Development of Innovation Capabilities in the New Zealand Seafood Industry Sector

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Abstract: Most seafood industries around the world are founded on wild capture fisheries which have been facing a static or declining resource base due to over exploitation. Achieving growth with this restraint is a challenge that seafood enterprises have struggled with globally for more than 20 years. Innovation efforts in this industry have focused on developing new sources of raw material, increasing financial returns through value-adding, increased efficiency of production and management integration. An early change in the management regime for wild fish stocks is identified as the key factor in encouraging innovation in the New Zealand seafood industry. The greater certainty in raw material supply provided by the management regime has enabled seafood enterprises to shift their attention from competing to secure sufficient raw material toward increasing their returns from the raw materials they know will be available to them. This paper examines the dynamics of innovation capability building and provides management directions for enhancing

innovation capability in this industry. Overall, it is hoped that this study may help to act as an exemplar for encouraging innovation in other national or regional seafood industries, and for other industries based on renewable natural resources.

Keywords: seafood; innovation; Quota Management System; innovation capability, New Zealand; aquaculture; biotechnology; national innovation system.

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1 Introduction

Historically the world's oceans were thought to be able to provide a limitless source of seafood [1]. However, production from global capture fisheries has remained more or less static at around 90 million tonnes since the late 1980's [2]. Capture fishing industries throughout the world have been undergoing dramatic structural changes over the past two decades as the harvest limits of many fisheries have been reached or exceeded. Further changes will occur as efforts are made globally to introduce more sustainable management regimes for wild fish stocks, including reducing fishing effort and the levels of government subsidies to fishing industries. The highly traditional nature of fishing activity in many countries has meant that these industries have often been slow to adjust to change and consequently this has caused significant social upheaval, especially among indigenous coastal people. Uncertainty of raw material supply, which is the core basis of sustenance of sea food industry sector, stimulates innovation drivers. A declining wild resource base combined with

increasing global demand for seafood products has created economic opportunities for innovators, thereby building an innovation culture. Since 1970 aquaculture has emerged as the fastest growing global protein producer with total annual production increasing more than 15 fold to well over 20 million tonnes [2]. However, throughout much of the world the economic benefits from the growth of aquaculture have not been driven by, or captured by, the existing wild capture industries [3].

The seafood industry in New Zealand provides a unique example where innovation has helped to transform the industry and people over the past 20 years from a traditional wild capture industry with limited growth prospects, to a future focussed industry with strong growth [4]. Furthermore, indigenous Maori have become major stakeholders and beneficiaries of economic growth during the transformation of this industry [5,6] and bringing a greater stability to social fabrics.

The aim of this paper is to present our fundamental hypothesis that innovation will greatly increase in seafood enterprises once they are provided with greater certainty in their supply of raw material. We provide evidence in support of this hypothesis by describing the recent transformation and increase of innovation activity in the New Zealand seafood industry following the introduction of a unique management regime for wild fish stocks.

2 Research Methods and Definitions

There has been relatively little research on innovation in seafood industries anywhere in the world, including New Zealand [7]. Therefore, data for this research was drawn from archival sources, interviews and case studies of selected fishery and aquaculture projects. Of particular importance as source material were the results of a number of seafood industry and government initiated studies of research, development and innovation activity in sectors of the New Zealand economy [8,9,10,11,12]. Initial results from in-depth innovation studies currently underway within the New Zealand seafood industry were also kindly provided through discussions with lead researchers identified in our acknowledgements [13,14]. The data from these disparate sources were collated, aligned and interpreted in order to formulate a coherent hypothesis around the reported transformation of the New Zealand seafood industry.

For the purposes of this paper "innovation" conforms to a broad definition that has evolved from Schumpeter's [15] early definition and that is commonly used by researchers, "Innovation concerns the search for and the discovery experimentation, development, imitation and adoption of new products, new processes and new organisational set ups" [16]. From this definition, "innovation activity" and "innovation behaviour" can be defined as activities and behaviours generated by individuals or enterprises that are innovative in nature. A "national innovation framework, or system" refers to the economic and social system within a nation, society, or sector which facilitates innovation activity within it [17,18].

