farm has 18 open air heated ponds which are each of 2,000 cubic metres capacity and are stocked at densities of 10 prawns per metre square, which is relatively low compared with farms overseas. With two harvests a year the production is 2.5 to 3 tonnes per hectare of pond. Most of the production from the farm is sold at the onsite tourist restaurant, with demand exceeding the present farm production. Consequently, the farm has proposed to expand production by establishing several satellite farms using the Wairakei based farm as the breeding centre. The farm is closely associated with a range of tourism activities, such as a prawn restaurant, farm tours and river cruises. There is further market potential for these prawns in New Zealand, but markets overseas are limited by the rapid expansion of prawn farming worldwide, especially in Asia.

Growing Biology

The growing biology of Malaysian river prawns is well known and reliable. They are a relatively robust species that can survive in water over a range of water salinities and quite high turbidity as their natural habitat ranges over muddy rivers and estuaries in South East Asia. However, warm water temperatures (26 to 32° Celsius) must be maintained as lowered temperatures lead to stress and mortalities. Similarly, the prawns can tolerate relatively low oxygen levels in the water but this can become a problem in the static grow out ponds that are often used for this species. Artificial aeration devices such as paddlewheels and bubbling systems are often used to ensure adequate aeration and water movement. Most of the production of Malaysian prawns is in tropical countries where water heating is not required, however, in New Zealand water heating has the potential to be a significant cost to farming operations. Hence, the Wairakei prawn farm has been successful as it has been able to utilise an extremely low cost natural heat source.

The prawns are most easily grown in ponds or tanks that can be over 3 hectares in size and around 1 metre in depth. Overseas they are grown in densities of up to 20 per square metre but lower densities are used at the Wairakei operation. The prawns can be grown to harvestable size in around six months or shorter depending on density and diets. Artificial foods are widely available overseas and feed conversion rates of better than 2:1 can be achieved. The Wairakei farm operation has been using locally produced feeds and is considering looking at using waste food material from other industries, such as from mussel farming. Up to four tonnes of prawns can be produced for each hectare of ponds over one ongrowing cycle and up to three cycles can be achieved in a year.

Any Malaysian prawn farming development in Northland would require broodstock to begin farming – these could either come from the existing farm or would need to be imported and undergo rigorous and expensive quarantine procedures. In the wild, adult Malaysian prawns generally move into estuarine waters to breed, so to initiate breeding activity in a farm situation broodstock are moved into breeding tanks containing brackish water of between 10 and 15 parts per thousand salinity. Depending on the size of the females they can each produce between 50,000 and 300,000 eggs, which take about three weeks to hatch out into swimming larvae. The larval stage lasts for up to a further three weeks and is feed on live brine shrimp and artificial feeds. During this period the salinity can be gradually reduced to duplicate the return to freshwater that takes place in the wild, or this can take place later at the post larval stage. Nursery tanks are usually used at the post larval stage to ensure they become well established and are robust enough to transfer into grow out ponds about a month later.

With multiple ponds, production can easily be staggered to ensure continual supply of fresh product for harvesting. Prawns generally require minimal processing after harvest, although they must be handled and transported quickly in a chilled format as they deteriorate quickly. They can also be easily frozen and packed for long distance transport. The existing prawn farm largely supplies the domestic market and there is apparently room for further expansion of this market perhaps by supplying a wider range of seafood outlets and replacing some imported prawn product. The potential extent of this expansion is likely to be limited at some point and may lead to erosion of existing prices, which run as high as $36 per kilogramme retail. Export markets are mostly already well served by the widespread aquaculture of this species, particularly in South East Asia, where the growing costs are substantially lower due to lower labour costs and no water heating requirements. Freshwater cultured prawns and lobsters suffer in the marketplace from not being as strongly flavoured as marine species such as the Penaeid prawn varieties, which are extensively imported in New Zealand. For this reason in offshore markets particularly, they usually do not attract as high prices as the marine species of prawn.

The Study Area

The continued existence of a Malaysian prawn farm in Wairakei has shown that the aquaculture of this species is feasible in New Zealand. However, the greatest cost in farming these prawns in New Zealand are the costs of heating the water for the extensive grow out ponds. To heat grow out water with conventional heat sources, such as electricity or diesel, would make farming uneconomic. The Wairakei farm is reported to use around 350,000 litres of high temperature geothermal water an hour for running its heat exchangers to maintain optimal water temperatures in the outdoor grow out ponds. This is a considerably large supply of heated water. There are some natural geothermal water supplies in Northland, especially around Ngawha, near Kaikohe. Top Energy Ltd which runs the geothermal power station near Ngawha has investigated the possibility of using waste heat for Malaysian prawn farming. However, on their current site there is insufficient clean water available for an aquaculture activity of this sort, although they would be prepared to investigate other aquaculture opportunities that could utilise the waste heat. It may be that there are other waste heat sources from a power station or industrial process that may also make Malaysian prawn farming a possibility for consideration in the area, however, this is unlikely.

Conclusions

Farming of Malaysian river prawns in Northland would be uneconomic unless a large and cheap alternative supply of heat energy can be found.

Freshwater crayfish, koura, keewai (*Paranephrops planifrons* & *P. zealandicus*)

Background

New Zealand’s largest native freshwater crustaceans are two species of freshwater crayfish. One species grows up to 75 millimetres in length and is found in the North Island and the north and west of the South Island. A second species is found in the remaining area of the South Island and grows slightly larger. There is no commercial fishery for these species, but there is some non-commercial harvest. There have been a number of attempts to commercially culture freshwater crayfish in New Zealand, as yet none have been successful. The Ministry of Agriculture and Fisheries has also conducted trials and concluded that their future as a cultured species was limited. However, one new venture in Central Otago attempting to farm the southern species of freshwater koura has been claiming some success using low technology open shallow ponds with a natural supply of freshwater and low grow-out densities. A second farm near Blenheim has also claimed some success and has been offering to sell its aquaculture methods to other groups interested in establishing koura farms.

Growing Biology

Freshwater crayfish are bottom dwellers living in a wide variety of habitats; ponds, lakes, streams, swamps and rivers with either a muddy or stony bottom. They are omnivorous scavengers feeding on whatever they can find. They are slow growing, very territorial, aggressive as adults and they can be cannibalistic at times. These are all features of species that generally make them unsuitable for aquaculture. They do require very high quality water that is free of pesticides, to which they are particularly sensitive. The markets for these crayfish are also limited, as they are not a recognised product in many parts of the world, including New Zealand. They are similar in appearance to other species of freshwater crayfish, such as the Australian redclaw, yabbies and marron, which are all generally much easier to cultivate and are already cultivated in many areas of the world. It may be possible to export New Zealand freshwater crayfish and to sell into the domestic market, but the returns given the difficulties of growing our species are likely to be poor. Therefore, the practical and economic feasibility of culturing these species are thought to be generally poor.

The Study Area

The northern species of freshwater crayfish is known to occur in streams and rivers in the Northland. A freshwater fish farm near Mangawhai is licensed for koura farming but has not developed this opportunity further. There are suitable small-scale clean freshwater sources for culturing this species in Northland.

Conclusions

Commercial farming of freshwater crayfish is unlikely to be economic in Northland.

Salmon species, hamana

Background

Salmons are a group of fishes that are mainly native to North America. Most of the salmons begin their lives in freshwater, move out to sea to mature, and return to freshwater to breed. As a result a variety of the salmons can be farmed in freshwater or seawater. They are generally good eating fish with well-recognised markets.

Methods of cultivating these fish include;

Ocean ranching,

Salmon are raised in freshwater and released into a river where they move out to sea to feed and grow. At between two and four years of age, some adults return to the release site where they are caught, and stripped of eggs or sperm to provide stock for subsequent releases, or are harvested for sale as food.

Pond rearing,

Salmon are grown to market size in freshwater ponds. They require artificial feed throughout, and stocks of salmon fry must be provided from other sources.

Sea cage rearing,

Salmon are initially reared in freshwater and subsequently transferred to sea cages and grown to market size. Artificial feeds are required throughout, and salmon fry must be provided from other sources.

The New Zealand Government approved commercial ocean ranching of salmon in 1976, and also granted a temporary licence for the pond rearing of salmon. Changes to the Marine Farming Act allowed sea cage rearing of salmon from 1982.

Salmon farming in this country has concentrated almost exclusively on quinnat (or chinook or king) salmon, (*Oncorhynchus tschawytscha*), although some work has also been done on sockeye salmon (*O. nerka*) and Atlantic salmon (*Salmon salar*).

Atlantic salmon (*Salmo salar*) can be reared in sea cages. This species is farmed extensively, particularly in Norway and Scotland. There has been little interest in farming this species in New Zealand because of the limited availability of wild broodstock.

Ocean ranching of chinook salmon has been attempted in the South Island but there were many problems largely because of poor returns of fish from the wild. There has also been some small scale freshwater pond rearing of salmon in the South Island that has been reasonably successful. However, it has been in the sea cage rearing of chinook salmon that New Zealand has been a world leader. Sea cage salmon farming operations can now be found in the Marlborough Sounds, Akaroa Harbour and Stewart Island. A relatively small freshwater rearing operation can be found in the north-west of the South Island and more recently there has been development of culturing operations in hydroelectric water canals in Otago and options are being explored for expanding this aquaculture activity by a number of investors.

The international market for farmed salmon products fluctuates dramatically partly to do with enormous supply capacity of Norway and the reliance on some higher value markets in some Asian countries. In addition, the allowance of imported farmed salmon product may also affect domestic prices for locally grown product, although it is thought that there is scope to expand both the domestic and Australian market for our farmed chinook salmon.

Growing Biology

The growing biology of most species of salmon is well-known. In general, salmon require large quantities of clean water, either saltwater or fresh. Salmon farming in this country has been centred on the South Island because these fish prefer colder water temperatures found at these latitudes. Higher water temperatures cause stress and make the salmon more vulnerable to disease and ultimately death.

Figure 9: Transferring king salmon fingerlings from the hatchery to an ongro wing farm.

The Study Area

Both freshwater and seawater temperatures in Northland are too high for the culturing of salmon species.

Conclusions

Salmon farming is not feasible in Northland due to unsuitable summer water temperatures.

Trout, taraute, brown trout & rainbow trout (*Salmo trutta* & *Salmo gairdenrii*)

Background

Two species of trout have been introduced to New Zealand and are now well established. The rainbow trout is a native of North America, while the brown trout is a native of Europe and it was introduced to this country in the 1860's.

The techniques of hatching, spawning and ongrowing both species of trout are well understood and have been used in New Zealand for enhancing the wild sport fisheries. There are at least two existing trout hatcheries in the central North Island, one of these supplies around 3,000 rainbow trout a year for stocking Kai Iwi lakes and other stocked fisheries in Northland.

Commercial farming of trout is not permitted in this country, although trout are one of the most widely farmed fish species in the world. Total world production of farmed trout in 1985 exceeded 1.5 million tonnes. In Australia the trout farming industry is a lucrative and rapidly growing industry, worth A$13.2 million in 1991 and growing to over A$27 million in 1998. The trout farming prohibition in this country is due to the concerns raised by recreational fishing interests about the poaching of wild fish, and claims of increasing risks of trout diseases. Leading experts on trout disease and poaching enforcement refute these claims. Trout are very closely related to salmon, so it is ironic that the farming of one species is banned while the other has had allowances made to facilitate farming. There is widespread interest in farming trout in New Zealand both in the sea and in freshwater. Allowing trout farming would undoubtedly spawn a multimillion-dollar aquaculture industry within a decade. This would include both the production of fish for human consumption and the advent of "fish outs" – ventures where visitors pay for the opportunity to catch cultivated or semi-wild fish from stocked ponds or natural waterways. Overseas, fish outs are major tourist attractions, which provide both unique fishing experiences (such as fishing for youngsters and guaranteed catches) and also act to relieve pressure on wild fisheries. However, the government has steadfastly refused to remove, or review, the ban on trout farming due to political concerns over the reaction from the recreational freshwater fishing fraternity.

Growing Biology

Trout can be grown in freshwater ponds and seawater cages to market size. They need to be fed artificial feeds when grown in high densities, but they have very good feed to meat conversion ratios. Trout have also been found to be very tolerant of culture conditions, although they do require a good supply of clean water. New Zealand is free of many of the trout diseases, which have caused problems in overseas farming operations. The hatchery and grow out cultivation of trout species has been very well described because they are so widely cultivated. Therefore, detail on these species has not been provided because it is freely available in a wide range of manuals and guidebooks.

The Study Area

There are some freshwater sources in the Northland, which could be developed to provide a reliable supply of clean freshwater that could be suitable for the pond culture of trout on a small scale. Water temperatures would be a critical factor in culturing trout in this region, as trout prefer cold water. Warmer water temperatures in Northland, particularly during the summer, could place farmed trout under stress making culturing much more difficult depending on the farming arrangements. Rainbow trout are the most tolerant of higher water temperatures and would be best suited for surviving the warm summer water temperatures in Northland.

The region has only a small recreational trout fishery, which involves around 700 people and is mostly focussed on the stocked fisheries of several water bodies, especially the Kai Iwi lakes. These fish are stocked from a trout hatchery at Ngongotaha, near Rotorua, although previously they were ongrown at a site near Kerikeri. The ponds at this site also provided fish out opportunities for young anglers to develop their skills. There is currently very little tourism activity associated with this fishery, unlike areas such as the central North Island. Tourist fish outs for trout could be possible in Northland should such operations be legalised. Such an operation would require an excellent quality water supply and careful monitoring during the summer months. Such fish out tourism operations are remarkably successful overseas especially when combined with game restaurants and visitor facilities. The Northland Region does not have a significant wild fishery for trout so any possible concerns about trout farming resulting in poaching from the wild fishery would not be credible.

Conclusions

Should legal impediments to trout farming be removed, the farming of rainbow trout in freshwaters would be feasible in Northland, but highly limited by the availability of good quality freshwater and higher summer water temperatures. There appears to be some potential for the development of tourist fish outs for rainbow trout in the Northland.

Channel catfish & Brown bullhead (*Ictalurus punctatus* & *I. nebulosus*)

Background

Channel catfish and brown bullhead are freshwater fish that are not native to New Zealand. Brown bullhead is already in this country and is found around the lower Waikato River. An attempt to import channel catfish into New Zealand was aborted due to environmental concerns.

Markets for channel catfish are large in North America, but the fish itself is of low value. Brown bullhead would be difficult to market and would also be a low value product.

Growing Biology

Both species prefer freshwater over 20° Celsius for rapid growth. Channel catfish is farmed extensively overseas, while much less is known about farming brown bullhead. Both species are very tolerant to a wide range of water temperatures and low levels of dissolved oxygen. They also can survive for some time out of water and endure handling stress well.

The Study Area

Both species could be cultivated in the study area. However, the introduction of channel catfish is unlikely given the environmental concerns which prevented them being imported into Northland previously. Brown bullhead may grow well in the Northland but their value is low and markets are limited.

Conclusions

Brown bullhead and channel catfish offer little commercial aquaculture potential for Northland given the current restrictions on importing exotic species for aquaculture.

Whitebait, inanga, atutahi (*Galaxias* species)

Whitebait are the juvenile stage of about five species of native fish. The adult fish live in freshwater, but the eggs and larvae are washed out to sea. Once developed into strong swimming juveniles they migrate upstream as whitebait. These fish are caught and fetch high prices - over $100 per kilogramme.

Attempts at artificially rearing whitebait species have met with some limited success. However, insufficient research has been done to develop a reliable culturing method for these species. There is currently an attempt to ranch whitebait in the Waikato by rearing adults and encouraging them to spawn and then awaiting the return of the juveniles "whitebait." However, at this stage there is considerable work to be done to develop the technique. Better returns could be expected in the short-term by protecting freshwater habitats of wild fish, such as spawning areas and adult fish habitat. There has been some aquaculture development of whitebait species in Chile, but progress toward large-scale commercial production has been slow due to the technical obstacles.

Recently there has been some commercial interest in ongrowing wild caught whitebait to their adult stage to provide a novel aquarium fish for some key European markets. In countries such as Germany, keeping cold-water aquarium fish is a very popular hobby and the supply of European species is limited in this multi-million dollar market. The giant kokopu and the red-finned bully are the two native freshwater species likely to have the greatest appeal in the aquarium markets, however, the aquaculture, larval rearing and wild habitats of the juveniles of these two species are very poorly understood. Therefore, it is unlikely that commercial aquaculture of these species can be developed in the short term.

The Study Area

Small volumes of whitebait are caught in spring on a number of Northland's waterways and the adult fish are known to breed in many freshwater areas.

Conclusions

The commercial aquaculture potential for these species in Northland is very limited until culturing techniques can be developed to a point where they can be commercialised.

Grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), goldfish **(*Carassius auratus*)**

Background

Grass carp are introduced freshwater fish that grow rapidly in culture and are easy to feed as they will consume water vegetation and a variety of easily formulated low cost feeds. These fish are tolerant of handling and adverse environmental conditions. They are most suitable for low intensity pond culture. There are existing markets for grass carp, particularly in parts of Asia.

Although they are thought to be unlikely to breed naturally in New Zealand waters there are concerns about the ecological impacts of grass carp if they were to be released widely into waterways. Currently there are controlled releases of grass carp for the purpose of controlling nuisance waterweeds. Silver carp are also used for controlling algal blooms in freshwater and are often used in conjunction with grass carp. Goldfish are bred at a number of centres around New Zealand. The total New Zealand market for goldfish is estimated to be around $1M p.a. and appears to be well supplied by existing breeding operations.

An aquaculture operation based around supplying grass carp and silver carp for clearing waterways is currently based north of Mangawhai.

The Study Area

An aquaculture operation based around supplying grass carp and silver carp for clearing waterways and the Asian fish market in Auckland is currently based north of Mangawhai. Attempts by the fish farmer to supply fish for grow out and weed control in other areas have been met with considerable delays in processing transfer approvals. Goldfish breeding operations are well-established elsewhere and are capable of fully supplying the limited New Zealand market.

Conclusions

The commercial aquaculture potential for these species in Northland is very limited.

Land-Based Seawater Aquaculture

Rock lobsters, crayfish, koura papatea, pawharu (*Jasus edwardsii* & *J. verreauxi*)

Background

The green or packhorse crayfish (*Jasus verreauxi*) is a large marine crustacean that grows to 700 millimetres in length and over 10 kilogrammes in weight. Although it is widespread throughout New Zealand, it only reaches commercially quantities in the north of the North Island. Very little is known about the biology of this lobster in the wild and its aquaculture potential is largely unknown. For example, very few larval and early post larval packhorse lobsters have been caught in New Zealand waters so that very little is known about their larval history and habitats in the wild. However, considerable research effort on many of the world's spiny lobsters has shown that this species has probably the greatest potential for larval culture through to early juveniles. This species takes significantly less time to complete larval development and the indications are that this could be sped up further through the use of controlled diet and water temperature. For these reasons both Japanese and New Zealand researchers are currently focussing their research efforts on developing this species for commercial scale larval culture. Unfortunately the ongrowing biology of this species is not so well known as very few animals have been ongrown. Results from these few studies and from investigations of lobsters in the wild would strongly suggest that these animals are relatively fast growing for a temperate lobster and are quite hardy in culture. However, until larval culture is taken to a commercial scale the aquaculture potential of this species is very limited at this stage. It is unlikely that commercial larval culture will be developed within the next five years but possibly within a decade.

The red rock lobster, or spiny rock lobster (*Jasus edwardsii*), is a large marine crustacean found around most of the New Zealand coast and can grow up to 500 millimeters in length and up to 8 kilogrammes in weight. This lobster forms the basis of one of this country's most valuable fisheries returning well over $129 million in export receipts in 2000. This species has a number of qualities, which allow it to fetch premium prices particularly in Japan and other parts of Asia. There is considerable room for the expansion of these markets. Worldwide there is currently little farming of rock lobsters and most lobster fisheries are over exploited. This suggests that markets will continue to remain under-supplied and that prices will continue to rise over the longer term. Over the last twenty years there has been considerable research conducted into cultivating the red rock lobster in New Zealand. Recent interest in Australia in farming the same species has encouraged a flurry of research activity, particularly in Tasmania. To date, there has been some limited success with hatchery rearing of larvae through to juvenile red rock lobsters and this work is continuing in Australia and New Zealand in an attempt to scale up the techniques to produce larger numbers of juveniles for less cost.

Wild-caught juveniles are readily available and large numbers are killed at times when cultivated mussels are harvested in some areas, particularly in Port Underwood in the northern South Island. There have been some experimental attempts at ongrowing juvenile lobsters taken from mussel farms and some of these cultivated lobsters were recently harvested as 300 gram animals. Provisions were made for the commercial collection of early stages of rock lobsters from the wild in the mid 1990's based on a quota trade off scheme. Under this scheme quota for legal-sized lobsters from the fishery is traded off in return for an allowance to take a set number of early juveniles from the wild for ongrowing. Resulting from this legal opening two commercial scale rock lobster aquaculture operations were set up in New Zealand that both relied on the collection of early stages of lobsters from the wild as their seed source. Both companies have now ceased their lobster farming efforts largely due to difficulties in securing a reliable supply of seed lobsters from year to year in order to sustain a land-based farming facility. A consortium of aquaculture enterprises is currently trialing the use of seacages for lobster culture with very promising initial results.