3 Current status of the New Zealand Seafood Industry

Although New Zealand is a chain of relatively small islands it has the world's fourth largest fishing zone which covers 2.2 million km^2 [19]. However, from this zone New Zealand produces less than 1% (around 750,000 tonnes) of the world's commercial seafood catch and around 90% of all seafood landed in New Zealand is exported [19]. Seafood exports are of key importance to the New Zealand economy as the fourth largest export earner with an estimated value of NZ$4.5B in total economic outputs [4]. Since 1975 annual seafood exports have grown from around NZ$25M to $1.2B in 2004 and the industry is aiming to achieve NZ$2B of export earnings by 2010 [20]. The New Zealand seafood industry is among the most internationally trade dependent in the world, with only Iceland placing a greater reliance on international trade for its seafood [6].

The New Zealand seafood industry is made up of over 2000 seafood enterprises which employ over 26,000 people in total [4]. The industry is one of the least subsidised seafood industries in the world, paying for all commercial fisheries management, compliance measures, enforcement and operational research, which in total amounts to 6.0% of the greenweight value of the entire landed catch.

The most important species by export value for the fishing year ending September 2004 were hoki (NZ$189m), squid (NZ$171m) Greenshell™ mussels (NZ$136m), rock lobster (NZ$100m), orange roughy (NZ$81m) and abalone (NZ$51m). During this same period New Zealand seafood products were exported to more than 100

countries, but the largest buyers were United States of America (NZ$203m), Australia (NZ$196m), Japan (NZ$174m), Hong Kong (NZ$134m), and China (NZ$107m) [20]. The relevance of sea food sector is two fold: it is a source of national icon with rich biodiversity and a knowledge system that is embedded in the traditional cultures.

4 Quota Management System

New Zealand introduced a property-rights management system (Quota Management System or QMS) for fish stocks for most major commercial fisheries from 1986 in an attempt to better manage fish stocks [21]. By 2004 there were more than 50 seafood species or species groups managed under the QMS and further species are being introduced into the QMS because of its success. New Zealand was one of the first countries in the world to introduce the QMS and remains one of the only places using the system [22,23]. The management system operates by fisheries scientists, working with government and industry to assess the population size of fish stocks in each of the major fishing grounds. These areas are called Quota Management Areas (QMA). From this information the Minister of Fisheries each year sets a Total Allowable Catch limit for each QMA that will ensure that the fish populations will produce the maximum sustainable annual harvest, which is a requirement under the United Nations Convention on the Law of the Sea. In fisheries where non-commercial fishers are active, a quantity of stock is set aside for them before the Total Allowable Commercial Catch (TACC) limit is set [4]. The TACC is reassessed and reset each year to accommodate natural fluctuations in wild fish populations. The TACC is divided into Individual Transferable Quotas (ITQ) which are rights to fish a defined share of the TACC. For example, ownership of 10% of the quota for a particular fish species in a QMA provides the right to harvest a 10% share of the TACC for the QMA each year in perpetuity. The ITQ itself, and the right to catch the associated share of a TACC for a year can be transferred to another person or company through sale or gift. ITQ is therefore a tradable asset in perpetuity and its value is a reflection of the market value of the species concerned, the TACC and market demand for access to the particular fishery. Consequently there is a financial incentive for ITQ holders to safeguard their investment by ensuring the fish stocks they represent are sustained and productivity is improved. A compliance system is also in place to

ensure that landed catches are always matched against annual catch entitlements awarded to ITQ holders and substantial penalties, including forfeiture of ITQ, are in place for offenders. The QMS have enabled a number of depleted inshore fisheries in New Zealand to be rebuilt with the aim of improving overall productivity and therefore returns to ITQ holders both directly from increased catches, and through the increased market value of the ITQ.

5 Indigenous Maori involvement in the New Zealand Seafood Industry

Prior to the arrival of Europeans in New Zealand in the eighteenth century, indigenous Maori were active fishers and traders of seafood among tribal and regional groups [24]. Consequently, Maori were quick to join early European sealers and whalers operating in New Zealand waters in the late 1700's and later Maori became commercial seafood suppliers in many parts of the country, while also undertaking domestic fishing activity [25]. Much of this indigenous Maori commercial fishing activity continued up until the mid 1980's at which time many coastal Maori were excluded from commercial fishing with the introduction of the QMS. The loss of indigenous commercial fishing rights through this process was challenged and subsequently the New Zealand government agreed to settle the dispute with Maori through the allocation of over NZ$200M worth of seafood industry assets and fishing rights to Maori. These resources were retained in Maori ownership and subsequently have been grown through prudent management (more than tripled in value to over NZ$800M), and a large portion of these assets are currently being devolved to Maori tribal groups [4,5]. Maori interests currently own half of the largest seafood company in New Zealand, as well as significant holdings in the largest oyster aquaculture company and one of the largest coastal fishing companies. It is estimated that Maori now own over a third of the entire New Zealand seafood industry and make up around a third of the total industry workforce in a nation where they represent less than 15% of the population [6].

6 The Drivers of Innovation

There is now strong evidence that innovation is a principal driver of economic growth in the New Zealand economy and it also appears to be a key driving force for the strong growth seen in the country's seafood sector over the last 30 years [26].

[Insert Figure 1]

The start of this increase in innovation activity in the seafood industry coincided with the introduction of clear limits on the commercial harvesting of major wild fish stocks and the allocation of property rights for commercially harvesting fish stocks through the QMS. The subsequent growth of the industry came from a range of innovative measures, including; implementing capital and labour saving practices and technologies, developing new value-added products and processes, as well as the development and rapid expansion of new aquaculture activities [27]. For example, technical innovation in deep sea fishing and aquaculture enabled the industry to build new raw material capacity by exploiting deep water fisheries, as well as rapidly increasing the production of new aquaculture species [4, figure 1]. In more recent years there has been a stronger focus on innovation in value-adding, storage and shipping, as well as the marketing of seafood products. Organisational innovation has also resulted in the emergence of highly vertically integrated and diversified seafood enterprises that are utilising a variety of raw materials and supplying a wide range of markets. The increased vertical integration is enabling these enterprises to exert greater control over production and capture more value from throughout the value chain, rather than from one part alone, such as capture, culture, processing, or wholesaling. For example, increased market value through controlling the value chain has come from the establishment of the first certified organic mussel farms in the world in 2004 [28], and in 2001 sustainability certification by the Marine Stewardship Council of the first large whitefish, New Zealand hoki.

This rapid increase in innovative activity following the introduction of harvest limits is in contrast to seafood industries in many other parts of the world, that are often characterised by more traditional and conservative management, rather than the application of innovative approaches to increasing value and efficiency during periods of reduction and uncertainty in the availability of raw materials [29,30,31,32].

Unfortunately, there is relatively little research that investigates these drivers of innovation, and innovation capability at a sector level, especially in well-established sectors of economies, such as the seafood sector [33,34,35].

[Insert Figure 2]

Several studies, mostly from Europe, suggest that seafood industries are struggling with diminishing access to wild resources, dramatic structural changes in at sea operations and supply chains, as well as increased competition with aquaculture development. Overall, these traditional seafood industries have tended to display a lack of innovative approaches to dealing with these changes and uncertainty, and have generally adopted low risk and short-term business strategies. Greater uncertainty due to changing circumstances and the availability of raw material has been identified as a major disincentive for seafood enterprises to engage in innovation. By contrast there is greater certainty in the supply of raw product for seafood enterprises in New Zealand that is provided through holding a property right that guarantees access to a fish stock, and some assurance that the right can be fully exercised because of sustainable management of fish stocks. Therefore, the certainty provided by the introduction and effective operation of the QMS in New Zealand appears to have been a key factor in promoting innovative behaviour at the enterprise level for the seafood industry for the past 20 years [10,36].

[Insert Figure 3]

There are good gross indicators of the recent innovation success in the New Zealand seafood industry. For example, methods for farming, processing and marketing the endemic New Zealand green-lipped mussel, *Perna canaliculus*, have spawned a new aquaculture industry worth close to NZ$300M p.a. in the last 20 years [37,38,39, figure 1]. There are also a number of specific indicators of innovation success. Econometric analyses of firm-level data shows that some firms in the seafood sector are achieving very high levels of relative economic efficiency, particularly through effective use of capital and labour saving technological change, i.e., high levels of innovation]. There is also good industry-wide performance data that clearly show increased efficiency and productivity through the application of innovation [figures 2

and 3]. In addition, broad surveys of New Zealand enterprises have reported levels of innovation in the seafood sector which are higher than many other sectors in the economy [figure 4]. For example, only 14% of seafood firms were found to have no innovation spending, compared to 26% across all economic sectors surveyed. Levels of value-adding for export products is also significantly higher for seafood products (72%), compared to other important primary producers in the New Zealand economy, e.g. meat (51%), dairy (35%), fruit and vegetables (35%) [11]. These indicators suggest that the sea food sector is continuously undergoing changes for increase efficiency and effectiveness.