Growing Biology

As for most spiny lobsters the larval development phase is long and complex. For example, the larvae of the red rock lobsters pass through 11 larval development stages that take a total of 200 to 400 days to complete. The larvae live in the open oceans and are active predators, probably eating a wide range of small swimming sea creatures, such as shrimps and copepods. Re-creating and maintaining these conditions in the hatchery for long periods of time has created great difficulties for groups attempting to culture lobster larvae. As already mentioned there has been some success on a research scale, however, commercial scale hatchery rearing of lobster seed for aquaculture will rely on further research to reduce the culture time and costs.

There is currently a quota trade off scheme to allow the harvesting of early lobsters juveniles from the wild. The scheme is a temporary arrangement by the Ministry of Fisheries to allow an opportunity to assess the feasibility of lobster collection and ongrowing. The scheme is currently under review by the Ministry. The cost of obtaining access to wild juveniles for aquaculture is considerable, as there is a need to apply and obtain a permit under the scheme, and if successful, trade off unfished rock lobster quota, which could cost in the order of $15,000 to $35,000 a tonne.

In the wild the lobster larvae metamorphose to become puerulus, which look like transparent tiny lobsters. The puerulus swims to the coast and looks for a crevice or hole in which to hide and change into a small bottom dwelling lobster. Most of the natural settlement of rock lobster puerulus occurs along the eastern coast of the lower half of the North Island, between East Cape and Cape Palliser. The puerulus are thought to swim inshore from out of a large oceanic eddy, which accumulates the planktonic lobster larvae offshore from this area of the coast.

To catch early rock lobsters from the wild, collectors with holes and crevices are used which mimic the natural crevices into which puerulus prefer to settle. There has been substantial work undertaken on improving the collection technology and its thought that there have been substantial improvements in collector efficiencies in recent years. Further improvements may be possible, as well as identifying particular areas of the coast or habitats that have naturally high levels of lobster settlement for commercial collections. Despite the difficulties of catching early lobsters from the wild it is thought that substantial numbers are available each year, although it may fluctuate from year to year.

Red rock lobsters have been found to be easy to keep and on-grow in seawater tanks. They can be held in tanks of different sizes and construction, although black polyethylene plastic tanks are frequently used. The tanks do not need to be particularly deep with only 150 to 200 millimetres of water depth required. Adjusting the density of lobsters in tanks appears to be important in maintaining continuing growth throughout the ongrowing size range. Unlike some overseas species, red rock lobsters are not territorial, or aggressive, or cannibalistic, provided they are well fed with a balanced diet. They are, however, susceptible to poisoning by their own waste products, such as ammonia building up in their tanks. It is critical therefore to maintain good quality water at good flow rates of around 0.5 to 1 litre per minute per kilogramme of lobsters held to ensure that waste products are removed from tanks. These flow rates are relatively high and there is the potential to lower them with better tank design and a more thorough understanding of the waste production and tolerances of captive lobsters.

It would seem that our red rock lobster might reach 200 grams in three years if grown at 18 - 20° Celsius. Re-circulation seawater systems for ongrowing lobsters would have an advantage of being able to maintain heated seawater over the winter period provided economical heat sources could be obtained. However, seawater cooling might be required during the summer if temperatures go over 22° Celsius where they begin to cause difficulties for captive lobsters. Although lobsters are quite tolerant of a range of water conditions rapid fluctuations in water quality such as temperature and salinity can easily kill or stress captive lobsters.

Wild lobsters are scavengers that will take a wide variety of live and dead food material. Often a large portion of the diet will consist of shellfish such as dog cockles and seasnails. Therefore it is not surprising that green-lipped mussels provide very good growth rates in captive lobsters and can be used as a complete food for aquaculture. However, farmed mussels are relatively expensive (mussels wholesale for around $2 per kilogramme for meat), although it has been found to be possible to substitute some mussel with other fish waste material for lobster culture.

There are relatively few known diseases of rock lobsters in culture, this may be partly due to the small amount of aquaculture of these animals. For most of the diseases that have been identified as having potential to cause problems for aquaculture there are remedies available or methods of prevention are known. As for any animal in high density culture, careful quarantine of animals coming into the facility or being moved around the facility are important in preventing disease outbreaks. This is particularly important for recirculation systems that have the potential to rapidly spread disease through a facility.

Cultured lobsters would probably be harvested at around 250 - 300 grams, which is below the current legal size limit. At this size they can attract premium prices in some Asian markets, and have the potential to open up new niche markets as “plate-sized” lobsters for restaurants and other high value outlets. Premium prices in Asia rely on the supply of live lobsters, which involves no processing costs, although there are additional costs involved in preparing, packing and freighting the live lobsters to markets.

The Study Area

Rock lobsters of both New Zealand species are found throughout the Northland Region on rocky reef areas on the open coast and in clean coastal waters. These species form an important commercial fishery for the region. Land-based cultivation of rock lobsters would require a clean and reliable seawater source, which is available on the open coast in the eastern areas of Northland. Summertime water temperatures would need to be closely monitored as previous studies have implicated high summertime seawater temperatures in lobster mortalities. The economics of land-based lobster aquaculture do not look as favourable as the seacage farming option partly due to their growth rate.

Lobsters are relatively slow growing for an aquaculture species and improvements in growth will come from developments of diets and using optimum water temperatures of between 18 and 20° Celsius. Recirculation systems are one way of maintaining optimum growing temperatures, however, generally these systems provide greater risk for culturing lobsters. The risks come from the potential to circulate diseases rapidly through the crop and the risk of systems failure in maintaining sufficiently high water quality for the lobsters. For this reason recirculation systems are expensive to operate as they require constant monitoring and adjustment to ensure that seawater quality is maintained. This becomes particularly apparent in an economic assessment of land-based lobster farming, which while cautious in its estimates of costs, indicates that infrastructure and operating costs are particularly important in determining the potential profitability of lobster farming anywhere in New Zealand. Savings in infrastructure for a land-based lobster farm could come from using an existing building or facility for conversion into a lobster farm with flow through seawater. Alternatively, open-air tank farms may also help to substantially reduce infrastructure costs for a flow through lobster farm. Seawater temperatures could be moved closer to the optimum growing temperature, perhaps by partial recirculation, or perhaps solar heating of water. Food costs were also identified as a significant component of lobster production if mussels are used as the main diet. It may be possible to access waste mussels from other areas of the country, or there may be local sources of seafood or meat waste material that could act as a low cost partial diet replacement for lobster aquaculture. Ultimately, it is likely that an artificial lobster diet will be developed that has the potential to substantially reduce growing costs and increase the growth of this species. NIWA is currently conducting research into larval rearing of rock lobsters and ongrowing in tanks at the Bream Bay Aquaculture Park.

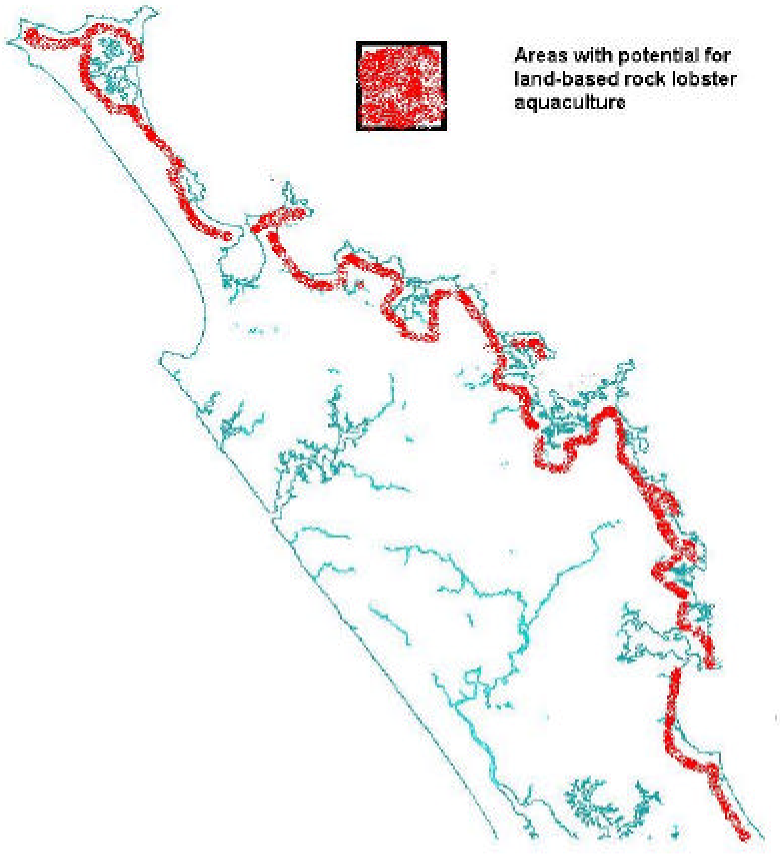

Figure 10: Map of Northland showing general areas with potential for land-based rock lobster farming.

Conclusions

Commercial red rock lobster cultivation is in its infancy in New Zealand, but is showing particular promise. Northland is a suitable area for the development of red rock lobster aquaculture based on our current knowledge and experience. Land-based aquaculture using a flow through or partial recirculation seawater system is technically feasible, but economic projections suggest that high infrastructure costs associated with land-based farming operations may make it uneconomic. Therefore, in developing a land-based rock lobster farm, controlling the cost of establishing farm infrastructure will be vital in determining the economic success of the venture. Low cost local sources of lobster food material may also improve the profitability outlook. The selection of a site with a reliably high quality seawater source will be critical to any land-based rock lobster ventures.

The potential for packhorse lobster cultivation in Northland is prevented by the unavailability of a commercial sized supply of seed lobsters. With rapid development of larval culture techniques this situation could change in the next 5 to 10 years. This species would also be ideally suited to aquaculture in Northland as it grows faster, has a higher water temperature tolerance and appears to be much hardier under culture conditions.

Paua (*Haliotis iris, H. australis, H. virginea, H. rufescens*)

Background

Three native species of abalone, or paua, are being developed as candidates for aquaculture and enhancement in New Zealand; the common or black paua (*Haliotis iris*), the queen or yellow-foot paua (*Haliotis australis*) and the virgin paua (*Haliotis virginea*).

The common paua is found around the coast of most of New Zealand and grows up to about 160 millimetres in shell length and specimens up to 180 millimetres have been recorded. The skin of this paua is coloured black, which greatly reduces their export market appeal. For this reason, most paua exported from New Zealand are canned after being processed to remove the skin colour. Common paua spat can be easily produced in a hatchery and are the focus of most current paua farming efforts in New Zealand. At present there are around 17 experimental and pilot paua farming operations around New Zealand mostly focussed on this species. Some have begun to reach commercial levels of production with nearly $400,000 in sales generated in 1998 and significant increases in production expected in the next decade.

The queen or yellow-footed paua (karahiwa or kahiwahiwa) is found around the entire coast of New Zealand and grows to 110 millimetres in shell length. This species can grow quickly under the right conditions and has pale coloured flesh that has greater export market acceptance. Queen paua spat can also be raised in a hatchery, but there have been some difficulties in doing so.

The virgin paua (koio or marapeka) is a smaller paua growing to 75 millimetres in shell length and is also found around most of New Zealand's coast. However, a separate subspecies lives in Northland, which only reaches 40 millimetres in shell length. This species of paua has white flesh, which would meet with strong export market demand. Unfortunately, this species is relatively small, slow growing and more difficult to feed. Virgin paua spat can be raised in a hatchery.

A further abalone species, the Californian, or red abalone, (*Haliotis rufescens*) has been suggested for introduction to New Zealand waters specifically for aquaculture. This species is farmed in the United States of America and produces a meat product with greater market acceptance than paua with correspondingly higher prices. However, attempts to introduce this exotic species have failed and are likely to in the near future.

In New Zealand the paua fishing industry (almost entirely wild caught *Haliotis iris*) is currently worth about $66 million in exports receipts in 2000. Our main export markets for paua meat are Hong Kong, Singapore, Taiwan and China. The New Zealand paua shell is the most brightly coloured of all the world's abalones and is prized for making jewellery. In addition to meat sales, paua pearls and paua shell are also exported. Paua pearls are made in aquacultured paua by carefully placing seed material ("mabe" is a plastic or shell insert that is the seed for the cultured pearl) within the living paua, where it is subsequently coated with the brightly coloured paua shell material.

Although a variety of abalone species are farmed around the world the industry is still on a relatively small scale in this country. Paua farming techniques have been developing in New Zealand for some time and consequently there are several different methods for farming paua have evolved including; in suspended containers at sea (such as plastic barrels), and in a variety of onshore tanks.

A number of New Zealand paua farming ventures are now routinely producing paua half pearls for the jewellery trade. A number of farmers are also investigating techniques to produce the more valuable full-round pearls. Paua pearls that have sold for good prices on the international market and many are now being processed locally into jewellery.

The basis of all paua farming and enhancement is paua spat supplied from a hatchery. Routine techniques for producing spat from all three species have been established for some time following research mainly by Ministry of Agriculture and Fisheries scientists.

Figure 11: Yellow-foot paua from a marine farm.

Growing Biology

There has been extensive research on the farming of New Zealand species of paua, in particular the common paua. A detailed manual on paua farming is available from NIWA if required.

All three species of paua have been bred in captivity although the hatchery raising of the common paua appears to be the easiest and most reliable of all three species. Ripe male and female animals can be induced to spawn in a hatchery using a chemical stimulus. After fertilisation the eggs develop into swimming larvae that do not need to be fed as they rely on their large yolk reserves. After about a week the larvae are ready to settle, a critical period in the culturing of paua spat because a great many can die if ideal conditions are not provided. The settling larvae, which are less than 1 millimetre long, require a tank with a large surface area covered in a film of growth on which they can begin to graze. A film of microscopic plants on the surface of the tank needs to be maintained in order to keep the tiny paua feeding and growing. Once the juveniles reach about 4 to 8 millimetres in size they can be weaned on to seaweeds or artificial foods for ongrowing.

The hatchery rearing of paua spat can be expensive and complex to establish so an alternative is to purchase seed paua from a number of existing hatcheries. Ultimately any large scale paua farm would want to secure its own breeding facility to guarantee seed supply and allow selective breeding to improve culture performance. Seed paua vary in price depending on species, size and number. Prices can range from $0.50 - $1.25 each for 10 – 20 millimetre juvenile common paua. Yellow-footed paua are generally more expensive because of greater difficulties in hatchery rearing spat. Once weaned the paua can be transferred to grow out tanks of which there are currently a variety of designs in use. Shallow raceways with a water depth of around 200 millimetres and a width of 600 millimetres have gained widespread acceptance. Provided there is sufficient water flow a raceway can be filled with sufficient paua to occupy all of the available floor space of the raceway.

In the wild, paua graze many different kinds of seaweeds, however, they generally prefer and grow best on red seaweeds. For paua culture, large quantities of fresh seaweeds are required because the food conversion rate is low (10:1 to 25:1 food conversion ratio = weight of food consumed: increase in body weight). Better food conversion for seaweeds has been reported for yellow-foot paua as high as 6:1 - 10:1, although the food conversion can run as low as 100:1 for some types of seaweeds. Seaweeds can be cultured in conjunction with a paua farming operation, but the quantities of seaweed involved for supplying a large paua farm are substantial given the poor food conversion rate. One seaweed that is commonly used is a filamentous red seaweed *Gracilaria chilensis* that is relatively easy to grow, often in paua culture effluent. Artificial paua foods are commercially available from a number of suppliers and are easier to use and have reasonable food conversion ratios (3:1 to 4:1). However, some of these foods are relatively expensive at around $6 - $7 per kilogramme although prices have been coming down as the volumes of feed supplied to the paua farming industry have increased. There is undoubtedly room to improve the formulation of artificial feeds for our paua species, as growth rates tend to taper off with most feeds after some time. For this reason supplying some seaweed feeds together with the artificial food helps to maintain growth rates perhaps by providing dietary variation and additional nutrients that may be limiting growth.

Very few diseases have been found to affect New Zealand paua species in cultivation. Those diseases that have been recorded have generally been found in conjunction with poor holding conditions or handling. Paua are particularly sensitive to poor water quality and physical damage from careless handling. Water temperature, salinity, oxygenation and nitrogenous waste loadings are particularly important for paua, especially the yellow-footed paua. Recirculating seawater systems need to pay particular attention to maintaining water quality, especially through continual replacement of a substantial proportion of the water in the system. Recirculation systems provide an advantage in being able to maintain water ideal water temperatures at relatively low cost compared to flow through seawater systems. Temperatures of around 18° Celsius are thought to provide the most rapid growth for all paua species but lower temperatures tend to produce less mortality. Temperatures over 25° Celsius are usually lethal to New Zealand paua species. Ideal culture conditions for common paua are relatively well known compared to the other two species for which there is a great deal less known.

Yellow-footed paua grow to about 75 millimetres in four years. Common paua grown for the meat trade are best sold at 75 – 100 millimetres of length, which takes about 4 – 5 years of ongrowing. Paua grown for pearl production are implanted at about this size range with a plastic or shell insert known as a “mabe” which is placed next to the shell. The insert is coated in shell over the following 2 or 3 years and is harvested by cutting them out of the shell. Only a small proportion of the inserts produce sufficient quality pearls for sale, and only a small proportion of these (<1 %) fetch gem quality prices which reportedly can go beyond $1,000 each for each pearl if they are large in size with steep rounded sides

Yellow-foot paua are not suitable for the production of pearls because they do not have brightly coloured shells like the common paua. However, the meat of this paua is more valuable because of the absence of the black skin that is found in the common paua. In the wild, yellow-footed paua grow to a smaller size therefore aquaculture of this species is best suited to the cocktail sized abalone market. Premium prices would come from delivering live yellow-footed paua into overseas markets. Unfortunately, this paua is easily stressed and is not well suited to conventional live transport methods. It may be possible to develop alternative methods as used in the live transport of fin fish species or exploit fresh packed or chilled markets which do not achieve as higher prices. Returns of up to $15 each have been reported from some Asian markets for live abalone of 75 millimetres in size. However, increasing worldwide production of cultured abalone will also be selling into these high priced markets. For example, Australia is predicting a very rapid growth of abalone production from aquaculture over the next five years.

Most wild common paua from New Zealand fisheries are canned after bleaching and sold in Asian markets particularly China, where abalone has traditional cultural significance. The product is bleached because the black skin coloration has a very poor market perception in Asia, particularly Japan where the highest prices are paid. Live and fresh chilled paua can achieve much higher prices, but again the black flesh colour of the common paua is a difficulty. It may be possible to selectively breed or develop lighter coloured paua for culture. Obviously, dark skin colour would not be an obstacle with culturing and marketing the lighter coloured species.

The Study Area

All three native species of paua are found in Northland but not in great abundance, and there is a small amount of commercial catch of the common paua. As discussed, the New Zealand paua species appear to be intolerant of a wide range of environmental variables and therefore water quality is of particular importance in culturing paua. These animals seem to have relatively low tolerances to reduced salinities, higher water temperatures, low oxygen levels, raised levels of nitrogenous wastes and high turbidity. These intolerances are reflected in their distribution in the wild; where they are only found in shallow subtidal areas with oceanic water away from major freshwater inputs, on exposed rocky coastlines, often in embayments with rounded cobbles and boulders. These biological intolerances are an important consideration in choosing appropriate sites for farming these species, in particular the water source needs to be of very high quality. Land-based paua farming systems must also be able to reliably deliver a continuous supply of good quality water. Parts of the eastern coast of Northland would appear to have a number of suitable areas that fulfil this criterion along the open coast with adjacent flat coastal land that would greatly reduce seawater pumping costs. In such a situation where there is a reliable supply of good quality seawater, a flow through seawater system would provide the greatest reliability at the lowest operational cost. In the wild, our paua species are found throughout the country where they are generally in greater abundance and growing to larger sizes in the cooler southern waters. The generally warmer waters of the North Island and Northland would produce faster initial growth rates in paua, but also greatly increase the risk of cultivation stress and diseases. Summertime water temperatures in Northland in particular are expected to regularly go beyond the upper tolerances of paua and would need to be monitored and controlled very careful to avoid major losses in a farm situation. Some research by the University of Auckland has shown that seed paua sourced from northern areas tends to perform better in northern areas and it may be that these paua are more tolerant of summer temperature highs.

Paua are herbivores that consume large quantities of seaweed in the wild. Growth rates of the paua are affected markedly by the variety of seaweeds consumed. Paua farmers are therefore faced with providing large quantities of quality seaweed to feed their stock. However, in New Zealand there are legal constraints on harvesting seaweeds from the wild. There are a number of suitable seaweeds that can be farmed in conjunction with a paua farm but it creates a more complex growing operation. Species like *Gracilaria chilensis*, however, are well suited to cultivation in the water temperature regime and high sunlight hours experienced in Northland. Several artificial paua foods are now available on the market, and although they are relatively expensive they do provide excellent growth rates for New Zealand paua and are now being used by most commercial paua farmers. Two of the leading brands of paua food are imported from Australia, so location of a farming operation in Northland is close to feed importing sources and to product export processing facilities.

In the last year a paua farming company has been established at the Bream Bay Aquaculture Park. To date the company has established broodstock in captivity and constructed an extensive farming system ready to proceed with commercial scale seed production and ongrowing. The company aims to produce paua meat for export.

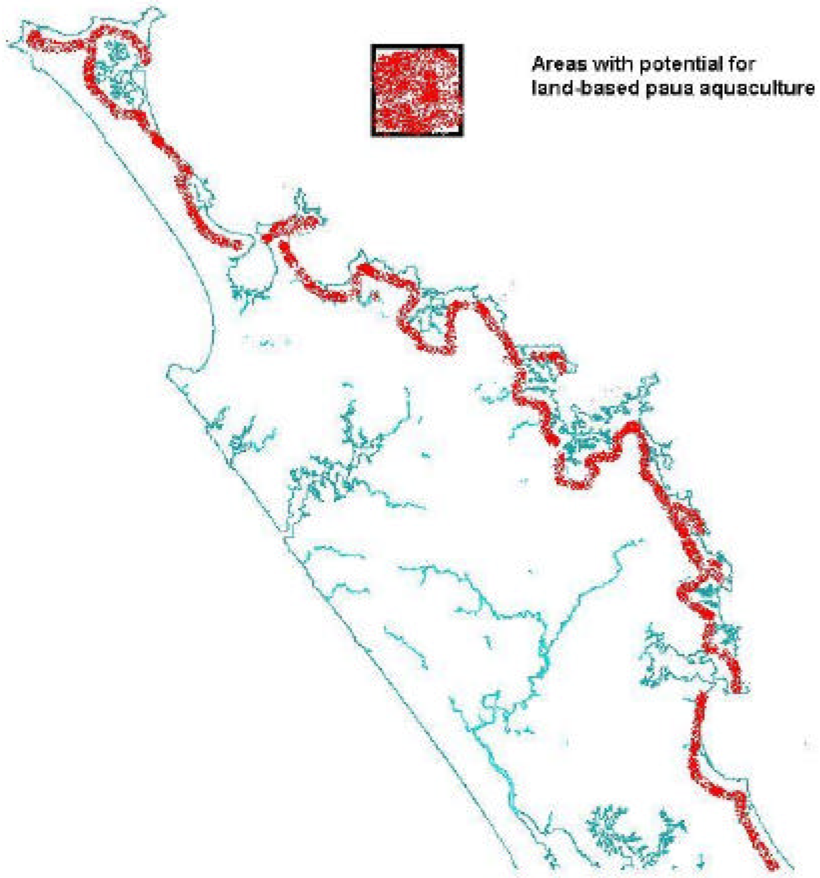

Figure 12: Map of Northland showing general areas with potential for land-based paua aquaculture.

Conclusions

In conclusion, it would seem that the cultivation of paua in Northland is entirely feasible, either for the production of meat and/or pearls. The common paua would be the most suitable candidate as a great deal more is known about the cultivation of this species. The economic feasibility of any proposed paua farming operation would need to be examined carefully, in terms of the farming method, production costs and product prices. The cost and sources of paua food would be particularly important considerations in any such commercial feasibility assessment. In developing a commercial farm close attention would need to be paid to the management of water temperatures, especially in late summer.

Seahorses, hinamoki (*Hippocampus abdominalis*)

Background

Seahorses are highly valued as ornamental aquarium fish, and for medicinal purposes in parts of Asia. The demand from these two markets has placed enormous pressure on wild fisheries, particularly in Asia where wild populations of seahorses have been seriously affected. Consequently there has been worldwide interest in developing aquaculture of seahorses.

The first large scale attempts at seahorse aquaculture began in China in the 1950's but with their switch to a more capitalist economy many of these became untenable. Very little information on what exactly these Chinese farms achieved with their early seahorse aquaculture efforts has ever been published. There are currently commercial attempts at seahorse culturing on various scales in a number of countries such as, Australia, Indonesia, Malaysia, New Zealand, the Philippines, Thailand and Vietnam. These ventures have met with variable success in terms of breeding and raising seahorses, but as yet there are no commercially viable seahorse farms consistently producing large quantities of seahorses. One land-based farm in Tasmania is producing good numbers of seahorses, but reportedly relies on related tourism activities for much of its income.

New Zealand has one species of seahorse, *Hippocampus abdominalis*. This is one of the largest seahorses in the world, reaching up to 350 millimetres in length. This species is also found in south-east Australia. Although there are two commercial ventures producing *H. abdominalis* in Australia for the aquarium trade, there is little published information available on successful culture techniques for this species, as well as its general biology and ecology. However, research conducted by NIWA has demonstrated that this species can be successfully reared through multiple captive generations in a land-based hatchery. High survival and good growth rates can be achieved with this species.

In New Zealand, seahorses and other syngnathids (pipefish) are prohibited as target species for commercial fishing, although they can be landed as incidental by-catch and sold to Licensed Fish Receivers, who can then sell them locally or for export. This has occurred on a small scale with large fluctuations in catches between years.

There is still an indefinite moratorium on the issuing of special fishing permits for non-quota species such as seahorses. Seahorses cannot be sold or displayed by pet shops unless purchased from a Licensed Fish Receiver, or permit holder such as a holder of a Freshwater Fish Farming or Marine Fish Farming licence who has cultured them.

In the medicinal market, seahorses are actively used as an ingredient in Asian traditional medicines, particularly traditional Chinese medicine, where they are credited with increasing and balancing energy flows within the body, as well as acting as a cure for such ailments as asthma, impotence, high cholesterol, goitre, kidney disorders, and skin afflictions, such as severe acne and persistent nodules. In traditional Chinese medicine, seahorses are sold as whole, bleached and dried animals, in pieces, as a powder, or in patented pill form. They are usually combined with a range of other animal and plant ingredients, the exact mix depending upon the medical condition and the person to be treated.

In 1994 it was conservatively estimated that at least 20 million seahorses were caught annually for the traditional medicine market. However, documentation as to the scale of this trade is scarce and the exact figure for the number of seahorses being traded in the medicinal trade is probably significantly higher than 20 million.

There are no fixed market pricing structures for seahorses in the medicinal market, and prices vary markedly. For example, the following prices were supplied by participants at a 1998 marine medicinal species workshop in the Philippines that specifically looked at the seahorse trade (prices are per kilogramme dried seahorse of good quality):

China:	1997 - NZ$572-1603/kg in Shanghai
	1998 - NZ$650-1137/kg in Shanghai
	1998 - NZ$642-894/kg in Tianjin
India:	1997 - NZ$76-167/kg
Korea:	1995 - NZ$420/kg
Korea:	1996 - NZ$407/kg

1997 - NZ$420/kg

Malaysia: 1995 - NZ$749/kg

(Note: It takes approximately 200 seahorses at 15 centimetres length and 5 gram dry weight to make 1 kilogramme dry weight)

The traditional Chinese medicine trade in seahorses boomed in the mid to late-1980's, following China's economic restructuring. The resultant over fishing caused a dramatic decline in many South East Asian populations of seahorses (e.g., by 50-70% in certain areas of the Philippines). Consequently, the quality of seahorses being traded has declined. Where once seahorses had to be of a certain size and quality for acceptance, inferior-sized and coloured seahorses are now being used and new areas are being fished. Declining availability of large, pale, smooth seahorses - which generally fetch the highest prices as a dried product - has been offset by increased production of cheap, pre-packaged medicines, which use darker, smaller and spinier animals.

It is estimated by Chinese traders that the traditional Chinese medicine seahorse trade is still increasing by 8 to 10% per year. Seahorses are now flagged by the UN Convention on International Trade in Endangered Species (CITES) as being at risk, but are not yet banned from export and import. There is a USA-generated move to include seahorses in a global agreement restricting trade in endangered animals. If seahorses become included, the international trade in wild caught seahorses will be prohibited, with the only permitted export, import and sale of seahorses occurring through licensed culture operations. In Australia, wild collection and sale of seahorses is illegal and seahorses and other related sygnathid fish, such as sea dragons, can only be exported if they have been produced through approved aquaculture or aquarium ventures.

Asian traditional medicine practitioners have indicated that the common New Zealand seahorse, *H. abdominalis*, is desirable for use in their trade because it is large, smooth and often pale in colour. In countries such as China these attributes obtain a high price and initial market reaction has been very positive, as *H. abdominalis* is sometimes twice the size of the average seahorse that traditional medicine practitioners usually use.

In comparison to the medicinal trade, the aquarium trade in seahorses is smaller, although potentially more lucrative on an individual animal basis. The aquarium trade has been estimated to involve around 200,000 to 1 million seahorses each year. These seahorses are collected from countries such as the Philippines, India, Sri Lanka, Thailand and South Africa, and are largely destined for the United States and Asian aquarium markets.

Live aquarium seahorses fetch a proportionately higher price per individual than they would as dried animals in the traditional medicine trade. For example, in New Zealand, when *H. abdominalis*, was being sold illegally by some pet shops 3-4 years ago, medium-sized (15 centimetre length) seahorses were retailing for NZ$15-20 each. In comparison, a similar sized animal (approximately 5 gram dry weight) retailing at a top price of $1,200 per kilogramme would be worth only $6 in the traditional medicine market. The retail price paid for seahorses in the United States aquarium trade currently generally varies between NZ$16-$90 depending on species and availability. Exceptions to this sort of price range can be found where specialized patented hybrid seahorse varieties are bred. For example, one Hawaiian seahorse aquarium culturist charges between NZ$40 and NZ$220 for their own hybrid varieties of seahorses. The aquarium trade has different desirable physical attributes to that of the medicinal trade. For example, striking colouration patterns and skin ornamentation are much more important and highly valued than outright size.

In New Zealand, although *H. abdominalis* cannot legally be sold when deliberately caught from the wild, it can be if it is cultured by a licensed venture. Currently, the only wild-caught seahorses that can be legally sold in New Zealand by pet shops are exotic seahorse species, such as *H. kuda* and *H. zosterae*. These exotic seahorses are typically imported at a wholesale cost of NZ$5-10 per seahorse and retail for between NZ$30-70 each.

Aquarium traders in the United States also readily sell these species when they can obtain them. However, as *H. abdominalis* is not currently commonly sold and is a temperate species, as opposed to the more usual tropical species which hobbyists in the States are familiar with, there is a necessity for the education of both aquarium retailers and the public who buy *H. abdominalis* as to what its particular aquarium requirements are for them to successfully maintain it.

Growing Biology

Seahorses prefer seawater with low turbidity, a stable salinity range and high dissolved oxygen. Most species are found in tropical waters, inhabiting seaweeds, corals, mangroves and sponges where sufficient quantities of prey occur. These fish are often found over the full range of exposure, from very sheltered harbours through to exposed open coasts. In New Zealand, *H. abdominalis* typically occurs around the whole country and is exposed to a temperature range of 8-24° Celsius. NIWA research has demonstrated that culture temperatures of 18-21° Celsius give best growth for this species.

Seahorses can be cultivated in tanks of a range of sizes, but features of tank design, particularly coloration and lighting are critical to ensuring the seahorses are able to catch live prey, particularly in the early juveniles where the highest mortalities commonly occur. Seahorses require some structural elements in the tanks in which to shelter and attach to – seahorses spend the majority of their time anchored to various substratum with their muscular prehensile tail.

The cultivation of seahorses generally requires the extensive cultivation of live food - small shrimps and such like, on which the seahorses feed. Seahorses are visual predators and rely heavily on the movement of their prey to attract them. This usually means that live food, such as brine shrimp (*Artemia* sp.), copepods or amphipods must be cultured. Alternatively, a plentiful supply of natural zooplankton and other live prey must be readily accessible. The optimal diet for seahorses is not currently known, but it appears that like many other fish species, highly unsaturated fatty acids such as docosahexanoic acid, arachidonic acid, and eicosapentaenoic acid are important in their diet.

The brine shrimp, *Artemia* sp. is commonly used for rearing seahorses, but a seahorse requires very large numbers of these shrimps on which to feed, and the brine shrimp must be enriched with an appropriate enrichment media to ensure the seahorses obtain adequate nutrition. Furthermore, seahorses swallow their prey whole and rapidly digest their food, such that they require live food to be continually available, and in abundance. The cultivation of large quantities of live food is expensive given the relatively slow growth rate of seahorses. Opportunities for harvesting suitable food for seahorses from the wild can provide a cheaper alternative to live food culture, but is unpredictable and unreliable.

The use of inert foods (e.g., frozen shrimp, artificial pelleted foods) has not been successfully applied on a commercial scale in seahorse aquaculture as yet, although

NIWA research has demonstrated that juvenile *H. abdominalis* can be weaned from live foods onto inert foods. However, this use of inert foods requires further refining before it is commercially applicable.

Simple techniques are available for bringing captive broodstock seahorses into breeding condition. Both captive and wild *H. abdominalis* are reproductively active for most of the year and appropriate photoperiod manipulation and feeding regimes are usually all that are required to stimulate courtship and mating.

Male seahorses take care of the fertilised eggs in their brood pouches. Upon release from the parent males brood pouch the newborn juveniles are 15-20 millimetres in length and fully independent. An average brood of New Zealand seahorses consists of about 250 or more juveniles and average brood duration is 30 days. Newborn juveniles need to be supplied with live food of an appropriately small size (e.g., instar II *Artemia* nauplii). The period of juvenile rearing of seahorses is particularly difficult, and, unless appropriate feeding/culture conditions are provided high mortalities can occur. However, juveniles grow quite quickly, reaching up to 80 millimetres in length after the first six months. At one year the seahorses are at a suitable size (100 - 150 millimetres) to be sold into the aquarium market. At two years the seahorses are a suitable size to sell to the traditional medicine market in China (>200 millimetres).

On-growing seahorses to market size in sea-cages is currently being trialed between NIWA and industry partners in different parts of New Zealand. Sea-cage culture dramatically reduces culture costs as the seahorses feed on the mobile epibiota that settles and dwells on the sea-cages. Initial results of the seacage trials are encouraging with excellent growth rates and acceptable levels of mortality.

The Study Area

Seahorses are found naturally in Northland and they could be cultivated in the area. The water volume requirements for land based aquaculture of seahorses appear to be minimal so they could be cultivated in either a recirculation system or a flow through system, or in sea cages. Seacage farming of seahorses in Northland appears to have some potential, although the siting of the seacages is likely to be critical to their success. A land-based recirculation system would provide opportunities to experiment with adjusting water temperatures to determine optimum growth and survival rates. A recirculation system would also provide more flexible opportunities for locating in areas suited to other features, such as high visitor numbers for a combination farm and tourism venture. The market prospects for seahorses are strong but there are still a number of areas of difficulty with culture. The high demand for live foods is a major obstacle for this species. It may be possible to develop methods for harvesting wild live food or ultimately weaning seahorses onto an artificial diet. The public aquarium at Pahia wharf has also developed methods of breeding seahorses, which have been used for the release of juvenile seahorses to the wild.

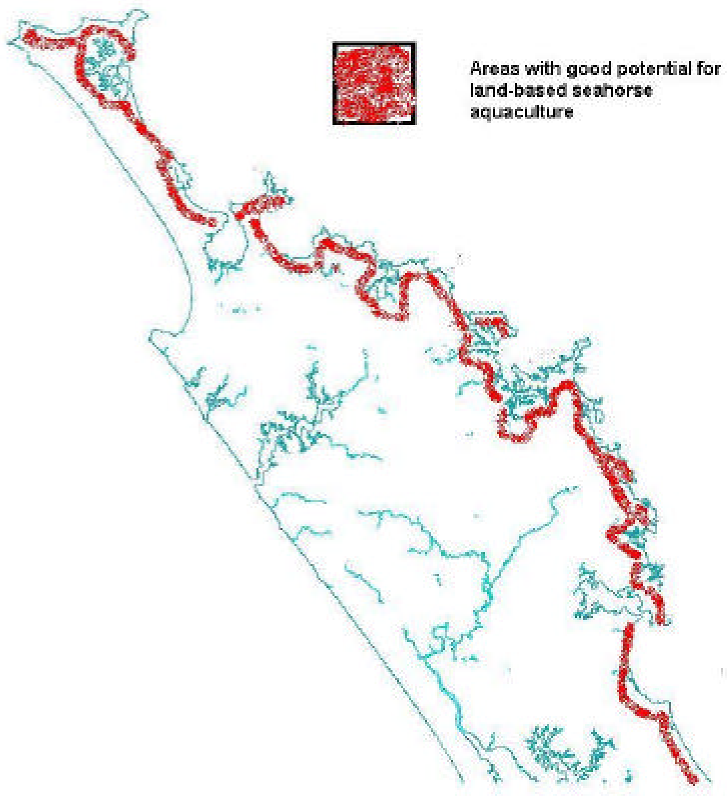

Figure 13: Map of Northland showing general areas with potential for land-based seahorse aquaculture.

Conclusions

Northland is well suited to the development of seahorse farming, perhaps in conjunction with a tourism venture. Such a tourism farm venture currently operates in Tasmania with the same species of seahorse that is found in New Zealand. For a land based seahorse farm, however, the requirement to provide large quantities of live feed over a range of sizes to feed seahorses is the biggest hurdle in making seahorse farming economically viable. Parts of the eastern coast of the Northland have areas of flat coastal land with access to high quality seawater. There are also many relatively sheltered areas with clean water that would be suitable for trialing the seacage culture of seahorses. Such trials would be essential to identify the most suitable sites for effective culture. They may also do well in more exposed areas of the eastern seaboard of Northland perhaps in subsurface moored cages that would be less prone to swell movement. The markets for seahorses are not well defined so some work may be required to establish supply links and the best available prices for seahorse product.

Grey mullet, kanae (*Mugil cephalus*)

Background

The grey mullet is a native marine fish, which can grow to 750 millimetres in length, but on average adult fish, only measure about 400 millimetres. Grey mullet are common in harbours around much of the North Island. They are a commercial species that is caught mainly in set and drag nets in harbours and estuaries, including the Kaipara Harbour. The annual New Zealand commercial catch of grey mullet is about 400 tonnes. The same species of mullet is farmed in South America, some Arab states, and in a number of countries around the Mediterranean and Asia. There has been some experimental farming of grey mullet in the Kaipara Harbour with little commercial success. The world markets generally consider grey mullet as a relatively low value fish species.

Growing Biology

Grey mullet enter harbours in the spring to feed on the bottom sediments in rich shallow waters, often venturing many kilometres up rivers. In autumn they gather in schools in the harbours and head out to sea to spawn. The young grey mullet move back into harbours to feed until they are ready to join the annual adult spawning migrations. A juvenile grey mullet takes about three years to reach 300 millimeters in length. Living in estuaries and harbours, these fish are very tolerant to reduced water salinity, low oxygen levels and high turbidity. The technology for hatchery rearing and culturing these fish is available and is in use in some parts of the world. Recent work in Guam has indicated that a commercial sized grey mullet hatchery would cost in the vicinity of NZ$2 million to establish and would require extensive farming operations to support the production capacity and costs. It may be possible to gain permission to gather juveniles from the wild for ongrowing on a small scale in shallow ponds in but this is unlikely to be economic in New Zealand. There is a domestic market for grey mullet, but export markets are thought to be limited, especially in terms of potential returns.

The Study Area

Grey mullet are recreationally and commercially fished in Northland, especially in areas such as the Hokianga Harbour. Pond farming of these fish would be possible around the margins of many of the northern harbours, either entirely land-based or by closing off embayments by bunding. The grey mullet farm on the South Head of the Kaipara Harbour and has been there for over ten years and has failed to become an established producer of large quantities of high quality mullet that would be necessary for it to be profitable.

Conclusions

Pond culture of grey mullet would be feasible in the study area but is very unlikely to be commercially viable unless it is carried out on a very large scale and can operate on a small profit margin, and can supply only the most lucrative markets for these fish.

Large fin fish species - snapper (*Pagrus auratus*), turbot (*Colistium nudipinnis*), kingfish (*Seriola lalandi*), groper (*Polyprion oxygeneios*)

Background

A number of marine larger finfish species show some promise for aquaculture in New Zealand, these include snapper (*Pagrus auratus*), kingfish (*Seriola lalandii*), and turbot (*Colistium nudipinnis*), groper (*Polyprion oxygeneios*)

Aquaculture techniques have been developed for snapper and kingfish and are extensively practised in Japan and other parts of the world. The culture of these species usually involves seacage ongrowing after initial rearing in a hatchery. It is very likely to be too costly to rear these species to commercial size in land-based facilities due to the large holding tanks and volumes of seawater that would be required, unless some novel technology for water management or reuse can be deployed.

A number of flat fish species are intensively commercially cultured in Europe and parts of Asia in land-based facilities. This activity includes the European turbot (*Scophthalmus maximus*), which is similar in appearance to our local species. Therefore, it might be expected that our turbot species may have some potential for land-based aquaculture.