[Insert Figure 4]

7 Certainty in Raw Material Supply Promotes Innovation

7.1 Positive Impacts on Innovation from QMS

Recent econometric analyses on the fishing industry in New Zealand provides strong evidence of marked increases in efficiency from rapid technological change particularly from labour and capital saving measures. For example, the national rock lobster fishing fleet has continued to gradually reduce due to consolidation and aggregation of capture resources as part of the improvement in catching efficiency [figures 2 and 3]. Catch effort has also moved seasonally to take advantage of better seasonal global market prices and is an excellent example of effective organisational innovation. There is clear evidence in this fishery that the average efficiency of firms has improved markedly since the QMS was introduced [figures 2 and 3]. This internalised structural change and drive for improved performance in this fishery appears to be a typical feature of changes in the New Zealand seafood industry associated with the QMS where firms are more motivated by recovering maximum returns from their catch allocation, rather than increasing their returns by maximising their catch. The drive for enterprise efficiencies appears to have extended to increased integration of seafood supply chains to make better use of processing, logistics and market connectivity through the increased aggregation of single species, and increased diversity of species encompassed. Consequently, larger seafood firms appear to be able to take greater advantage of these scale and diversity efficiencies and they are taking a more dominant role in the New Zealand industry. They have

also achieved sufficient global capacity and connectedness to begin to integrate offshore seafood investments such as processing plants, fleets, and aquaculture sources into their supply chains hence making them well advanced in terms of globalisation.

The incentive for New Zealand seafood enterprises to achieve efficiencies by integrating a wider range of species and expand raw material supply options has included the rapid development of aquaculture supplies in New Zealand [42]. As a result, compared with other countries the New Zealand aquaculture industry has a very high level of ownership and involvement from seafood enterprises previously principally involved in wild capture fisheries [43]. The integration between the two has undoubtedly assisted with the rapid growth of aquaculture in New Zealand through assisting in production, processing and market innovations build on the knowledge and experience from taking wild capture product to market.

7.2 Possible Negative Impacts on Innovation from QMS

Although the introduction of a rights-based management system for New Zealand fisheries appears to have encouraged innovation and growth in the seafood industry there appears to be some negative aspects to this policy framework for innovation. The economic prudence of sequestering significant amounts of capital in quota ownership, thereby making it unavailable for innovation and direct wealth generating activities, is under scrutiny [23]. Moreover, the effectiveness of the QMS in optimising sustainable yields for the fishing industry relies heavily on a continuous supply of high quality scientific information on fisheries resources. Such information is increasingly difficult to maintain due to heavy focus on applied research agenda where research is funded for commercially driven objectives.

The QMS system is also saddled with the bureaucratic management processes applicable to the seafood enterprises [44,45]. Overwhelmingly government regulations and policies were significant barriers to innovation, more so than for any other sector of the economy. Outdated local aquaculture policies and regulatory

frameworks were also cited as requiring major reforms to bolster innovation [42]. In particular, the aquaculture firms have argued that greater certainty of property rights for marine farm space would enhance their opportunities for longer term investment and growth as it has for the wild fishery sector.

Most of the research expenditure and intellectual capacity in New Zealand dealing with seafood resources has been focussed on understanding and managing the marine environment, rather than specifically increasing the opportunities for deriving increased wealth from marine resources. Likewise, the requirement for the fishing industry to fund external research providers for fish stock assessments appears to have restricted their interaction with research providers as an effective source of expertise for other innovation needs.

Interviews with research and development managers in the seafood industry found that they commonly criticised the perceived inability of science providers to respond effectively to industry needs or what were seen as "commercial realities," yet it is well known that a thorough understanding of the strategic needs of a science purchasing sector is essential if science providers are to adequately deliver effective scientific innovation services. These poor linkage between the two groups is probably the main cause for New Zealand seafood enterprises having a very high reliance on in-house research and development expertise and activity which accounts for over 40% of industry R & D expenditure.