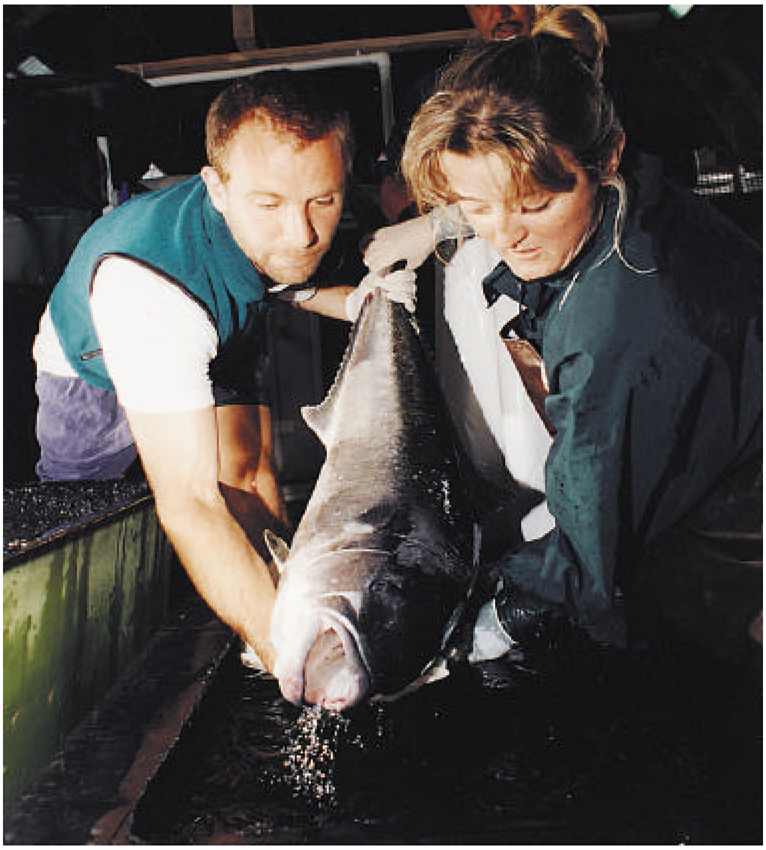

Figure 14: Transferring a broodstock kingfish from one tank to another in preparation for the breeding season.

Growing Biology

Hatchery techniques for spawning and rearing snapper, Japanese kingfish and New Zealand turbot are known, but highly technical and expensive to undertake. Techniques for hatchery rearing New Zealand groper from eggs are not known, and techniques for overseas groper species are still in development. The juvenile fish of all species of finfish will generally only eat large amounts of cultured live food , such as brine shrimps, making them relatively expensive to rear except on a large scale. The juvenile fish are also extremely sensitive to water quality and stress, so that losses can be very high if they are not properly cared for. Moana Pacific Fisheries Ltd was running a pilot scale snapper hatchery at Kawau Island in the Hauraki Gulf, which was producing batches of up to 10,000 juveniles at a time for ongrowing in seacages and release into the wild for enhancement trials. The same hatchery was also involved in some experimental work on New Zealand kingfish production in conjunction with

NIWA. Moana Pacific Fisheries Ltd also has a small area at the head of Bon Accord Harbour on Kawau for seacage ongrowing of finfish, which is currently stocked with juvenile snapper. Moana Pacific Fisheries has now relocated their fish hatchery production to the Bream Bay Aquaculture Park. The Bream Bay has also been the site for some very initial work looking at the potential for breeding groper. Turbot larval rearing research has also been conducted by NIWA in their Wellington research facility. Ample turbot juveniles are now being experimentally ongrown. Results from these turbot have been a little disappointing as growth and survival rates in culture conditions are well below what might have been expected compared to wild fish and other species of turbot cultured overseas.

The Study Area

All four species are found in the study area. In particular, snapper (karati) are found throughout coastal areas of Northland and three of them are a popular target species for commercial and recreational fishers. Any land-based finfish hatchery facility would require a good quality source of seawater which is available on the eastern coast of the Northland, such as at the Bream Bay Aquaculture Park site. The Bream Bay site is currently producing small commercial quantities of snapper and kingfish fingerlings.

Only turbot might be suited to intensive land-based cultivation, while snapper and kingfish and groper are better suited to seacage ongrowing. Moana Pacific Fisheries has been working with Ngati Wai in applying for a resource consent to establish a pilot cage farm site for farming kingfish and snapper at Peach Cove, near Whangarei. The application has now been approved by the regional council, but is now under appeal from residents concerned about the potential impacts of the pilot farm. If established, the farm site would provide the opportunity to assess the feasibility of commercial kingfish and snapper farming in the Northland Region.

Conclusions

The potential for commercial scale land-based farming of turbot, snapper or kingfish in Northland is limited due to the greater costs associated with land-based aquaculture operations. Intensive land-based culture of turbot may be possible using high technology flat fish farming systems imported from Europe, but the high cost of production is unlikely to be recovered in the market price for this species. Seacage farming of snapper and kingfish is more likely to be viable for the study area and could form the basis of a substantial industry for Northland.

Flat fish species – yellow-belly flounder (*Rhombosolea leporina*), greenback flounder (*Rhombosolea tapirina*), black flounder (*Rhombosolea retiaria*).

Background

A number of smaller flatfish potential may have some promise for aquaculture in New Zealand mostly three types of flounder, the yellow-belly flounder, greenback flounder, and the black flounder.

Growing Biology

All three of these flounders are typically found in harbours and estuaries, but also in coastal areas to a depth of 100 metres. Their ability to live in a range of habitats indicates that they are likely to be adaptable and relatively hardy aquaculture species. It may also be possible to farm some of these species in freshwater in a land-based facility. Recently inland turbot farms in Europe have developed effective recirculation technology for intensive farming of these fish. These New Zealand flat fish species are thought to grow relatively quickly under suitable conditions and produce a fish product with moist high quality flesh with good markets, especially in parts of Asia. Higher prices are likely to be obtained if the farmed fish can be delivered to market live, which seems possible. Relatively little is known about farming these species, although considerable amount of research and some pilot scale production of the greenback flounder has taken place in Australia.

The Study Area

Only the yellow-belly flounder is found in Northland, while the other two species are common on the east coast of the South Island. The yellow-bellow flounder does have potential to be farmed in Northland, probably in land-based farming system. This would require some development of hatchery and grow out methods for this species, which could utilise previous development work undertaken on the closely related greenback flounder.

Conclusions

The yellow-belly flounder appears to have some potential for land-based aquaculture in Northland. However, this potential would need to be assessed in terms of the technical difficulties that would need to be overcome to make commercial scale farming possible, as well as an economic appraisal.

Gracilaria seaweeds (*G. chilensis*, *G. secundata, G. pulvinata*, *G. truncata*)

Background

Gracilaria seaweeds are a group of fine red seaweeds with four native species found in New Zealand. Most of these seaweeds can be processed to provide agar chemicals a gelling agent used in food and chemicals, or these seaweeds can also be used as a fodder crop for cultures of herbivorous fish or molluscs, such as paua. They usually produce a lower grade agar than the *Pterocladia* seaweeds, and are therefore less valuable. Worldwide about 5,000 tonnes of agar are processed annually from about 30,000 tonnes of *Gracilaria* harvested mainly from the wild in Chile, Argentina, Brazil and South Africa.

Species of *Gracilaria* seaweed are finely branched and some can grow to 300 millimetres in height. They are usually brown to red in colour and are mostly found around harbours and in other nutrient rich waters. *G. truncata* and *G. chilensis* are found throughout most of the country, while the other two species are confined to smaller areas.

Growing Biology

The New Zealand species of *Gracilaria* generally grow intertidally on sheltered and exposed coasts, sometimes extending into the subtidal. They can tolerate widely varying water temperatures, salinities and water turbidity. In the Manukau Harbour for example, a large population of *G. chilensis* is associated with long periods of exposure to air, widely fluctuating salinity and very high turbidity. However, salinity in the range 20 to 33 parts per thousand and water temperature in the range of 10 - 28° Celsius gives the most optimal growth conditions for *Gracilaria*.

In open waters, there are basically three approaches to planting *Gracilaria* crops; on the seafloor, on nets or lines, and on floating rafts. With each approach, either vegetative material or spores can be planted. Alternatively, *Gracilaria* can be farmed in ponds, raceways or tanks. Overseas studies have found that seafloor plantings and line farming methods may provide sufficiently large crops to make the procedure profitable, provided labour costs are low. However, the results may be of limited value in this country where labour rates are much higher. Several attempts at *Gracilaria* farming in this country have not been successful. The most recent, an experimental *Gracilaria* farm in the Mahurangi Harbour near Auckland has run into difficulties with wild fish consuming the crop before harvest.

An alternative to open water cultivation is intensive pond culture consisting of a series of shallow ponds (of up to 1 hectare in size and about 1 metre deep) filled with seawater and seeded with chopped *Gracilaria* plants. Some exchange of water in the ponds is desirable to encourage growth by providing additional nutrients and maintaining salinity. Artificial nutrients can be added to the ponds to encourage growth of the seaweed but it needs to be applied carefully to avoid encouraging nuisance species. An alternative is to discharge effluent water from other aquaculture activities through the *Gracilaria* ponds to allow the seaweed to strip the nutrients from the wastewater. Ponds can be harvested every one to two months by removing excess

Gracilaria from the ponds. Depending on growing conditions up to 15 tonnes per hectare per annum can be produced by this method.

There are no viable export markets for *Gracilaria chilensis* as the production costs and large volumes in developing nations would make it difficult for locally produced seaweed to compete after including freight charges. The existing markets for *Gracilaria chilensis* are limited in extent in New Zealand. There currently is little or no interest in the use of *Gracilaria chilensis* for producing agar chemicals in this country. Some local manufacturers of paua feeds are buying cleaned and dried *Gracilaria* at up to $2,000 per tonne but the overall quantities involved are small. A number of paua farms currently use small quantities of fresh *Gracilaria* to improve growth and feeding of paua. Therefore, there may be opportunities to develop *Gracilaria* cultivation in conjunction with a paua farming operation.

The Study Area

G. chilensis and *G. truncata* are both found in the Northland, especially in the Kaipara Harbour. Areas of this harbour could be suitable for open water *Gracilaria* farming, particularly in shallow and accessible areas. Land-based farming of *Gracilaria* would appear to be entirely feasible in many locations in the study area. However, the desirability of doing so is uncertain given the very poor market prospects for the end product. A small experimental *Gracilaria* farm was established in the Matakana Estuary more than ten years ago but it has failed to produce commercial quantities of the seaweed.

Conclusions

Gracilaria farming is feasible in the Northland Region. The strongest prospects for a commercial farming venture would be in conjunction with a paua farm, using effluent water for nutrients for seaweed culture and using the seaweed for paua culture. The economic feasibility of such a *Gracilaria* farming operation would need to be assessed in conjunction with the proposed paua farming operation.

Shellfish/Fin Fish Hatchery

Background

Marine hatcheries are like commercial laboratories that are capable of rearing large numbers of juvenile shellfish, or fish, for ongrowing on marine farms. Hatcheries replace the need to collect wild spat or juveniles that can often be an expensive procedure. Hatcheries also offer greater control over the quality and timing of the production of juveniles. Juveniles can be produced on demand to suit the growing seasons, or the farmer. Hatcheries allow stock to be selectively bred to improve aquaculture production. Selective breeding programmes in species such as oysters have been used to significantly lift the growth and product quality of aquaculture species overseas, and has been used to produce excellent results with some salmon farmed in New Zealand.

Currently a number of small commercial hatcheries are operating around New Zealand producing mainly paua, Pacific oyster spat and salmon fry. Several research hatcheries also occasionally sell batches of shellfish spat and post-larval fish, such as snapper. For example, the Cawthron Institute in Nelson has been supplying small batches of oyster spat to some Northland farmers, by couriering them in carefully packed containers. NIWA at Bream Bay Aquaculture Facility has also been providing flat oyster and Pacific oyster spat, as well as kingfish fry for marine farmers, including some in Northland. NIWA facilities further south also provide paua spat and salmon fry to the aquaculture industry. As yet there are no large scale commercial hatcheries operating in New Zealand that are capable of large scale spat supply and providing genetically improved stocks. Such hatcheries are a now a feature of nations with advancing aquaculture industries.

Growing Biology

Commercial shellfish hatcheries generally require a clean reliable source of oceanic seawater as cultures of larvae and phytoplankton are particularly sensitive to changes in water quality.

Shellfish hatcheries are expensive to establish and run because they require considerable technology and expertise to operate.

The Study Area

A large commercial/research hatchery is already operating in the study area at the Bream Bay Aquaculture Park. Further south, Moana Pacific Fisheries Ltd and Electronic Navigation Ltd have run the Pah Farm fish hatchery on Kawau Island that has been producing snapper and more recently kingfish. The commercial operation of this hatchery has now moved to NIWA's Bream Bay Aquaculture Park, which has greatly improved their water quality and access. The NIWA facility is also actively involved in the hatchery and nursery rearing of a number of species including, eels, Pacific oysters, flat oysters, snapper, kingfish, green-lipped mussels, crayfish and paua. There are other coastal sites available in the region that could provide supplies of relatively clean seawater and be suitable for establishing a commercial hatchery. However, it would be more economical to work on the NIWA site where the infrastructure is established and there are other support facilities and expertise immediately at hand. The Northland Region has good transport connections with existing aquaculture areas in New Zealand that would be purchasing the seed stock produced by a hatchery. This is important as the delivery of spat to ongrowing sites because prompt transportation is a critical factor in ensuring the delivery of healthy spat from a hatchery. The current markets for hatchery production are limited due to the current state of New Zealand's aquaculture industry. The Pacific oyster and mussel farming industries currently prefer to rely on wild caught spat, and all other aquaculture is on such a small scale as to not require large-scale hatchery production. However, the situation is changing with both the oyster and mussel industries becoming increasingly interested in using hatchery supplies of seed. The development of selective breeding for these species would also serve to increase the reliance of the aquaculture industry on hatchery produced seed stock, as well as lifting production performance.

Conclusions

There is a wide range of suitable sites for operating a shellfish/fish hatchery in the study area. NIWA is currently operating a facility in Northland which has good fundamentals such as water quality and infrastructure and is encouraging commercial enterprises interested in developing hatchery technology onto the site. This cluster of aquaculture technology is an effective means of encouraging commercial development in areas where previously there has been little. Similar models have worked well overseas, such as the Aquaculture Center at Harbor Branch Oceanographic Institute in Florida.

Scampi (*Metanephros challengeri*)

Background

Scampi are prawn-like crustaceans that usually live in deep water on the seafloor. New Zealand has only one deep-water species of scampi (*Metanephros challengeri*) that is commercially fished extensively off the Bay of Plenty and further south. By contrast, Australia has fisheries for three species. Scampi are a high value species with assured markets.

Growing Biology

Very little is known about the biology of the New Zealand scampi species. Indications are that they grow very slowly in the wild, although this may be due in part to the cold deep water in which they live. It is not known if these animals could be acclimatised so that they could be cultivated in warmer water temperatures. If they could it would have the potential to greatly enhance their growth. Animals held in captivity by NIWA have been found to be aggressive and cannibalistic which does not augur well for aquaculture initiatives. Very little is known about the feeding or breeding of scampi. It has been suggested that eggs could be removed from ripe females caught in the fishery and then reared for aquaculture as they have relatively few larval development stages. It could be expected that scampi would require clean oceanic water for culture given that they are found in deep water offshore.

The Study Area

Scampi are found offshore from the Northland Region living in bottom sediments generally in water greater than 80 metres deep. Any cultivation of scampi in the study area would rely on access to high quality seawater from the open coast.

Conclusions

Currently there is insufficient information to recommend attempts at scampi aquaculture in Northland.

Swimming crab, papaka (*Ovalipes catharus*)

Background

New Zealand's most common swimming crab is found around most of the country in clean water harbour channels, open sandy beaches and sandy seafloors generally out to 50m deep. It grows up to 150 millimetres across its carapace. There is some commercial fishing for these crabs around New Zealand under fisheries permits mainly using pots or lift-trays, but the species is comparatively low value compared to other overseas crab species partly due to its poor meat yield. There is some commercial fishing of paddlecrabs off the east coast of Northland. The New Zealand paddle crab belongs to the Portunidae family, or swimming crabs, which are distinguished by the flattened end segments on the back legs, these are used for swimming and digging. The Blue crab of the East coast of America, *Callinectes sapidus*, belongs to the same family. This species sustains a fishery ranging from 45,000–89,000 tonnes per annum and produces four distinct product lines; whole fresh crab, soft shell crab, crab paste and crab meat which is sold fresh, frozen, canned and pasteurised. Another member of the swimming crab family has recently been found in New Zealand, an immigrant from Eastern Australia, which is extremely aggressive compared to the native species.

Growing Biology

Swimming crabs require clean water, but can tolerate some salinity fluctuations. There have been some attempts to grow these crabs in ponds, but there needs to be more research into their growing requirements. There is a high market demand for soft-shelled crab products, but again research is needed to develop a reliable method of inducing soft shell stage in this species of crab. Currently the soft shell crab market demand outstrips supply and the price is high ex-factory FOB New Zealand $30 per kilogramme. In order to grow, crabs must shed their exoskeleton or shell. This is accomplished by the development of a new skin below the shell. When the crab is ready to moult it pumps itself full of water and splits open its shell. Once the shell is split the crab climbs out and continues to pump itself full of water, stretching the new skin in the process. This new skin is soft and velvety at the point of emergence from its old shell, but it quickly hardens over the next 6–24 hours through the deposition of calcium to form a new shell. At the point of first emergence the crab is "soft shell" and can be cooked and eaten whole without the difficulties of removing the shell. Overseas, soft shell crab fisheries target crabs in pre-moult condition, and hold them in a culture system and by reading the signs in the crab it is possible to determine when the crabs will moult and go into the soft shell stage. In the blue crab fishery these crabs are held in shedding trays and the newly moulted crab is removed from the water and killed. Once out of the water it is not possible for the crab to harden its shell. The product is visually appealing as it appears like a whole crab, although the eyes and gills are usually removed. Thus with minimal processing a premium product is ready for serving at top quality restaurants.

The soft shell blue crab is a seasonal product with most of the moulting occurring during late summer to late spring with major peaks during this time, when up to 50% of the population could be moulting. During the summer months moulting tends to occur mainly in crabs under 50 mm carapace width. Thus any soft shell crab industry in New Zealand would need to be built around the same product lines found in the USA blue crab fishery.

A significant investigation into the economic and biological feasibility of a crab fishery, in the Nelson Bays area, based on soft shell culture and supported by crab meat and crab paste products was undertaken in the period 1986 – 1989. Dominion Salt Ltd in partnership with Macdonald Trade Corporation Ltd undertook an exhaustive economic investigation into the potential fishery as well as investigating the biology of the crab including growth rates, reproductive cycle, fecundity, moult cycles, recruitment, food selection, food consumption, oxygen consumption rates, biomass estimates and sustainable harvest rates. The outcome of that investigation was the recommendation that a fishery be established with a view to developing a soft shell crab product. However, as a result of the share market crash of October 1987 and the difficult venture capital market resulting, the industry was never established.

Fresh crabmeat with its delicate flavour and texture is a specialist item commanding a high price both in New Zealand and overseas. Hand picked crab meat is far superior to machine picked meat but is clearly more expensive to obtain due to the labour cost. Estimates of crabmeat yield from crabs greater than 100 mm is about 30% of the live weight. Approximately half of this is easily extracted by hand picking, with picking rates being about 3.5 kilograms of meat per hour. Machine extracted meat from the hand picked frames can be used for crab pate and crab paste products. Hand picked crabmeat fetches around US$40 per kilogramme retail which equates to about NZ$20 per kilogramme ex-factory New Zealand.

Hard shell crab can be fished by potting and trawling. Currently targeted crab fishing operations are restricted to permit holders using pots, however, large numbers of crabs are taken as by-catch in other fishing operations such as trawling and set netting. There is currently a moratorium on issuing further paddle crab fishing permits.

Pre-moult crabs stop feeding and seek shelter, hiding by day and becoming more active at night. As they are not feeding, baited crab traps are not an efficient method of capture. By far the most effective capture method is the use of a small otter trawl towed at 1 knot or less, when fitted with a tickler chain and fished at night this method can yield good catches of crabs. Regardless a large portion of the catch is likely to be hard shell crabs and methods for holding, feeding and identifying or inducing moulting would need to be determined before the higher value soft shell crab product could be developed.

The Study Area

The swimming crab is found in the Northland Region and is the basis of a small commercial fishery. Any pond culture of the species would rely on a supply of clean seawater from the coast and a much greater understanding of their culture biology.

Conclusions

Currently there is no immediate potential for the aquaculture of swimming crabs in the Northland Region. In future it may be possible to develop holding and control methods for producing soft shell crab products from swimming crabs harvested from the adjacent coastline, or culturing the crabs from through their lifecycle.

Penaeid prawns (*Penaeus* spp.)

Background

A variety of exotic penaeid prawns including; *Penaeus japonicus*, *P. monodon*, *P. sylirostris*, *P. vannamei* could be cultivated in New Zealand. These species have been widely cultivated in parts of Asia, Europe, North America and Australia. Their biology and culture methods are well understood and are freely available. There are several difficulties with growing these species in this country. They are exotic species, which need to undergo rigorous environmental assessment and then expensive quarantine procedures, before they can be released in New Zealand. Most of the penaeid prawn species that can be cultivated are warm water species. To cultivate these species in this country it would be necessary to heat their water. This creates a major expense for cultivation of tropical prawns in this country.

Growing Biology

The culture of these species is well known and is possible with a wide variety of techniques including intensive tank systems, to low technology extensive field pond systems.

The Study Area

Penaeid prawns could be cultivated on land in the Northland Region, but it would be uneconomic because of the costs of raising water temperatures sufficiently to suit the prawns. It may be that there exists a sufficiently large natural geothermal source of water that could be used for heating water for prawn culture. However, given this scenario it would still remain difficult to compete on product price with large, highly developed and efficient overseas prawn farming ventures. There was a high profile prawn farming venture involving Chinese technology over a decade ago based on South Kaipara Head. The facility lurched from one difficulty to another until finally closing down.

Conclusions

Penaeid prawn culture should not be considered for the Northland Region as it is unlikely to be economic given the requirement for heating water to culture these tropical prawns. There are also likely to be issues with importing these exotic species to New Zealand that would not be easy to overcome.

Sea urchins, sea eggs, kina (*Evechinus chloroticus*)

Background

The kina is a spiny urchin found mainly on rocky subtidal areas around most of New Zealand. It grows up to 120 millimetres in test diameter. The gonad, or roe, of these urchins are well known kaimoana. There are some limited sales of harvested kina on the domestic and export markets. The most valuable markets for kina roe are in parts of Asia, however, the New Zealand species does not produce a premium product that could compete with the quality of Japanese urchin roe. However, there is the potential to improve the roe quality through supplementary feeding of specialised diets. Recent research has indicated that this has some potential in the New Zealand species. Kina larvae are easily reared in a hatchery and could be used for enhancement or aquaculture. Sea urchin roe, or "uni" is regarded as a delicacy in Japan and top quality

Japanese uni fetches up to US$130 a kilogramme. The harvest of urchin roe from Japanese waters has declined from a peak of 27,500 tonnes in 1969 to 13,700 tonnes in 1998. This marked decline resulted in Japan importing uni produced from wild urchin fisheries throughout North and South America. As a consequence, many of these fisheries are now badly depleted while demand and prices for the product continues to increase. Japan currently imports over US$300M of uni a year.

Growing Biology

Kina live on rocky reef areas and are omnivorous. They feed upon whatever they come across, particularly large brown algae. Kina grow relatively quickly given a suitable food source and reach harvestable size within two years. Hatchery techniques for inducing spawning and rearing larvae have been developed. Land-based ongrowing of kina has not been attempted in New Zealand. However, research in this area is currently taking place in Japan using raceways for culturing the urchins. The large food requirement of the urchins is being satisfied with terrestrially grown fodder crops. The researchers are also attempting to develop holding regimes to develop large ripe gonads in the farmed urchins. We currently have very little information that would be of use in developing the aquaculture of kina. NIWA is currently researching the development of an artificial diet for urchins that can be used for enhancing the roe quality of wild caught urchins.

The Study Area

Kina are found throughout the Northland Region on most rocky reefs particularly on coastal areas in the eastern area of the region. Quantities of kina are commercially harvested from a number of areas in Northland by special permit holders. These wild caught urchins would have the potential to be used for a kina fattening operation based in Northland, to produce a high quality uni for export to Japan. There are ample suitable areas for establishing a land-based seawater system for farming kina and for kina fattening. Kina have particular importance for kaimoana in Northland – any development of the kina fishery would need to ensure that cultural use of this seafood was not compromised.

Conclusions

The prospects for cultivating kina anywhere in New Zealand are poor at present given the lack of knowledge about the aquaculture and biology of kina. Fattening the roe of wild caught kina to produce a high value product for export may well be feasible but will require some development work and some economic assessment. This is very worthy of consideration as a longer-term development option for the Northland Region.

Holothurians, sea-cucumbers (*Stichopus mollis*)

Background

Sea cucumbers are sausage-shaped creatures that inhabit shallow waters around much of the world. The largest New Zealand species is found around most of the coast in shallow waters on soft sediments with clean water. *Stichopus mollis* grows up to 200 millimetres in length and where conditions are suitable quite large numbers can be found together. Sea cucumbers are harvested in many tropical countries for sale in Asia and parts of Europe, particularly France. Japan and some other tropical countries are now culturing some more valuable species of sea cucumbers. The New Zealand species is considered to be of relatively low commercial value, because of its small size and relatively poor quality flesh. Regardless this species may have some commercial potential given that international prices for sea cucumbers can range quite high and that it may be possible to farm sea cucumbers alongside other species such as paua. The New Zealand species has also been found to contain a compound with medicinal properties (anti-inflammatory) for which there is some commercial interest in developing.

Growing Biology

Very little is known about the growing biology of the New Zealand sea cucumbers, although some information is known about their breeding cycle. More recently a research project at the University of Auckland has been investigating their larval culture and possible techniques for grow out.

The Study Area

Sea cucumbers are found throughout the Northland Region in sheltered areas around harbour mouths and in sandy areas between rocky reefs. There is no commercial fishery for these creatures at present in Northland.

Conclusions

The native sea-cucumber may have some commercial potential for aquaculture, but this extent of this potential is currently unclear and awaits further detailed research.

Seaweeds: Agarweed (*Pterocladia lucida* & *P. capillacea*), Dog-ear seaweed (*Curdiea coriacea*), Asparagus seaweed (*Asparagopsis* spp.), *Delisea* spp. Kelp (*Ecklonia radiata*)

Background

Two native red seaweeds; *Pterocladia lucida* and *P. capillacea*, have been used for over 40 years as the major source of raw material for the manufacture of agar in New Zealand. Agar is a chemical gelling agent used in medical applications and a variety of other products. Both species of seaweed are found in shallow waters growing on rocks. They are found throughout most of New Zealand, although they are very uncommon in the cooler waters of the South Island. These seaweeds are most common on the coasts of Wairarapa, Hawkes Bay, Poverty Bay and the Bay of Plenty. *P. capillacea* is tufted, bright crimson in colour and grows to about 100 millimetres in height. It is used only to a limited extent in the manufacture of agar. *Pterocladia lucida* is a tough plant that grows up to 500 millimetres in height and is also a rich crimson colour and is the mainstay of agar manufacture. The main processing plant for extracting the agar from these seaweeds is located just outside of Opotiki Township.

An unusual red seaweed only found in Northland, dog-ear seaweed (*Curdia coriacea*), is known to contain a high value gelling agent suitable for use in scientific research. Some limited research into the biology of the species found that it was relatively slow growing and its reproductive biology was complex – making it a difficult potential aquaculture species.

Asparagus seaweed (*Asparagopsis* spp.) is found in Northland and is rapid growing and in some situations quite common. Extracts from overseas species have been utilised in cosmetics, particularly in the treatment of acne. The status of the New Zealand species in terms of their potential for this use is unclear.

Extracts from *Delisea* spp. have recently been developed in Australia for extracting materials that prevent the formation of bacterial films on surfaces, a property which has a multitude of commercial applications. It is unclear whether the New Zealand species contain similar materials and whether they can be cultured.

Kelp species overseas have been investigated extensively and found to contain a rich variety of useful chemicals including natural deodorising agents and medicinal chemicals. The chemical properties of the most commonly occurring kelp in Northland, *Ecklonia radiata*, have not been investigated in any detail, nor has the potential for aquaculturing the species.

A great many other seaweeds are found in Northland which have overseas relatives that are being developed commercially, mostly for the valuable chemicals they produce. However, relatively little is known about the chemical properties of New Zealand seaweeds and their potential for aquaculture.

Growing Biology

Both species of *Pterocladia* seaweed are found in a variety of growing conditions. They appear to be able to tolerate a wide range of wave exposure and water quality. Larger populations are generally associated with moderately to highly exposed, shallow reefs, with clean seawater. There has been some research into the possibility of farming *Pterocladia* species both in New Zealand and overseas. An American company reputedly spent about US$11 million attempting to establish a *Pterocladia* and *Gelidium* seaweed farm in California. The venture failed due to the great difficulties involved in farming these seaweeds. A suitable aquaculture methodology is yet to be developed for these seaweeds.

The Study Area

Both types of *Pterocladia* seaweed are found in the Northland Region and are gathered for agar production. They are collected as beach cast drift seaweed or live plants can be harvested from the wild with a harvesting permit. Harvested plants can re-grow if the base of the plant (the holdfast) is left intact. In this way the same plants can be cropped repeatedly. The removal of marine herbivores and competing plants may also encourage *Pterocladia* growth in an area. Large quantities of agarweeds are gathered as beach cast material from around Reef Point near Ahipara.

For the other seaweed species the commercial potential of their chemical constituents have not been fully evaluated and therefore it is difficult to assess their commercial potential. However, their immediate potential for aquaculture is non-existent.

Conclusions

At present there is no potential for cultivating *Pterocladia* species or the other seaweeds outlined in the Northland Region due to the lack of farming technology and knowledge of their commercial value for these species.

Wakame seaweed (*Undaria pinnatifida*)

Background

Undaria pinnatifida is a large brown seaweed, which is a native of Japan. Two varieties of the species have been accidentally introduced to this country. It is an annual plant attaining a length of up to 3 metres. The Japanese eat all parts of the main plant fresh, or after preserving by salting or drying. The combined Japanese and Korean crop of *Undaria* is about 400,000 tonnes annually and worth about $700 million. Recently a New Zealand company identified a useful natural anti-viral drug from the seaweed and has reportedly been looking for supplies of the seaweed for processing.

Growing Biology

Undaria pinnatifida prefers the sheltered conditions of harbours. It can tolerate some reduced salinity and turbidity. In Japan and Korea where this seaweed is farmed extensively the annual water temperature range varies much more than in New Zealand. Farming techniques in these countries have been developed to accommodate the seasonal water temperature changes. For New Zealand these seasonal growing techniques will require major adjustment to suit local conditions. However, if this can be achieved it may allow the year round supply of fresh wakame which is more likely to fetch better prices. The Korean crop of wakame is currently the main supplier of the Japanese shortfall in production. This wakame is generally of poor quality due to the presence of pests in Korean waters. It would appear that these pests are not present in this country opening the way to the cultivation of top quality wakame for export.

The Study Area

Undaria pinnatifida has not been found growing naturally in Northland, although it is found in other parts of New Zealand, such as Wellington, Timaru, Oamaru and Bluff Harbours, and more recently the inner Hauraki Gulf. The intentional transfer of this introduced seaweed to Northland is very likely to cause environmental concerns. Also, it is not clear if the conditions in the Northland would suit the cultivation of this seaweed, however, it would seem that the lifecycle of this seaweed requires cooler waters. Current research underway in Nelson should assist in identifying some of the pre-requisites and methods needed to farm this species in New Zealand. Most of these research efforts are focussed on growing the seaweed in the sheltered waters of the Marlborough Sounds. In other countries such as Japan, wakame also tends to be cultivated in sheltered waters that may make wakame farming feasible in this area.

Conclusions

The cultivation of wakame in Northland is unlikely at present given the environmental concerns about introducing this exotic seaweed to the Region. However, if the seaweed continues to spread around New Zealand as it has to date it is quite possible that it will become established in the Region, making it a stronger prospect for local aquaculture.

Nori seaweed, karengo (*Porphyra* spp.)

Background

Seven native species of *Porphyra* seaweeds are known in New Zealand. They are all members of the red seaweed family, and most of them are red in colour, although some are greenish in colour. The main species of interest in New Zealand is *Porphyra columbina* that grows up to 200 millimetres across. It is usually found on upper intertidal rocks in moderately sheltered to open sites in most parts of New Zealand.

The market potential for *Porphyra* seaweeds is thought to be limited. The Japanese market for this seaweed is large, but it is already over-supplied and is protected by import restrictions. Large markets also exist in Korea and China, but locally grown product can be produced very cheaply because of low labour costs.

Growing Biology

Very little is known about the growing biology of New Zealand species of *Porphyra*, although cultivation techniques for Japanese species are well known. In Japan the species are artificially seeded onto growing nets or sticks suspended in the sea, sometimes in intertidal areas. The fully-grown seaweeds are later harvested often using mechanical harvesters.

A small *Porphyra* farm operated for several years near Invercargill using the same Japanese growing techniques, but on a low technology basis with a New Zealand species of *Porphyra*. The operation succeeded in producing good quality seaweed, but collapsed due to a lack of capital and local markets. The small scale growing operation was also relatively labour intensive given the finished value of the potential crop.

The Study Area

Porphyra species are found in the Northland Region and are harvested by a few local people for their consumption particularly from rocky intertidal areas. Some sheltered harbour areas in parts of the region may be suitable for cultivating this seaweed, however, greater research and economic assessment would need to be undertaken before proceeding with attempts at cultivation.

Conclusions

The farming of *Porphyra* species in the Northland Region is unlikely to be feasible given the lack of suitable growing techniques currently available.

Neptune's Necklace (*Hormosira banksii*)

Neptune's necklace is a common brown seaweed found around much of New Zealand, including throughout much of Northland. Very little is known about its ecology, although it is known that it is easy to extract "seeds" from ripe plants, opening the way for aquaculture. It has been suggested that this species could be cultivated as a fodder crop for paua, as a source of alginate chemicals, and as an ornamental plant for Japanese food tables. A similar shaped and traditionally used Japanese species, *Meristheca papillosa*, is in short supply and fetches high prices. No research into the cultivation or the value of Neptune's necklace has been undertaken. The most suitable area for aquaculturing this species is likely to be the sheltered harbour areas found throughout Northland.

Seabed Aquaculture and Enhancement

Introduction

The majority of aquaculture activity currently occurring in Northland involves structures in the marine environment, placed on the seabed. The viability of some of these species for the Northland Region are outlined in this section. Included in these descriptions are the options for enhancement, the artificial increase of wild fish stocks an activity that has brought substantial economic benefits in some fisheries, such as the Nelson and Golden Bays scallop fishery.

Rock Lobsters (*Jasus edwardsii* & *J. verreauxi*)

Background

There is growing worldwide interest in the enhancement of wild fisheries of lobsters. Extensive research has been done on the enhancement of both the European and American clawed lobster species. This has been driven by the aquaculture difficulties faced with these species, which are aggressive, territorial and cannibalistic. Recent results from enhancement trials in the United Kingdom have produced some promising results where in some areas up to 40% of reared juvenile lobsters released into the wild were later captured as legal sized lobsters by commercial fishers. Research on our red rock lobster species has indicated that like the clawed lobsters the mortality of early juveniles in the wild is very high. Rearing beyond this early vulnerable juvenile size may greatly improve their chances of survival when released into the wild fishery. There have also been recent suggestions by scientists that new designs for lobster seed collectors could be incorporated into artificial habitats. These would serve to attract settling lobster seed and then ensure that they have adjacent safe habitat in which to reach a size where they are less prone to predation. Recently work has begun by NIWA in areas of the coast north of Gisborne to establish if such small scale, low cost, low environmental impact devices can be installed on the coast to enhance lobster survival during the critical first years. However, their eventual effectiveness on Northland's coasts is unlikely, as research on this coast has suggested that natural settlement levels of seed crayfish are very low on both the east and west coasts.

Growing Biology

The biology of red rock lobsters and the sources of lobster seed for aquaculture is outlined in more detail in the land-based aquaculture section of this report.

A previous economic assessment of land-based aquaculture suggested that seacage farming of lobsters could provide an alternative to overcoming the high infrastructure costs associated with land-based farming methods. Such farming techniques would involve the use of structures in sheltered waters for maintaining the seacages. Deep-water cages in more open waters may be vulnerable to weather damage and theft, but are likely to overcome some of the substantial infrastructure costs associated with land-based farming methods.

Indications from the economic assessment were also that the early growth of lobster from puerulus is quite rapid and is relatively low cost to achieve due to minimal feed and water requirements. If juveniles could be grown to a sufficient size for release into the wild that they are much less prone to predation then such an enhancement scheme could also be economically feasible. Unfortunately, there is very little known about the predation of juvenile lobsters, particularly in relation to size and different habitats. In addition, the fisheries administrative arrangements in New Zealand are not conducive to generally encouraging enhancement arrangements unless sponsored by the government for the benefit of all fisheries participants, or that the benefits can be captured on a significant scale by the commercial fishing sector. It is likely that inshore seacage farming of rock lobsters would require clean and sheltered to semi-sheltered waters that are 8 to 20 metres deep. Proximity to mussel farming activities would assist with food availability initially, but may not be necessary. A nearby wharf for deploying seacages and servicing equipment would be desirable.

The Study Area

The Northland Region includes a number of existing areas of lobster habitat that produce good commercial quantities of lobsters and that could be suitable for enhancement. There are sheltered waters suitable for seacage farming of lobsters in the study area. It may also be possible to sea cage lobsters in deeper waters, perhaps using subsurface suspension as a means of overcoming the damaging effect of swell movement on captive lobsters.

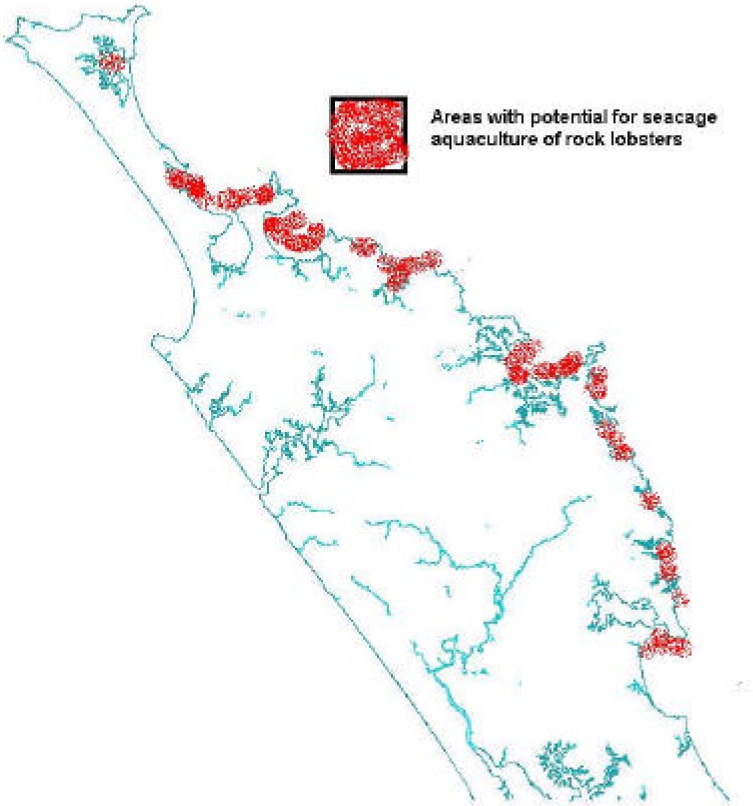

Figure 15: Map of Northland showing general areas with potential for seacage rock lobster aquaculture.

Conclusions

There is insufficient knowledge at this stage to encourage lobster enhancement programmes for Northland, however, it may be worthwhile undertaking some enhancement research in this area as there are existing productive areas of lobster habitat. Seacage farming of lobsters in the semi-sheltered waters of the eastern coast of Northland is feasible and is likely to have considerable commercial merit. More exposed water culture methods may be relatively easy to develop and are also worthy of consideration. More recent seacage trials elsewhere in the country suggest that summertime water temperatures in Northland would need to be examined more closely to establish whether they are responsible for summertime deaths. Enhancement of the wild populations of red rock lobster on the eastern coast of Northland may be possible, but further development of the methods needs to be achieved, and the ownership issues would need to be clarified further.

Figure 16: Small scale trials of seacage culture at Kawau Island near Auckland produced promising results.

Paua (*Haliotis iris, H. australis, H. virginea*)

Background

The artificial enhancement of wild abalone stocks has been extensively investigated in many countries around the world. The world leader in abalone enhancement is Japan, which runs very large-scale enhancement programmes for abalone on its coasts. These enhancement programmes are heavily subsidised by the Japanese government. The scheme relies on the release of large numbers of hatchery-raised juveniles back into the wild. The enhancement does increase the size of the total wild fishery, but observers suggest that it would not be economically sustainable without government funding.

There is no commercial ranching of paua in New Zealand yet due to legal constraints. ("Ranching" is where an area of natural seabed is farmed exclusively or where marked juveniles are released into the wild and their ownership is retained by the farmer for exclusive harvest). However, there have been trials of artificially enhancing wild beds of paua the results of which do not look very promising as yet. These have suggested that hatchery raised juvenile paua experience high mortalities when released into the wild. Such enhancement techniques are used overseas for commercial abalone fisheries. In Japan, for example, the enhancement techniques are widely practised with several species.

In addition to paua enhancement a number of paua farms have relied on barrel culture. Plastic barrels with meshed ends containing paua, which are suspended in the water column in sheltered waters. Such an approach avoids the high costs of establishing land-based paua ongrowing systems. There are mixed reports on the success of barrel culture methods of paua, some suggesting that the method is wasteful of food material as it is easily lost from the barrels and consumed by small mobile visitors to the barrels. Other reports suggest that the paua are easily lost from the barrels when small and that in some areas paua shell worm are a serious problem.

Figure 17: Large adult common paua among boulders on the seabed, are not a common sight in the Northland Region, where paua tend to grow to a smaller size due to the warmer water temperatures.

Growing Biology

The growing biology of paua is outlined in more detail in the land-based aquaculture section and in a separate handbook that is available from NIWA if required.

The Study Area

The study area does not include significant areas of paua habitat that would be entirely suitable for paua enhancement. There are sheltered and clean waters available for possible barrel culture of paua on the eastern coast of Northland and it may be possible to develop methods of barrel culture in more exposed waters.

Conclusions

The prospects for enhancement of wild stocks of paua are currently poor for the Northland because the areas of natural habitat and wild populations are limited. There are areas on the eastern coast that could be considered for barrel culture of paua.