The requirement for a high level of contribution to funding research for resource information to run the QMS also appears to have dampened enthusiasm for private industry investment in research and development expenditure with external research providers for undertaking research work other than for resource management [46]. For example, research on marine bioactives, biotechnology and aquaculture has received only a small portion (3%) of the total private sector research funding despite these two areas having significant commercial growth potential [48].

8 Changes in Enterprise Innovation Behaviours

The ability to develop innovation capacity is partly an acquisition of innovation mindset. There is a widely held view that innovative behaviour is part of the innate psyche of New Zealanders that arose from pioneering settlers, mostly from Europe, who transformed "wilderness into gardens" [49]. Indeed an endemic expression, "number 8 wire," that is used widely to refer to local innovations is based on the use of a type of flexible fencing wire by farmers to make innovative repairs and gadgets. Indigenous Maori also demonstrate high levels of innovative and entrepreneurial behaviour [50]. It is not clear why this is, but one of the important conditions for developing and sustaining innovative capacity is the ability to leverage prior knowledge and absorb new knowledge. Knowledge related issues are also fundamental for Maori culture where learning and sharing of knowledge is deeply rooted in cultural values. Sharing food for example, is an important cultural ritual for Maori.

Individual innovative behaviour also expresses itself through the development of innovative enterprises and this appears to have been the case in the New Zealand seafood industry. Some of the key characteristics that have helped to build innovative capacity in this industry have been identified and include [51];

- A vibrant and entrepreneurial culture.
- Very good market feedback and connectivity.
- Strong communication and networking between key participants.
- Co-operation and knowledge sharing in early development.
- Effective industry co-ordination, leadership and representation.
- An enhanced ability to absorb knowledge.
- Rapid identifiers and adopters of new technology.
- Sufficient resources to support the effort involved.
- Close involvement of specialist suppliers to the industry.
- Strong capabilities and commitment in the industry for research and development.

The management and sharing of knowledge within the industry appears to be changing alongside structural changes in the industry. For example, open sharing of knowledge and innovation has played a key role in rapid innovative development of oyster and mussel aquaculture industries in New Zealand over the last 30 years [38]. A survey of the seafood industry in the 1990s found that half of the industry took no action to protect their knowledge related assets, and less than a third were aware of the risks of not doing so [51]. However, the aggregation and corresponding increased level of corporate ownership in this industry has led to much less open sharing of information and signs of active intellectual property management (e.g. increased number of patents etc) in an attempt to secure competitive advantage from innovation for the individual enterprise.

On one hand there is a need to base the effective resource management of the industry on good scientific principles and on the other the industry growth is increasingly reliant on securing competitive advantage from the application of science and technology. The science providers are also increasingly reliant on commercial scientific investment, but are also being actively encouraged by the government to capture and commercialise the results of all their research. These conflicts of interests are not by any means conducive to the systematic build up and effective use of knowledge for the marine environment for which the knowledge-base is known to be sorely lacking. For example, the rapid development of the Greenshell™ mussel industry during the 1980's relied on the open sharing of results of research and development on farming methods among entrepreneurial pioneers [38]. However, in recent years technology for Greenshell™ mussel hatchery culture has been developed in parallel by separate seafood enterprises working with different research providers with little or no sharing of information [52,53]. The development of these restrictions on exchanges of scientific knowledge and increasing inflexibility of boundary-spanning social networks may be counterproductive to the development of the industry. Furthermore, the emergence of a desire to create competitive advantage through the accumulation and application of proprietary knowledge may also reflect a failure by enterprises to recognise the true benefits of collaboration and knowledge sharing [54,55]. Collaboration can enable the pooling of risk, reduction of innovation

investment, and increase the critical mass necessary to obtain an adequate return on investment before competitors gain access to the same knowledge [55].