Snapper and kingfish (*Pagrus auratus, Seriola lalandi*)

Background

Snapper and kingfish are two highly prized fish species found in northern New Zealand. The commercial fishery for snapper is extensive and valuable, while the commercial fishery for kingfish is very limited in extent. Both species are also prized as sport fish. Very closely related snapper and kingfish species are farmed commercially in a number of countries, mostly in seacages. In addition, to aquaculture there is enhancement of wild stocks of these species, particularly in Japan. The results from studies of these enhancement programmes suggest that the returns of released fish to commercial fisheries are limited. However, while these results may indicate an outcome for similar enhancement activities in New Zealand it may not necessarily hold. For example, juvenile snapper habitat in northern New Zealand is extensive unlike areas of coastal Japan. Unfortunately, very little information exists about the survival of juvenile snapper or kingfish in this country on which to make some preliminary judgements on feasibility of enhancement. In the case of snapper, there is sufficient information to strongly suggest that there is a survival bottleneck in the larval or early juvenile stages, which greatly limits the overall recruitment to the fishery. NIWA has been conducting research into the habitat preferences and survival of juvenile snapper that may help to provide useful information about how snapper for enhancing the wild fishery could be released into selected areas to greatly improve their chances of survival.

Growing Biology

The growing biology of snapper is well known and hatchery techniques for New Zealand snapper have now been established and have been in operation at Pah Farm on Kawau Island, and more recently at the Bream Bay Aquaculture Park. The growing biology of New Zealand kingfish is not as well known but intense efforts are being made to rapidly develop the technology. NIWA and Moana Pacific Fisheries Ltd are currently working on developing farming methods for kingfish, and a number of other commercial parties are interested in farming this species in New Zealand.

The Study Area

The study area has an extensive population of snapper, which forms an important commercial, recreational and customary fishery. Kingfish are a significant recreational species in many parts of Northland also. The effectiveness of enhancing wild stocks of either of these species is uncertain at this time and would require further study before any firm conclusions could be drawn. There are opportunities for seacage rearing of both of these species in sheltered or semi-sheltered growing waters with good quality water on the eastern coast of Northland. An resource consent application for a temporary pilot scale snapper and kingfish seacage farm at Peach Cove near Whangarei has been approved, but is being appealed by some concerned local residents. They have also formed an action group known as the Peach Cove Fish Farm Action group to oppose the development, and are actively involved in circulating material relating to the impacts of fish farming studies overseas with species other than kingfish and New Zealand snapper.

A variety of offshore fish farming systems are being developed overseas that can be deployed in deepwater offshore and often submerged to a depth where they are not a navigational hazard. Some of these systems could be suitable for ongrowing kingfish and snapper. Most of these farming systems are still in development and they generally require excellent shore based facilities for the associated much larger vessels and equipment required to deploy and manage these farming systems.

Seacage farming of finfish such as kingfish and snapper will initially require seacages moored in sheltered to semi-sheltered waters of good water quality that is 8 to 30 metres deep, preferably with some current flow. Proximity to good wharfage is usually essential for servicing seacage aquaculture equipment of any size. In the future, it may be possible to move seacage farming of finfish further offshore into more exposed and deeper water.

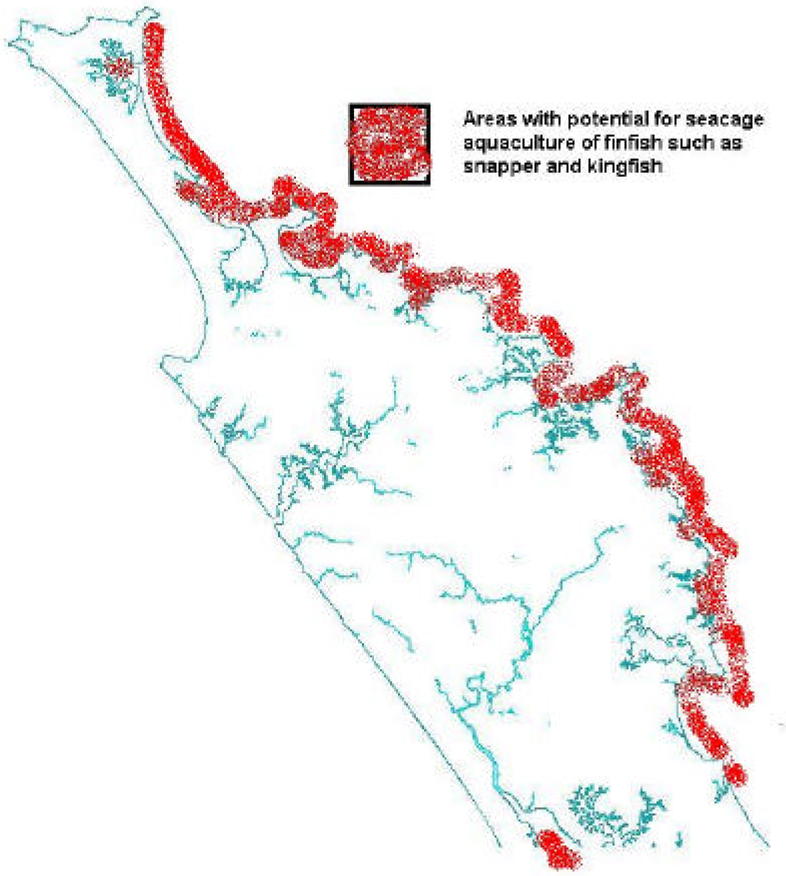

Figure 18: Map of Northland showing general areas with potential for seacage aquaculture of finfish such as kingfish and snapper.

Conclusions

The seacage rearing and enhancement of wild stocks of kingfish and snapper appear to have some considerable potential for Northland particularly in the warm sheltered and semi-sheltered waters on the eastern coast. However, as the Peach Cove application has demonstrated, proposing fish farms for these areas is likely to be contentious. New offshore aquaculture technology also provides an alternative option for finfish farming in this area that could avoid some of the community concerns. However, offshore technology is still being developed overseas, and fin fish farming technology for local species needs to be more advanced and better understood before attempting to transfer the operations offshore. The enhancement of wild stocks of kingfish and snapper using reared juveniles has considerable potential for areas such as the Bay of Islands where there is strong recreational fishing interest. However, a major difficulty is obtaining the revenue to fund the cost of raising the juvenile fish for release. It could be that forming an enhanced recreational fishing only area such as in Bay of Islands could have significant advantages in attracting visitors to the Bay, with the economic benefits from their associated visitor spending. Licence or entry fees to recreationally fish in the area and/or contributions from local businesses could be used to fund the enhancement programme.

Green-lipped or Greenshell™ mussel, kutai (*Perna canaliculus*)

Background

The green-lipped mussel is a native bivalve shellfish that is found around much of New Zealand, but tends to be more abundant in some areas of the North Island. It grows up to 165 millimetres in length and is an excellent eating mussel. These shellfish are extensively farmed in New Zealand and marketed overseas under the trade name “Greenshell” mussels.

The experimental culture of green-lipped mussels began in the Auckland area in the mid 1960’s following the collapse of the Hauraki Gulf mussel dredge fishery. Interestingly, a recent survey showed that the original massive beds of wild mussels in the Hauraki Gulf have still not recovered after the commercial fishing stopped more than 30 years ago. Cultivation of mussels in the Marlborough Sounds began shortly after the fishing stopped in the Hauraki Gulf, when the Tasman Bay mussel fishery also collapsed. This is an excellent example of how aquaculture has helped to remove the commercial pressure off wild stocks of seafood.

Today, green-lipped mussels are generally cultivated on longlines suspended from a series of large, plastic buoys. The longline droppers are typically between 10 and 20 metres in length and are seeded with mussel spat taken from the wild by holding them against the suspended grow out rope with a cotton stocking which later rots away.

Green-lipped mussels take between 12 and 18 months to reach harvestable size depending on the growing conditions. Mussels can be harvested throughout the year subject to their "fatness" or breeding condition. A typical fully developed 10 x 220 metre longline farm unit can produce on average 150 tonnes green weight of mussels a year, although this figure can vary markedly with farming techniques, and the quality of the growing waters. The mussel farming industry in New Zealand currently produces around 75,000 tonnes of mussels from a total of approximately 3,000 ha of water space. This earns in excess of $170 million in export receipts. The industry is now highly competitive with several large companies, such as Sanford Ltd and Sealord Shellfish Ltd dominating the market. As mussels are a relatively low value product, profits rely heavily on the use of highly mechanised handling and processing techniques which can produce large volumes at low cost.

Growing Biology

Green-lipped mussels appear to be able to tolerate a wide range of water quality, but grow best in sheltered waters, of reasonable depth (up to 40 metres) with oceanic salinity, low turbidity, warmer water temperatures, with ample phytoplankton food supply, preferably moved in by gentle currents. For these reasons mussel farming has concentrated and prospered in the Coromandel and Marlborough Sounds areas. As a particularly active filter feeding shellfish, green-lipped mussels require water of a high public health quality.

In New Zealand, mussel farm production has been expanding exponentially, and as a consequence the demand for seed mussels or spat is continually increasing. Until recently, various attempts at culturing commercial quantities of mussel larvae have largely failed to produce commercially viable quantities of, so the industry has remained entirely dependent on spat caught from the wild. Most spat comes from Ninety Mile Beach in Northland, where it is periodically cast ashore attached to drifting seaweeds and other flotsam (referred to as Kaitaia spat). Beach cast material is harvested, chilled and freighted to mussel farms throughout New Zealand, where it is attached to mussel farm ropes for ongrowing. Currently, a much smaller quantity of mussel spat is also caught closer to the marine farming areas, mainly on artificial settlement material suspended in the water column. For mussel farmers this source of spat is generally more costly to gather and process than that from Ninety Mile Beach, but it represents the only alternative.

The occurrence of spat on Ninety Mile Beach is highly seasonal, with very little being harvested for 4-5 months of the year. In some years mussel spat has failed to appear on the beach, creating severe shortages for mussel farmers. In recent years the localised occurrence of the toxic algae *Gymnodinium catenatum* led to a ban, and later strict controls on the shipment of Kaitaia spat. This created production difficulties for the mussel industry and necessitated the cleaning of Kaitaia spat prior to longline seeding to limit the spread of toxic cysts (seed-like stage) from the toxic algae. This process had added significantly to the cost of Kaitaia spat. In addition, the mussel industry has found that spat collected from other locations produces adult mussels that appear to fatten at different times of the year. By farming mussels from a combination of spat sources it helps to spread out the production of fat mussels throughout the year. Sealord Shellfish Ltd working at Bream Bay Aquaculture Park to develop the technology to produce commercial quantities of mussel spat artificially as an alternative supply to wild spat.

The Study Area

Conventional mussel farming techniques are currently used in a relatively small number of sheltered areas of Northland, and most established production is at Houhora Bay. Since the mid 1980's the farmed area in Houhora Bay has grown from around 4 hectares to over 20 hectares and production of mussels is around 500 tonnes per annum. The area appears well suited to producing mussels with only severe north-easterly storms causing problems for farming operations. The Houhora Wharf is about to be upgraded and this will assist in improving mussel farm support activities.

Proposing large-scale mussel farm development in the sheltered waters of the eastern coast of Northland is likely to meet with strong public opposition. For example, earlier proposals to establish mussel farms near Whangaruru and Karikari Bay attracted strong public interest and concern. Mussels could be farmed using existing technology in many areas including around Rangaunu Bay, Doubtless Bay, Bay of Islands and Whangaruru. . There has been some experimental and pilot scale long line farming of green-lipped mussels in semi-exposed waters, at the entrance to the Marlborough Sounds, Hauraki Gulf and also in the Eastern Bay of Plenty. The Ministry of Agriculture and Fisheries carried out mussel farming experiments in the Eastern Bay of Plenty between 1977 and 1982 using a variety of raft and longline techniques. Study sites were established in relatively shallow inshore areas, mostly with some shelter from headlands, at Te Kaha, Whitianga Bay (10 km southwest of Te

Kaha), and Little Awanui (5 kilometres southwest of Te Kaha). Mussels were successfully grown on 60 metre experimental longlines with droppers spaced every 0.75 metres. The longlines were supported by 55 kilogramme surface floats and anchored with 500 kilogramme mooring blocks.

Growth rates were reported to be higher than those obtained from less exposed sites in other regions, with mussels reaching an average length of 110 millimetres after 22 months of growth. Peak mussel condition was obtained during the spring months from August-November. Mussel condition declined over summer and remained relatively low during autumn and winter. The study concluded that growing mussels on mini-longlines was feasible in semi-exposed areas of the Eastern Bay of Plenty and therefore it is likely that it could be feasible in exposed areas further offshore in Northland.

Mussel spat collection and seed cultivation is also potentially a commercial option for Northland, which is known to have reasonably high levels of mussel spat in the water column at many times of the year. An aquaculture operation has applied for a 30 hectare mussel spat catching and ongrowing site in the southern half of the Kaipara Harbour, that is currently being appealed to the environment court. Further sites for mussel spat collection may be possible in the northern half of this harbour depending on the technology that is deployed. The Hokianga and Whangape Harbours as well as areas off Reef Point are all known to have good natural mussel spatfall. Recently a small operation has begun investigating mussel spat catching near the mouth of the Whangape Harbour, following a lengthy legal battle for the resource consent that has allowed them to proceed.

Mussel farming has been undergoing a major expansion phase in New Zealand. In the eastern Bay of Plenty two companies have applied for resource consents to develop open ocean mussel farms; Eastern Seafarms Ltd wish to develop a 4,750 hectare farm approximately 6.2 kilometers offshore of Opotiki, and Bay of Plenty Mussels Ltd have applied to develop an area of 4,009 hectares of mussel farm approximately 11.9 kilometres offshore from Pukehina Beach, north of Whakatane. Eastern Seafarms Ltd is a joint venture company with the major shareholders being Whakatoea Maori Trust Board, Tasman Mussels Ltd (50% owned by Sanford Ltd) and New Zealand Seafarms Ltd. Bay of Plenty Mussels Ltd is a joint venture company owned by Tasman Mussels Ltd and New Zealand Seafarms Ltd. If successfully developed these farms will cover an area approximately three times that currently farmed in New Zealand.

The applicants plan to use submerged longlines for spat collection and mussel grow out. Both proposals include a four-stage development plan where, subject to the economic viability, the number and density of longlines will be increased over time. At full capacity Bay of Plenty Mussels Ltd plan to have 8 farm blocks, each containing 123, 200 metre mussel lines spaced at 50 metre centres (total number = 984 mussel lines). Eastern Seafarms Ltd plan to have 16 farm blocks, each containing 82, 200 metre mussel lines spaced at 50 metre centres (total number = 984 mussel lines). If successful, there may be opportunities to transfer these successful technologies to other parts of the country such as Northland.

Overseas, the development of mussel farms in exposed offshore waters is still mostly in its early stages. Offshore farm structures must be able to survive continuous swells, currents and storm events, with limited maintenance and intermittent site visits for servicing. Capital and running expenses are expected to be substantially higher than for sheltered farms, yet they will receive the same value for their product. As a consequence the economic aspects of offshore mussel farming are questionable at present, particularly for small-scale operations. Larger scale operations offer the opportunity to create efficiencies which may overcome some of the higher operating costs involved in offshore farms. Nevertheless, promising results are emerging from the USA and Canada, which suggest that offshore production is feasible. GRT Aqua Technologies Ltd from Canada are growing blue mussels at two exposed offshore farms using submerged longlines.

Researchers from Woods Hole Oceanographic Institute have also been developing submerged longline technology, with an emphasis on creating secure mooring systems that can withstand long fetch wave and swell conditions typical of offshore situations. They conducted offshore trials in water 42 metres deep, using a 130 metre subsurface longline held at 7 metre depth with 1 metre steel floats and secured by 2 tonne DorMor anchors at each end. The steel floats were attached to the anchors with polyester, samthane coated, anchor rope attached between lengths of 20 millimetre mooring chain. Droppers were spaced at 3 metre intervals with additional support floats spaced along the longline. With this configuration they successfully grew blue mussels to harvestable size over a 19 month period. Based on the results of this study the group developed an economic model of offshore mussel culture. They concluded that offshore mussel culture would be profitable in New England, USA, with dockside prices of US$0.65 - US$0.80 per pound. However, they emphasised that the risk of losing crops was significant and suggested that diversification across two or more crops (e.g., mussels and scallops) may help offset the added risk and achieve full utilisation of support vessels. The Japanese also have developmental exposed water farming of shellfish species. However, it is difficult to obtain useful and relevant details of these techniques in order to assess their relevance to New Zealand mussels.

Green-lipped mussels can be grown in sheltered to semi-exposed waters in water between 8 and 30 metres deep. Water quality is not as critical as it is for some species such as rock-lobster and finfish. Some current flow is desirable and proximity to wharf services are desirable. Areas further offshore in exposed waters may also be suitable for green-lipped mussel aquaculture if the farming technology can be developed to work in these areas.

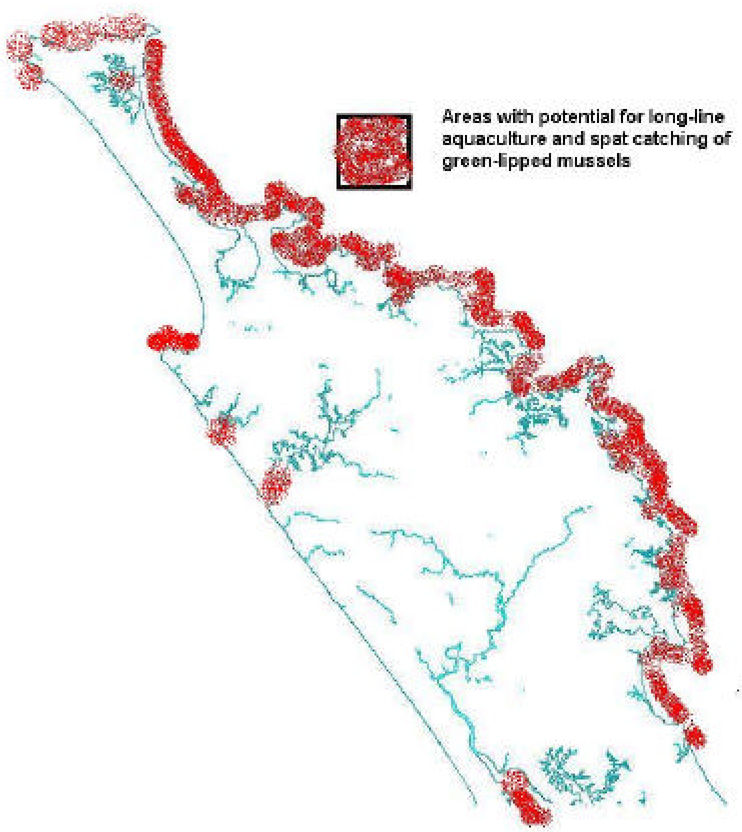

Figure 19: Map of Northland showing general areas with potential for long-line aquaculture and spat catching of green-lipped mussels.

Conclusions

The success of the Te Kaha trials in the early 1980's suggest that some areas of semi-exposed coast in the eastern part of the Northland Region could be suitable for mussel farm developments. Areas on the west coast of the region appear to have potential for commercial mussel spat collection. Most mussel farming in New Zealand has developed into extensive farming areas with efficiencies in operation based on large scale of farming activities. Therefore, small-scale mussel farming, as already occurs in Northland, is much less efficient. Farming in more exposed waters well offshore may also be feasible, but it will require a significant investment in research and development, and a greater amount of capital expenditure. Furthermore, offshore mussel farms would be competing directly with sheltered farms, yet their running costs are likely to be greater, and they will be exposed to a greater element of risk. Large scale, open-ocean mussel farms may therefore be viable, but the economics have yet to be proven. However, if offshore mussel farming is successfully developed in New Zealand it could also have other potential benefits such as developing aquaculture infrastructure that can also lead to greater diversification of aquaculture activity in the Region.

Demand for mussel spat will continue to increase sharply as new mussel farms continue to come into full production and further pressure is placed on the existing major supply of mussel spat from Ninety Mile Beach. Changes in the management regime for spat gathered on the beach may also greatly alter the current economics of spat sources. As a consequence, there appears to be some scope for the commercial catching and supply of seed mussels from areas in Northland. Impetus should be given to identifying new, high settlement areas and refining techniques for collecting spat on artificial materials and efficiently transporting them to mussel farming areas. The Kaipara, Whangape and Hokianga Harbours, and areas off Reef Point would seem to provide locations which appear well suited to developing these kinds of spat catching technologies and commercial operations.

Pacific oyster, tio (*Crassostrea gigas*)

Background

The Pacific oyster is a bivalve shellfish that grows to about 120 millimetres in length, and specimens up to 300 millimetres have been recorded. These oysters are native to Japan and other parts of Asia and they were introduced to New Zealand in the late 1960's. They were first noticed on the east coast between the Bay of Islands and Auckland, however, they have now spread over much of the northern half of the North Island.

Pacific oysters are the most widely farmed and eaten species of oyster in the world with current world production well excess of 3 million tonnes valued at over US$3,500M. At the time of their arrival in this country there was a small and struggling oyster farming industry based on the native rock oyster, *Saccostrea commercialis*. Within a decade this industry had switched entirely to farming the Pacific oyster because of its faster growth and more reliable spat fall. Today, the Pacific oyster is farmed in many harbours from Ohiwa Harbour northwards. The main growing areas are the Bay of Islands, Mahurangi Harbour and Coromandel. The cultivation of Pacific oysters has also been established in the Marlborough Sounds in recent years.