9 Encouraging Further Innovation Activity

The introduction of the QMS has helped to encouraged strong innovation activity within the New Zealand seafood industry which has in turn resulted in economic growth for the sector. However, our research suggests other further adjustments are needed in the national innovation framework to foster further ongoing innovation in the sector. For example, there are strong indications that the introduction of tradeable in-perpetuity property rights for marine aquaculture space in New Zealand would continue to generate economic benefits through similar mechanisms attributed to the QMS for wild stocks [8]. Aquaculture enterprises have had difficulty raising capital and undertaking innovation activities under the outdated marine farming laws [3,8,42]. The New Zealand government is currently reviewing aquaculture legislation and has indicated an unwillingness to formalise tradeable in-perpetuity property rights for marine aquaculture space despite the substantial potential economic benefits.

Nationally, the human skills capacity and research spending on seafood innovation is focussed heavily on resource understanding and management and not on wealth creation [45,46]. Economically important emerging areas such as marine biotechnology and aquaculture do not feature highly in anticipated skills needs or in overall levels of research expenditure [3,45]. For example, there are no tertiary institutions in New Zealand offering training in marine biotechnology while at least five different universities offer degrees in marine science. A tertiary degree in aquaculture science will be offered for the first time in New Zealand in 2005 [56]. Greater emphasis on public research funding needs to be placed on developing capacity for wealth creation.

The QMS while apparently encouraging industry innovation, also places considerable financial and bureaucratic burdens on industry to underpin effective stock management. This tends to distort relationships with external research providers and

reduces the level of industry investment in direct wealth creating research and development. To reduce this burden it will important to encourage a more co-operative approach to managing fish stocks and introduce a greater amount of innovation to the methods for determining fish stock levels. The New Zealand Seafood Industry Council is now promoting an Industry Development Framework aimed at achieving these goals [27], and there are now excellent examples of innovative fish stock models being used to reduce costs associated with fish stock assessments [57].

There has been a very heavy reliance by the New Zealand seafood industry on in-house innovation activity, when stronger innovation performance could be achieved through building strong networks and linkages with science providers, tertiary institutions, and other enterprises in the sector. Some new models for fostering stronger external innovation linkages have been attempted recently and appear to be proving to be successful. For example, the Bream Bay Aquaculture Park was established by the largest state-owned research provider, the National Institute of Water and Atmospheric Research [52]. The site has attracted the collaborative engagement of private industry partners on a number of commercial development projects including large scale farming of abalone, kingfish, groper and hatchery rearing of mussels and oysters. Likewise, a cluster of seafood enterprises, industry peak bodies, research providers and training centres have spawned a research and development consortium with a collaborative development agenda [59].

Cluster models may also be a useful tool for helping to encourage seafood enterprises in New Zealand to increase their level of innovation spending which is currently relatively low by world standards [18,58]. In New Zealand the overall private sector research and development expenditure in relation to GDP is amongst the lowest in the OECD, while the government sector spending is above the OECD average [26,58]. The reasons for the low investment by the private sector are not clear, but may be linked to the large number of small firms in the New Zealand economy which overall may tend to invest less in innovation activities. This has been found to be the case in the seafood sector where smaller companies were found to spend considerably little of their turnover on research and development activities compared to larger enterprises. Cluster or network schemes may therefore be helpful in bringing groups of smaller

enterprises together to share knowledge and resources. A cluster approach has been found to be very successful in similar circumstances among small marine services industries in New Zealand [60].

There has been a tendency for the seafood industry to focus more on production and process innovation versus market and product innovations that are targeted further down the value chain [7]. These later value innovations tend to provide higher value returns. The reasons for this pattern are unclear, but may relate to the depth of global market knowledge required to be truly effective in this area of innovation for global seafood products. This is supported by the observation that the large seafood companies such as Sealord Ltd, which maintain offshore marketing offices tend to be more actively engaged in these types of innovation. For example, Sealord's vacuum packed Greenshell™ mussels in white wine and garlic sauce won the best single new product in the world award at the Salon International de L'Alimentation International Food Exhibition in Paris in 2004 and is now selling well in international markets [61].

10 Conclusions

The New Zealand seafood industry has performed well compared to many seafood industries based on wild capture fisheries in other parts of the world during the same period. The evidence strongly suggests that the growth in this industry has been due in a large part to the introduction of an effective rights-based wild fish stock management system which has provided more operating certainty for seafood enterprises. This has encouraged strong and ongoing innovation activity within the industry which has in turn resulted in good economic growth for the sector. While the introduction of an alternative fisheries management regime in New Zealand has provided a strong foundation for encouraging innovation, this study has identified a number of other areas where the national innovation framework could be improved. Investing in implementing such improvements in the seafood sector is likely to provide excellent returns to the New Zealand economy because of the sector's high performance with innovation to date. Furthermore, the industry is experienced and well positioned in the global marketplace to take advantage of increasing demand for seafood products. The high level of indigenous Maori involvement in the New

Zealand seafood industry can also be expected to have considerable benefits because as a people they have been economically disadvantaged in other areas of the economy.

The new economic growth theories now incorporate technological change as endogenous to the growth process [62] and economic studies have demonstrated the important role played by science and technology related inputs [63]. However, our study suggests that an underlying resource management framework that ensures sustainability and greater certainty in the raw material supply is fundamental for inducing innovative business behaviour at the enterprise level. Innovation framework based on a sustainable raw material provision has created a robust innovative culture that has potential for further growth in this sector.

The innovation framework based on supply of raw material in the New Zealand seafood industry may well be applicable to nation's engaged in traditional industry sectors such as seafood and forestry. In particular the ability of the QMS to establish a foundation which provides greater certainty to seafood enterprises around the availability and access to raw materials (i.e., fish stocks) appears to enable the enterprises to focus more attention on more economically beneficial and socially justified innovation activities. The provision of raw material to be taken here from a system's perspective rather than simply augmenting the raw material exchange or supply. Similar benefits may also exist for the development of other extractive industries based on renewable resources, such as forestry, fresh water and land development.

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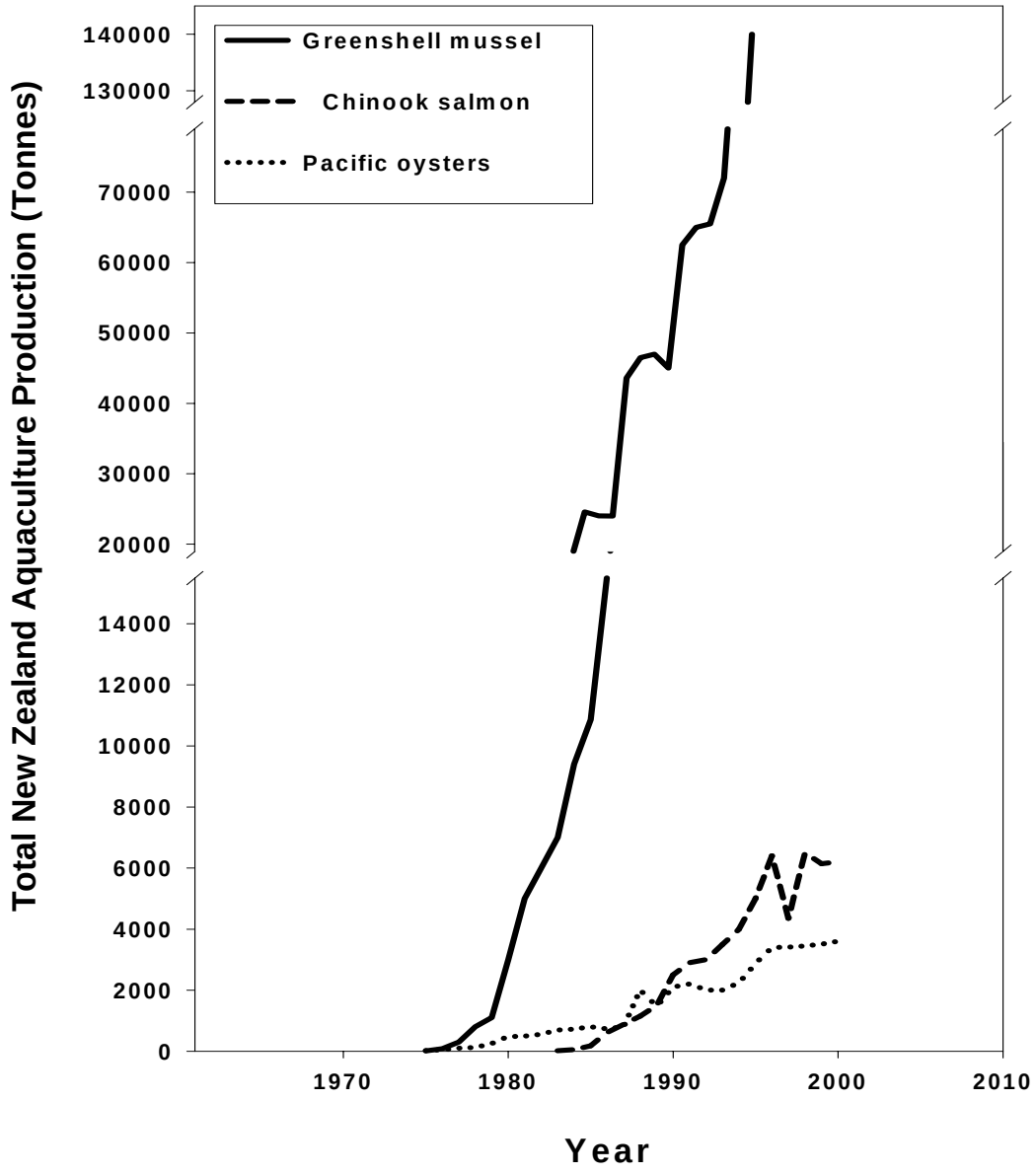
Figure 1 Rapid start up and increase in aquaculture production in New Zealand