There are a variety of ways of cultivating Pacific oysters. The most common cultivation method in New Zealand is on intertidal structures or "racks," which can hold oysters in a number of ways. The oysters can be attached to sticks made of wood, plastic or cement fibreboard, or held in flat trays, in small plastic baskets, or in larger plastic mesh bags. Pacific oysters can also be cultivated in suspended culture either in trays, lantern nets, plastic mesh bags, or attached to plastic pipes or scallop shells.

Young Pacific oysters or "spat" are collected from the wild in the settlement season during the summer. Spat are allowed to settle on material on which they will be on-grown or from which they can later be removed. The main spat catching area in the North Island is the Kaipara Harbour, which has reliable and heavy spatfalls in summer. Several oyster hatcheries now provide an alternative year round supply of Pacific oyster spat. Oyster hatcheries are able to produce commercial quantities of spat artificially. Overseas there has been a trend for oyster farmers to switch to hatchery reared spat. It can be expected that this trend will also be followed in this country because hatchery reared spat is generally less costly to obtain than wild spat, and can greatly improve the quality of the farmed product. Also, the hatchery spat can be procured year round to suit oyster growing seasons, and the parental stock can be selected to provide positive farming attributes, such as disease resistance, faster growth, less growth variability. In addition, modern hatchery techniques can manipulate oyster breeding to produce "polyploid" oysters that maintain their condition and can therefore be sold throughout the year.

In New Zealand the oyster industry is currently worth well over $20 million, with in excess of $6 million in exports receipts. The main export markets for Pacific oysters are Australia, United States, Singapore, Taiwan, Japan, Hong Kong, and French Polynesia.

The Pacific oyster industry is becoming an increasingly competitive industry both locally and overseas. Increasing production and export capacity from parts of Asia and Australia are expected to erode international prices. However, recent aggressive marketing from a cluster of New Zealand companies, some with growing operations in Northland, has seen new export opportunities open up in parts of Asia that are paying considerable premiums over other existing export markets. These are based on being able to consistently farm and supply only premium quality oysters. There are likely to be other opportunities to develop premium offshore markets for New Zealand oysters to bring in better returns and offset some of the freight costs associated with New Zealand's remote location. For example, North American and European markets have discerning niche sectors that are prepared to pay premium prices for high quality product that can be produced from farms in places such as in Northland.

Pacific oyster production and processing is very labour intensive. New Zealand has relatively high labour rates when compared with other producing countries making it more difficult for oyster farmers to compete on a cost basis alone. The development of mechanised bulk handling techniques has the potential to reduce labour costs particularly in subtidal culture systems.

Figure 20: Pacific oysters being farmed on sticks, a common farming method in Northland (Photo: NZOIA).

Growing Biology

Pacific oysters can tolerate an extremely wide range of growing conditions. However, they appear to grow best in more sheltered waters, in the mid-tidal level, with warmer waters and ample phytoplankton food supply. They can also grow quickly over a wide range of estuarine salinities and water turbidity. They will also grow well when continually submerged, where they are occasionally found in the wild. Warmer water temperatures over summer are critical to the breeding cycle of Pacific oysters, with temperatures over about 20° Celsius required to trigger spawning. For these reasons Pacific oyster farming has concentrated and prospered in the shallow, sheltered, warm and nutrient rich waters of harbours in the northern half of the North Island. As an active filter feeding shellfish, Pacific oysters also require water of a high public health quality.

The Study Area

Northland is the largest Pacific oyster farming region in New Zealand with around 670 hectares of intertidal farm space allocated, although not all of it has been developed due to some areas being unsuitable. Northland is estimated to be currently producing around 70% of the 3.5 million dozen oysters, valued at around $20M of which about 85% comes from exports. The industry is estimated to employ about 400 people directly both part time and full time (around 320 FTE), in both growing and processing operations. Economic studies of intertidal farming of Pacific oysters in Australia have estimated that economic flow on effect from this activity are high – around 1:1. On this basis the Northland could be expected to produce and equivalent amount of economic activity indirectly, as it gross business turnover each year (i.e. around a further $20M in 2002). Much of the flow on effect runs to local property and business services, manufacturing, trade and transport industries. Flow on impacts on employment run at under the 1:1 ratio and on this basis the indirect employment from Northland's oyster industry is about a further 140 jobs.

Oyster processing is labour intensive and much of the processing of Pacific oysters is done in Northland at plants at Awanui, Waipapakauri, Kaeo, and two in Whangarei.

It may be possible to grow Pacific oysters on submerged offshore longline systems in deeper waters offshore, but to our knowledge this has not been attempted previously on a commercial scale. This may be worthy of consideration as a means of diversifying any successful offshore mussel farming development.

Pacific oysters are best farmed in intertidal areas with good water movement and water with low contamination with faecal coliforms and other pollutants.

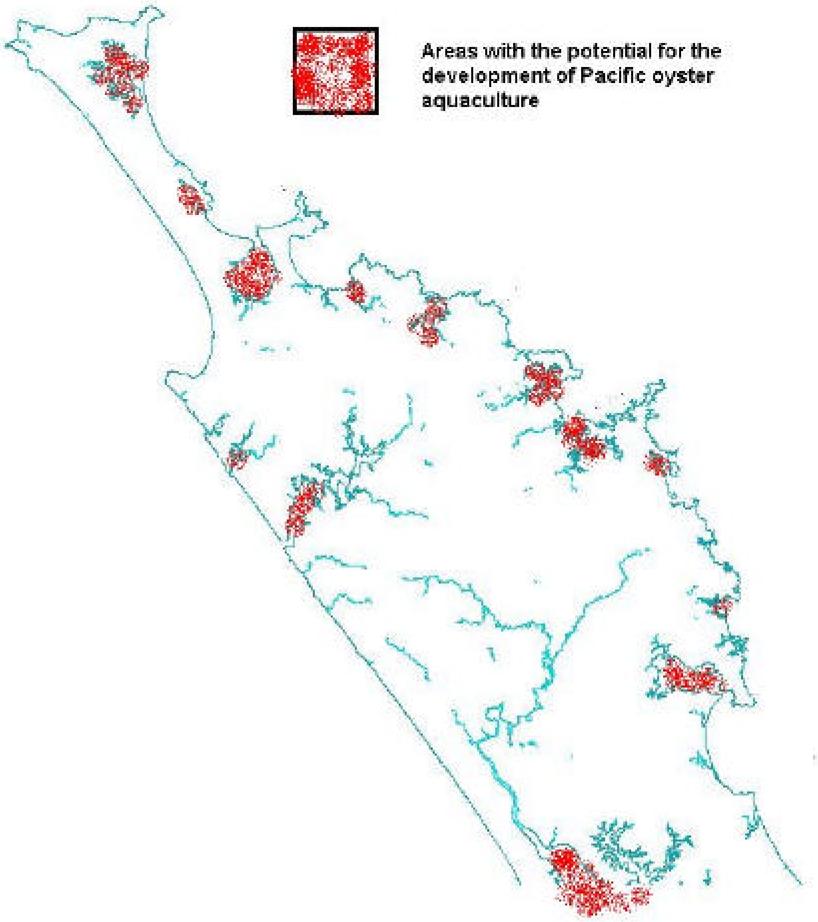

Figure 21: Map of Northland showing general areas with potential for intertidal Pacific oyster aquaculture.

Conclusions

There is good potential to greatly expand the existing commercial scale intertidal cultivation of Pacific oysters in Northland, especially by developing new farming space in areas that have already proven good oyster production. Initial pilot scale culture using hanging basket methods and relaying oysters into the Kaipara Harbour for finishing have been very successful in producing high quality oysters for export. There are concerns amongst the local community and planning agencies about expansion of aquaculture most areas of Northland.

The oyster industry in Northland is fragmented to some extent and could be co-ordinated more effectively over issues that unite the industry, such as law reform, promotion and marketing. This was reflected in the difficulty in accessing reliable figures for the industry for Northland for this current study. It might be expected that these figures would have been collected by the industry to measure the performance of the industry and help promote the importance of the industry to the region. The industry is aware of this problem and in recent years has moved to employ a part time professional to help with administrative duties for the industry. Further support may help to unite the industry more effectively.

The rock oyster, tiopara, ngakihi (*Saccostrea commercialis*)

Background

The rock oyster is a native species of oyster found around the north of the North Island. It grows up to 135 millimetres in shell length. This oyster has excellent eating and keeping qualities and was the basis of the first oyster farming industry in New Zealand until the arrival of the Pacific oyster in the 1960's. Few rock oysters, if any, are still farmed in this country.

The same species of oyster (*Saccostrea commercialis*) is still farmed quite extensively in parts of New South Wales where it is known as the Sydney rock oyster. This oyster is in short supply in Australia and attracts a price premium over Pacific oysters largely because of a strong traditional preference for their consumption.

Growing Biology

Wild rock oysters are found attached to rocks in the mid-littoral zone on sheltered to semi-exposed shorelines. They are tolerant to reduced salinities and raised water turbidity, but not to the same extent as Pacific oysters. Rock oysters can tolerate longer periods of aerial exposure and therefore can live on higher tidal heights than Pacific oysters.

Rack farming methods used for Pacific oysters are suitable for rock oysters in sheltered waters although the farming heights normally need to be adjusted to account for the differences between the two species.

The Study Area

Rock oysters are found throughout the study area on sheltered and semi-exposed shores, including some partly sheltered faces on rocky headlands on the exposed coast. These oysters have been cultivated in the Bay of Islands previously but all oyster farmers switched to the Pacific oyster more than 20 years ago because they were easier to farm.

Conclusions

The prospects for farming rock oysters in the Northland Region are poor because of the slow growth rates and the likely high costs of production compared to Pacific oysters which are currently farmed in the region.

Blue mussel, torewai (*Mytilus edulis*)

Background

The blue mussel is the most widely cultivated and eaten mussel in the world. It occurs naturally in New Zealand, but is less common in the north of the North Island. The blue mussel is generally considered to be inferior to our native green-lipped mussel and is not farmed purposely in New Zealand. However, it often occurs as a nuisance, fouling organism on mussel farms in parts of the Marlborough Sounds, where they are almost always sorted and dumped during harvesting.

Growing Biology

Blue mussels can grow quickly given good growing conditions. They appear to be able to tolerate a wide range in water quality, but they grow best in more sheltered waters with oceanic salinity and reasonable depth (up to 30 metres). Growth is also related to turbidity, water temperatures, and phytoplankton food supply. Like green-lipped mussels, the blue mussel is a particularly active filter feeding shellfish requiring water of a high public health quality.

The Study Area

Wild blue mussels are probably found in the study area in very small numbers, mainly on rocky outcrops on the open coast. Overseas, blue mussels are widely cultivated in suspended culture in a similar manner to our green-lipped mussel. Attempts to establish markets for these mussels have failed because the product is not recognised on the domestic market and exporters must compete with overseas growers that produce large volumes at low prices, without having the high transport costs faced by New Zealand farmers.

Conclusions

The current outlook for blue mussel farming in New Zealand is very poor.

Flat oyster, tiopara (*Ostrea chilensis*)

Background

The flat oyster is known by a variety of names including, the mud oyster, the dredge oyster, the Chilean oyster, the southern rock oyster and the Bluff oyster. The flat oyster is a native bivalve shellfish that grows up to 105 millimetres in shell length. Two commercial dredge fisheries for this oyster are based around oyster beds in Tasman Bay and in Foveaux Strait. Some farming trials of this species have begun in the Marlborough Sounds with promising results. This same species of oyster is also a native of Chile where it is harvested from the wild and farmed.

The flat oyster is a strongly flavoured premium-eating oyster. They are similar in appearance and taste to the European flat oyster (*Ostrea edulis*) that is widely cultivated in Europe and North America. Many of the European farms have been badly affected by a disease, *Bonamia*, which has also wiped out many of the oysters in Foveaux Strait. This disease has created new domestic and export market opportunities and inflated prices due to the shortage in supply. Wholesale prices in 2002 were reported as going as high as $13 a dozen for one period compared to less than $5 a dozen for premium Pacific oysters.

Growing Biology

The flat oyster is found in a variety of habitats from sheltered harbour shores out to open oceans down to a depth of over 500 metres including in Northland. For example, a small dense bed of these oysters is found near the entrance to the Whangaroa Harbour. These oysters can tolerate a wide variety of environmental conditions, including reduced salinities, relatively high turbidity, and a wide range of water temperatures (although they appear to prefer cooler growing waters). They are intolerant of being left out of water and are generally found subtidally or at the extreme low tidal level. A more detailed report outlining the issues associated with cultivating this species is available from NIWA if required.

In the South Island these oysters are being grown experimentally together with green-lipped mussels on long-lines and in suspended trays, or trays resting on the seafloor.

In Chile they are farmed in suspended culture after the oyster spat are settled on scallop shells which are then threaded onto ropes, which are later hung from buoys. Racks on the low shore and tile culture (oysters grown on ceramic tiles and pipes laid out on the seabed) methods that are used on the European flat oyster would also probably be suitable for the New Zealand flat oyster. Like other active filter feeding shellfish, dredge oysters require water of a high public health standard.

Spat supplies for this oyster are also difficult to obtain from both wild-caught spat and hatchery sources.

There have been some initial attempts at enhancing the flat oyster fisheries in Foveaux Strait and Nelson but the benefits of these attempts are unclear.

The Study Area

Small wild populations of these oysters have been found in a number of locations in Northland. From a biological perspective locations such as the Hokianga and Kaipara Harbours would probably be suitable for farming this oyster, however, areas suitable for suspended shellfish culture are limited within these harbours. Recently a consortium of oyster farmers and processors, which are mostly based in the Auckland Region, have undertaken some initial trials of farming these oysters in a number of locations, including the northern arm of the Kaipara Harbour. Early growth rates of these oysters were promising, but there were problems with high mortality in some locations, including the Kaipara Harbour. The examination of a large number of oysters from the Kaipara Harbour and other locations around the Auckland region failed to find any sign of the disease, *Bonamia* sp. that has caused extensive mortalities of oysters in the Bluff fishery and among oysters being experimentally cultured in the northern South Island. NIWA's Bream Bay Aquaculture Park facility has recently been involved in investigating the hatchery production of flat oyster spat from northern broodstock. Several large spawns have now been settled, however, there have been problems with getting good early growth following settlement.

Enhancement of wild populations of oysters would not appear to be an option given that there is no existing commercial fishery or substantial populations in the area.

Conclusions

The prospects for large scale farming of flat oysters in the Northland Region are unclear. Rapid growth rates seem to be possible, however, the cause of high mortalities and uncertainty about a reliable seed source need to be resolved before commercial farming could become established.

Scallop, tipai (*Pecten novaezealandiae*)

Background

The New Zealand scallop is a bivalve shellfish that is only found in this country. Scallops grow to 160 millimetres across their shells. They are found as free-living shellfish resting on soft sediments on the seafloor, usually in dense beds in many places around most of New Zealand. A number of other species of scallops are found around the world where they are subject to fishing, cultivation and enhancement programmes.

The New Zealand species produces high quality meat that has been successfully exported for many years as a product harvested from the wild. Existing commercial scallop fisheries are located in Nelson/Marlborough, Coromandel/Hauraki Gulf and areas of the east coast of Northland. Areas of the east coast of Northland from Mangawhai northwards have produced substantial amounts of scallops for commercial fishers in the past, but this fishery has been highly variable with relatively low catches since the 1980's when Northland catches exceeded 500 tonnes greenweight. Like scallop fisheries around the world, the availability of wild scallops is highly variable due to natural fluctuations in recruitment processes.

Scallops are regarded as being suitable candidates for aquaculture because of their high value and an unsatisfied global market. Scallops from this country sell well in existing markets for good prices. Increased returns could be achieved with improved marketing, packaging and presentation.

Attempts to farm scallops in New Zealand using suspended lantern culture techniques developed in Japan, have so far been largely unsuccessful until recently as major problems were encountered. The lantern nets holding the scallops became heavily fouled and the death of scallops in many areas was attributed to presence of viral disease. It was also found that the scallops required a considerable amount of handling, so much so, that the high labour costs would probably make such commercial aquaculture development unlikely. However, some recent research has shown that modified suspended lantern culture techniques can produce good growth and survival rates of scallops in suitable locations. Further work is probably required to develop these study results into a commercial scale operation.

Trials of seabed farming/ranching of scallops in the Marlborough Sounds have been delayed because of legal obstacles.

Attempts at raising scallop spat in hatcheries in New Zealand have so far proved largely unsuccessful. However, the techniques for gathering scallop spat from the wild are well known and have been used to greatly expand a very effective and highly profitable wild fishery enhancement programme in Tasman Bay. Over 400 million seed scallops are caught from the wild each year and re-seeded into the fishery, and into recreational fishing areas. Despite this success with scallop enhancement in the South Island, the success has not been replicated in scallop fisheries in areas of the North Island.

Growing Biology

Scallops are generally found on firm seabed in relatively shallow water (down to 40 metres depth) in open coastal situations and in large harbours. For example, most of the fisheries in New Zealand are found in large shallow embayments such as Tasman Bay, Mercury Bay and the Bay of Islands. Smaller populations are sometimes found in and around harbours. Scallops prefer low turbidity water with oceanic salinity, but can tolerate some reduction of these factors. Exposed and open coastal areas tend to provide less favourable habitat for scallop populations.

The Study Area

Wild population of scallops are found throughout the Northland Region, especially on the east coast from Mangawhai north to Spirits Bay. Within this area there are extensive areas of suitable seabed habitat for scallops, including around the areas of the existing populations. Potential habitats also exist on the west coast of Northland, however, these have not been explored in great detail for scallop populations. Recreational and commercial fishers intensively fish the populations on the eastern coast of Northland. Some initial scallop spat catching trials have been undertaken in various parts of Northland and caught commercially viable numbers of spat. Despite the positive results of the research it did not proceed to an enhancement programme.

Seabed ranching of scallops is unlikely to be impossible given New Zealand's legal arrangements for managing wild stocks of fish.

The farming of scallops using lantern nets is could be possible in sheltered areas of Northland. Areas in the Kaipara Harbour may be suitable, but higher current flows in tidal channels are likely to stress the scallops on the farm. Areas on the east coast such as Whangaruru Harbour could also be very suitable for scallop farming using these techniques. Locating suspended culture systems offshore in more exposed waters, such as associated with offshore mussel farming, is unlikely to be successful given that scallops are easily stressed by excessive water or swell movements.

Seabed enhancement of scallops is best done in water between 5 and 35 metres depth with a clean sandy seafloor with minimal predators, such as starfish, present. The handling culture of scallops is best done in clear coastal waters that are sheltered to semi-sheltered and are 8 to 20 metres deep.

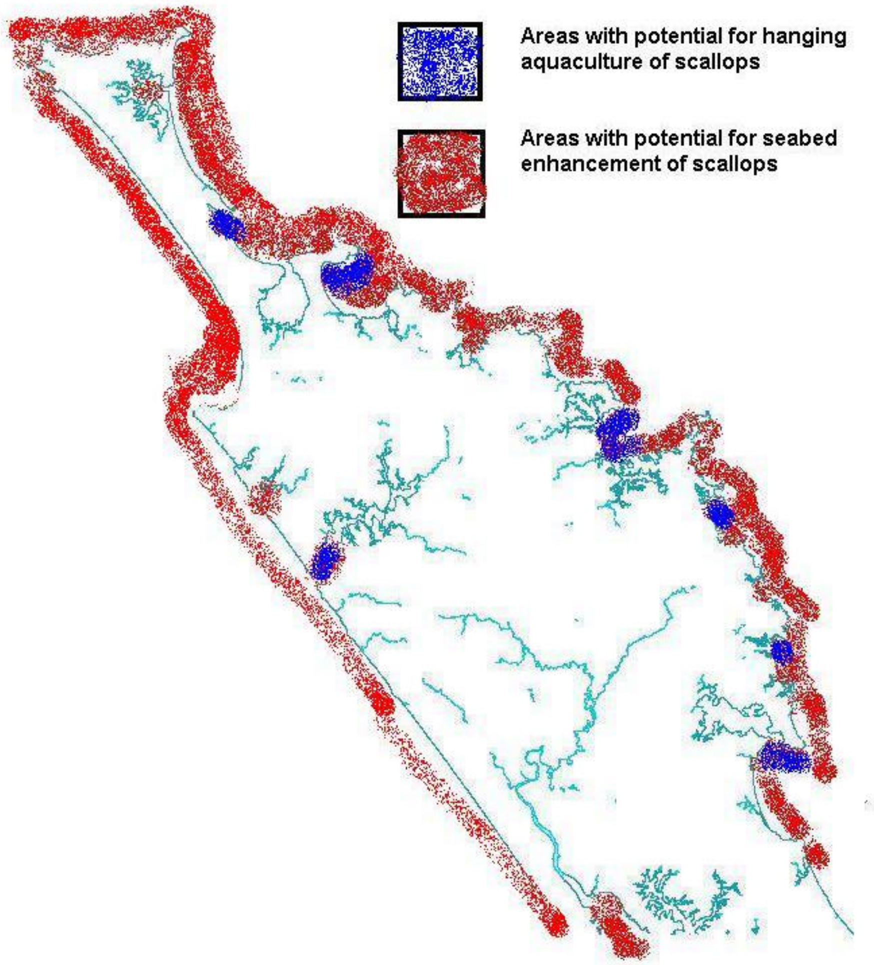

Figure 22: Map of Northland showing general areas with potential for hanging aquaculture and seabed enhancement of scallops.

Conclusions

Enhancement of wild scallop fisheries would appear to have some considerable potential for providing a valuable commercial fishery and/or an enhanced recreational fishery in many areas of Northland, especially in areas on the eastern seaboard. Some of the investigative groundwork for a successful enhancement programme has already been done, such as identifying a local seed catching areas. An enhanced recreational fishery for scallops could be included in an enhanced recreational fishing area, such as the Bay of Islands, which could have significant advantages in attracting visitors to the

Bay, with the economic benefits from their associated visitor spending. Licence or entry fees to recreationally fish in the area and/or contributions from local businesses could be used to fund the enhancement programme.

The prospects for commercially farming or ranching scallops in the study area using seabed farming methods are poor given the lack of legal mechanisms to establish private ownership of scallops resting on the seabed.

The prospects for farming scallops in hanging cultures are uncertain as further development work is required to refine the grow out technology for the New Zealand species.

Toheroa, tuatua and pipi or kokota (*Paphies ventricosa*, *P. subtriangulata*, *P. australis*)

Background

The toheroa, tuatua and kokota are three closely related native bivalve shellfish that live in soft sediments in shallow waters. All three of these shellfish are found commonly on coasts around New Zealand, often in very high abundances. For these reasons they have always been an important kaimoana for coastal Maori.

The toheroa is the largest of the three growing to a size of 140 millimetres in shell length. This shellfish prefers very exposed clean sandy beaches, and is found on many west coast beaches of the North Island. The tuatua grows to 90 millimetres in shell length and is found around most of New Zealand on exposed clean sandy beaches. Consequently the tuatua is found on most surf beaches around the North Island. The kokota (or "pipi" as it is often called) is found around most of New Zealand and grows to 85 millimetres in shell length. Kokota prefer the shelter of clean harbours and are found in most northern harbours.

Very little is known about the current levels of domestic fishing harvest of these shellfish, although it is thought to be quite substantial in some areas, especially in Northland where there is a substantial rural Maori population. Small quantities of kokota and tuatua are also harvested commercially from designated areas. In the

North Island there has been a ban on collecting toheroa for over a decade due to the small size of wild populations, however, illegal harvesting of toheroa is thought to be widespread. Toheroa populations have never recovered from intensive commercial fishing earlier this century and the reasons for this are not clear.

Currently there is no commercial farming of any of these shellfish, although Maori in some areas have been attempting to re-kindle traditional transplanting techniques to enhance existing beds, re-establish beds that have disappeared, and establish new beds of kokota.

All three types of shellfish have been raised successfully in hatcheries. Only the kokota is sufficiently easy to rear and settle in a hatchery for it to be done on a routine basis in large quantities. Such hatchery reared kokota spat could be used for seabed farming or enhancement. It is doubtful that farming these shellfish would be economic, especially when there are probably wild beds that could sustain greater fishing pressure.

Kokota and tuatua are currently sold on the domestic market and exported either, live, shucked and frozen, or as clam chowder preparations. Export markets include North American and Europe where they are sold as clams. Live clam exports can return reasonable prices, but airfreight costs are substantial because of their low value to weight. The supply chain for exports of these shellfish also involves so many agents that often the returns to the harvester and processor are minimal.

Growing Biology

As discussed earlier, the toheroa, tuatua and kokota, occupy quite different habitats on soft shores. Experimental transplants of these shellfish have shown that the toheroa and tuatua are not resilient to changes in their growing conditions, while the kokota is. The tuatua and toheroa prefer living in clean sediments, with oceanic salinities, lower turbidity, and rich phytoplankton supplies. They can be found from upper tide levels, but are generally found from the mid-tidal level out into the nearshore subtidal zone. Kokota can tolerate a variety of salinities, and higher turbidity than tuatua and toheroa. However, increased silt loadings tend to exclude kokota from many harbour areas. Kokota have been grown in experimental suspended culture and shown increased growth rates over animals found in the sediments in the wild. Similarly, in the centre of kokota populations the density of animals is so high it is thought to reduce overall growth rates in the population and sometimes distort shell shapes. Controlled thinning and relocation of juveniles could lead to greatly enhanced productivity from these populations. However, more would need to be done on specific populations to clarify these possibilities.

The Study Area

The tuatua, toheroa and kokota are found in the study area. Tuatua are found in extensive beds along much of the open coast beaches on both the east and exposed west coast of Northland. Toheroa are found in numerous beds scattered along west coast beaches, especially Ninety Mile Beach and beaches near Dargaville. Kokota are found in beds in the cleaner and deeper sediments toward the entrance of harbours and estuaries in the study area, such as the Whangarei, Houhora and Parengarenga Harbours. Many of these shellfish beds in Northland are of importance for recreational and traditional harvest, however, some could be of sufficient size to sustain some commercial harvest and bed manipulation. However, concerns about impacts on the recreational and customary fisheries would be substantial.

In terms of developing these shellfish resources, the existing beds of kokota could be enhanced or attempts could be made to establish new beds. Such development is unlikely to have any commercial benefits unless the intervention is minimal and the increase in productivity is very marked. The areas of suitable habitat available for such potential manipulations in the study area are extremely limited

Conclusions

The opportunities for developing the aquaculture or enhancement of toheroa, tuatua and kokota resources are probably very limited for the study area. It may be possible to develop methods to farm kokota in the Northland, but the returns from doing so are likely to small, given the relatively low value of this species in both domestic and export markets.

Littleneck clams, cockles, tuangi (*Chione* (*Austrovenus*) *stutchburyi*)

Background

The littleneck clam is a native bivalve shellfish found around New Zealand in tidal mud and sand flats. It grows up to 60 millimetres in diameter and it is commonly known as a "cockle" after it was incorrectly identified by European settlers. To Maori it is most frequently known as tuangi. The species is more closely related to the littleneck clams and is currently sold as the "New Zealand littleneck clam" in North American markets. The New Zealand species is difficult to raise in a shellfish hatchery, unlike some overseas species of clams. Ongrowing techniques are well developed for clams in countries such as the United States of America, France and Spain. A wild harvest of manipulated beds of littleneck clams is currently underway in Golden Bay and some mussel farmers have experimented with suspended culture. Currently the wild harvest of this species is cost effective, but aquaculture is likely to be economically marginal at best. There is a small domestic market for these clams, as well as export markets in Europe and North America. There is a considerable non-commercial harvest of littleneck clams, including in the study area.

Growing Biology

There has been surprisingly little research into the biology of littleneck clams in New Zealand. There is information on their breeding cycle, but relatively little is known about their growth rates. Surveys of harbour areas have often found very extensive beds of this species, usually living at the mid-tidal level in many harbours. They appear to be able to tolerate a wide range of environmental conditions, low salinities, high turbidity, exposure to air and pollutants etc. They are generally not found in areas with very muddy sediments suggesting they require quite firm substrate in which to live. The extensive populations are usually well structured with areas of high densities of large individuals lower on the shore and extensive areas of small individuals at lower densities. Research suggests that growth rates are greatly limited by the high natural densities of these shellfish in the wild, and therefore, artificial thinning greatly often increases growth rates in the remaining animals. The presence of large numbers of juveniles around the edges of populations also creates the opportunity for collection and re-seeding of areas. Such manipulations have been allowed for one farmer in Golden Bay following extensive and difficult pursuit of permission to do so. Studies on harvesting of wild populations suggest that littleneck clams are extremely resilient to harvest pressure and that many natural populations could be fished more intensively.

The Study Area

Littleneck clams are found in most of the harbour and estuary habitats in Northland. Many of these populations are important for recreational and customary fishing activity. An important commercial fishery for these clams takes place on Snake Bank at the entrance to the Whangarei Harbour. There may be some small-scale opportunities for manipulating wild populations, and perhaps some trials of rack and bag culture of cockles in Northland. As for other bivalves, such as kokota, the financial margins in farming these shellfish are likely to be small, so that any manipulations or structures would need to be kept to a minimum. In addition, concerns about protecting recreational and traditional food sources may create significant obstacles to proposing such developments.

Conclusions

Wild populations of littleneck clams in the study area may not yet be fully utilised making the pursuit of aquaculture, enhancement or manipulation of such beds unnecessary. There is likely to be strong regulatory, public and iwi resistance to allowing greater commercial access to beds of littleneck clams in Northland. Given this scenario it is would seem that the pursuit of aquaculture of this species should not be given priority in the Northland Region.

Mud snails, karahu (*Amphibola crenata*)

Background

The karahu is a native air-breathing snail found on high-tidal mud flats in the North and South Islands. It grows up to 30 millimetres in diameter. The karahu was a popular traditional food for Maori living around harbours. For some Maori the karahu remains important as kaimoana.

Growing Biology

The karahu lives on high-tidal mud flats often among fringing saltmarshes and mangroves. It feeds on mud by digesting the organic detritus and algae found on the surface of the mud. The habitat requirements of this snail are therefore quite specific, very sheltered, muddy, nutrient rich shores, with organic detritus. Unlike most marine molluscs these snails mate and lay eggs onto the mud in a gelatinous egg mass containing up to 10,000 eggs. These eggs develop into larvae that are released and are thought to settle in the vicinity. Such a straight forward breeding cycle would be amenable to the development of simple enhancement techniques.

The Study Area

Karahu are found in most estuarine and harbour areas of the Northland Region due to the presence of suitable habitat. These snails are harvested to a limited extent for domestic use, but not commercially. Elsewhere in the North Island there are reports of Maori marae fund raising efforts that involve the collecting and selling karahu at Polynesian markets in Auckland. The market potential of this species is likely to be very limited to some domestic niche markets. Few countries overseas have such shellfish, and where they do, they are likely to be of low value.

Conclusions

The karahu has very limited commercial potential. Enhancement techniques could be developed to improve wild populations, however, these animals are likely to be already very abundant in parts of the study area.

Horse mussel, taharoa or waharoa (*Atrina zelandica*)

Background

The horse mussel is a native bivalve found around most of New Zealand. It has a large wedge-shaped shell that grows up to 300 millimetres long. Horse mussels are found buried in soft sediments on the seafloor, often in quite dense beds around much of New Zealand to depths of 50 metres or more. A number of other species of horse mussels are found around the world where they are subject to fishing. Cultivation and enhancement programmes could be developed given that their spat are often caught alongside scallop spat in some northern areas.

Wild stocks of horse mussels in New Zealand are currently not harvested commercially in any quantity, although there is a small amount of non-commercial harvest. The domestic market potential is limited as it is not a recognised fish product. The Japanese consume the shell muscle (adductor muscle) of their native species and the local supply cannot meet demand. In other Asian countries the dried horse mussel is used in traditional medicines. The export potential for this mussel in Japan has been investigated. However, it was thought it would be to costly to harvest and process the product in order to fetch the premium Japanese prices.

Growing Biology

Very little is known about biology of the New Zealand species of horse mussel, although its growth rates are thought to be as fast as the Japanese species. Also the mortality of juvenile mussels is known to be high. As wild fisheries for this species are currently thought to be uneconomic, this would tend to suggest that any potential aquaculture or enhancement of horse mussels would also be uneconomic.

Studies in the Marlborough Sounds have found that the horse mussels provide an important habitat for other species of marine creatures including juvenile fish. Harvesting these mussels may therefore have far reaching ecological consequences.

The Study Area

Horse mussels are found in the study area growing subtidally in the soft sediments of the harbours and in offshore areas along much of the east coast of the Northland Region.

Conclusions

Commercial horse mussel aquaculture is unlikely to be viable given the current market situation.

Surf clams, kaikaikaroro, kuhakuha, pukauri (*Mactra* spp. & *Spisula* spp.)

Background

Surf clams are a grouping of generally large bivalve shellfish which live in seafloor sediments usually just offshore from coastal beaches down to depths of 20 metres. Some of these species can grow up to 110 millimetres in diameter. The New Zealand surf clams include several species of both *Mactra* and *Dosinia*, as well as *Spisula aequilateralis*, *Bassina yatei* and *Paphies donacina*. There are many large and extensive commercial surf clam fisheries around the world where these shellfish rate highly as seafood. In New Zealand there are some limited commercial fishing of surf clams. Aquaculture and/or enhancement of these species may be possible, however, very little is currently known about their breeding biology or hatchery production.

Growing Biology

Very little is known about the growing biology of this group of species. Scientists are currently conducting research into the biology of some of these species. Initial results indicate good early growth rates for some species.

The Study Area

Wild populations of surf clams have been reported from the Northland Region but the extent and location of these populations are unknown.

Conclusions

Aquaculture/enhancement development of these species in Northland is unlikely while there is a largely un-fished wild resource in New Zealand.

Pearl oysters (*Pinctada fucata* & *Pinctada maxima*)

Pearl oysters are tropical species not found in New Zealand that are used for producing artificial pearls for the jewellery industry. Methods of reliably producing round and half-round pearls, and mother of pearl shell have been developed with these species for many years.

Pearl oysters are unsuited to New Zealand conditions because they require very warm and clean water, with little fluctuation in temperature and salinity.

Harbour clams, purimu (*Venerupis largillierti*)

The harbour clam is a filter feeding bivalve shellfish that grows to 70 millimetres in diameter. They live in mud and sand in harbour and estuary channels around most of New Zealand. Therefore, they are probably found in the study area. The New Zealand harbour clam is very similar in appearance and probably in biology to the Japanese harbour clam, which is aquacultured extensively in parts of the world. Marine farming trials of the New Zealand species is currently proceeding in the Marlborough. There is a large wild resource, which is currently not exploited, and while this is so the aquaculture potential is limited. Investigations of this species in the Whangateau Harbour near Warkworth found they grew relatively quickly which would indicate they may have some potential for aquaculture in the future.

Geoducks, hohehohe (*Panopea zelandica* & *P. smithae*)

Geoducks are large bivalve shellfish, which are characterised by burying themselves deeply in the sediments and extending a large siphon to the surface of the sediments to feed. They are found in shallow water off sandy beaches around much of the country and grow to about 120 millimetres in shell length. The larger of the two New Zealand species, *P. zelandica* were up until recently harvested commercially by divers from around the north of the South Island in small quantities. Geoducks are highly prized in North American and Asian markets where they can fetch up to $20 each. Techniques for farming a closely related geoduck have been developed in the USA in recent years. The geoduck seed are hatchery raised and then out-planted low on the shore inside a buried ceramic pipe so that they are protected from crabs and can later be relocated for harvesting. However, very little is known about the biology, aquaculture or enhancement of the species in New Zealand. A consortium of aquaculture and fishing companies is currently investigating the feasibility of developing the New Zealand geoduck species for aquaculture. Results from the initial research suggests the New Zealand species is slow growing and may not be able to be cultured in high densities, indications that it may not be a suitable candidate for aquaculture.

Whelks, kawari (*Austrofusus glans*, *Cominella* spp.)

Whelks are predatory and scavenging sea snails living on the seafloor on most parts of the coast. A variety of whelk species are consumed in Asia and in parts of Europe. New Zealand has a variety of native whelk species, including the Cominellids. These species are ubiquitous throughout the country and a number of species inhabit the study area. Recently there has been some experimental fishing of these species in the north of the South Island. Many of the native whelk species produce egg masses which would be easy to collect and rear. This could make enhancement and aquaculture quite feasible. As a relatively low-priced product, the economics of farming these species would deserve closer scrutiny and farming techniques would firstly need to be established.

Octopus, wheke (*Octopus maorum*)

The coastal octopus, *Octopus maorum*, is found throughout Northland waters in shallow coastal areas often around reefs or harbour entrances. It grows to over a metre in armspan and is thought to live for only one year, breeding once and then dying. Octopus are a delicacy in some cultures and traditional were consumed by Maori in large quantities when available. There are strong markets for octopus meat in some countries, however, indications are that the prices are not sufficiently high to warrant aquaculture development in New Zealand. Higher prices per weight are obtained for baby octopus, small juvenile octopus, which are mainly produced by small farms in Asia, particularly China. Very little is known about the biology or aquaculture of New Zealand octopus, although it is known that they are relatively easy to hold in captivity and that the growth rates can be expected to be exceptional. Therefore, it is unlikely that octopus aquaculture has any potential for development at present. However, octopuses do fascinate the public and therefore an octopus farm would attract strong tourism interest.

Medicinal Uses of Shellfish

A variety of shellfish are used in traditional oriental medicines. They are usually dried and then ground to a powder, often including the shell. The powder is then prescribed as treatment for a variety of illness. A shortage of wild shellfish due to pollution and over-harvesting in parts of Asia has created a shortage of some materials. Some small quantities of product is already produced and exported to Asia from New Zealand, probably illegally. Greater work is required to identify the species of interest, their aquaculture and economic potential. At present this knowledge is difficult to access due to strong cultural identity and mystique associated with the use of these traditional Asian medicines.

There is also potential amongst many shellfish and other marine flora and fauna as sources of chemicals for western medicines. However, much of this potential remains unexplored. NIWA is currently conducting some research into trying to screen a variety of marine creatures to establish if they have any medicinal or nutriceutical (cosmetic) properties that would predispose them to developing commercial aquaculture production.

Valuable Shell Species

A variety of shellfish shells are in demand by shellfish collectors and jewellery makers overseas. They usually tend to be the more colourful or unusually shaped shells. Only premium quality shells can be marketed and the markets are relatively small.

The following species have ready markets overseas; *Poirieria zelandica*, *Muricopsis octogonus*, *M. espinosis mariae*, *Pterotyphis eos paupereques*, *P. eos eos*, *Pachymelon wilsonae*, *P. smithi*, *P. grahami*, *P. lutea*, *Alcithoe larochei*, *Iredalina mirabilis*, *Marginella larochei*, *Amalda mucronata*. Shells from some of these animals can fetch up to $1,000 each, although most are worth substantially less. The shells from other members of the Cypraeidae, Harpidae, Marginellidae, Muricidae, Pleurotomariidae, Strombidae, Volutidae, Bursidae, Haliotidae, Mitridae and Olividae are also popular amongst shell collectors. A number of these species are found in the study area although virtually nothing is known about them and their potential for aquaculture.

Some species, such as volutes and giant clams, are farmed overseas and the shells sold to collectors. No such culture is currently occurring in New Zealand, although it could be expected to develop with the increasing culture of native abalones (paua).

A variety of other shells are thought to be collected from the wild and sold commercially overseas, mostly illegally.

Seasponges

A wide range of New Zealand seasponges have been tested for the presence of bioactive compounds that have potential for medicinal applications. To date, one species of seasponge, *Lissodendoryx* sp. has yielded a chemical product that has shown great potential value for chemotherapy. This product looks set to proceed to clinical trials. Other chemicals from other species of New Zealand seasponges are also being investigated and a number of these are showing promise for producing useful chemical compounds. Should one of these species be proved useful through clinical trials it could be expected that they will meet with immediate and valuable market demand. At least two other species of seasponge that are found commonly on the east coast of the Northland Region are showing particular promise as a source of an anti-inflammatory drug and an anti-cancer drug. It is likely that if their medicinal use were approved, the Northland Region would be an obvious choice for early development of aquaculture techniques. In addition to their use for the extraction of medicinal chemicals, seasponges are also used for bathing and for artwork. A number of New Zealand sponges have the properties that would make them suitable for commercial bath sponges and methods for farming these species are being researched at present and are some way off commercialisation. Some of the native bath sponges that have proceeded to initial trials for farming have been sourced from Northland's waters. The initial results from the grow-out trials indicate that the growth rates of the bath sponges may be too slow to make their aquaculture commercially viable. NIWA has been conducting most of this seasponge research work as part of its aquaculture development programme.

Aquaculture Tourism

Aquaculture tourism is a growing phenomenon worldwide where visitors usually pay to be shown around an aquaculture facility and sample the produce. Important examples of this concept are the tours and restaurant associated with Malaysian prawn farm in Wairakei. To a much lesser extent an oyster farm in the Ohiwa Harbour operates a nearby fish and chip shop sited on the main road, which provides an important outlet and promotional opportunity for their oyster farming business. In Australia oyster farming areas have large take-away and restaurant outlets on main highways, emphasising the fresh nature of their produce on offer. For example, the "Big Oyster Restaurants" built in the shape of giant oysters are an important feature of northern New South Wales. Also, the oyster farming towns of Forster and Tuncurry on the New South Wales coast have an annual weekend oyster festival which attracts thousands of tourists from as far away as Sydney (more than two hours drive). The weekend features numerous events including oyster shucking, eating and sack lifting contests, as well as wine and oyster tastings and numerous other public events. A town like Pahia or Russell could promote and host such a festival, such as a wine and seafood themed festival that could become an annual focus for tourist visits. Farm tours associated with paua, seahorse, octopus or crayfish farming activities could also provide a valuable cash flow alternative to the seafood production from such a plant. A paua farm in Rotorua and in New Plymouth both operate visitor centres that provide an opportunity to promote and sell their pearl and meat products, especially among Asian visitors which frequently purchase expensive take home packs of paua product. The Pahia Aquarium, which is involved in culturing seahorses, is the only tourism aquaculture experience currently available in Northland as far as could be ascertained.

Fish outs also provide a potential tourism/aquaculture synergy and the possibilities for trout fish outs and enhanced recreational fishing areas have been discussed earlier.

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