Source: Jeffs [22]

Figure 2 Reduction in national fleet of commercial rock lobster fishing vessels due to capital saving innovation following the introduction of the QMS

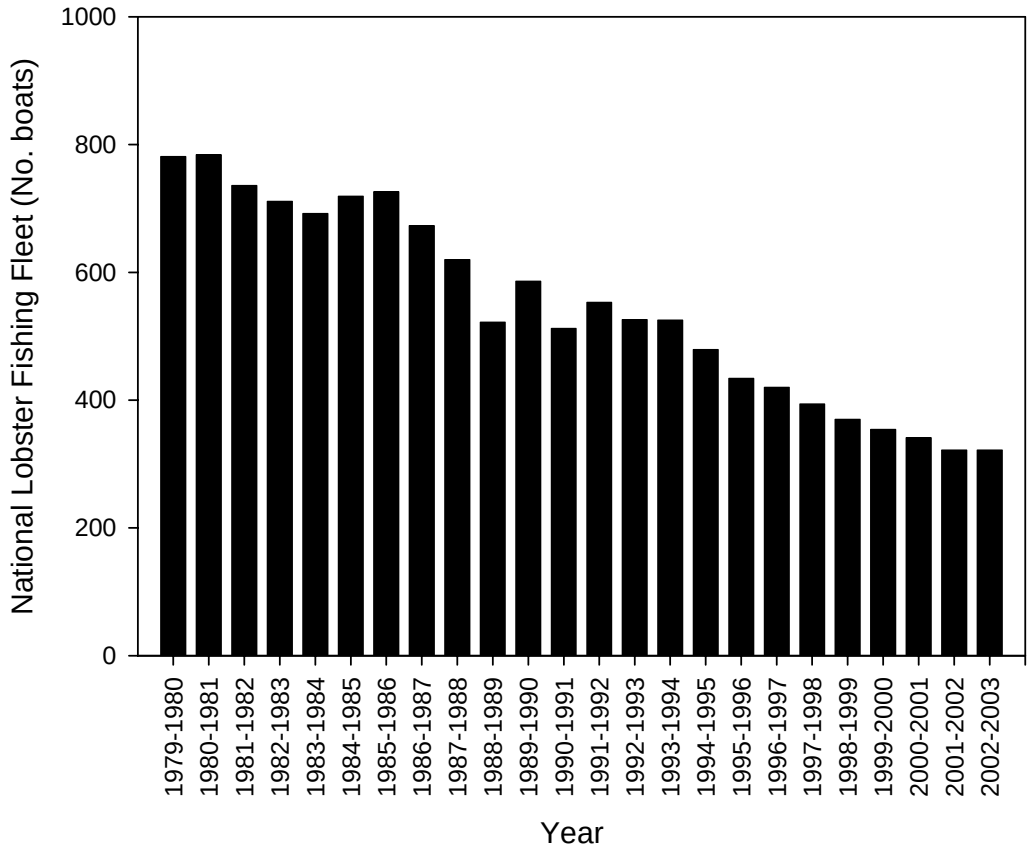
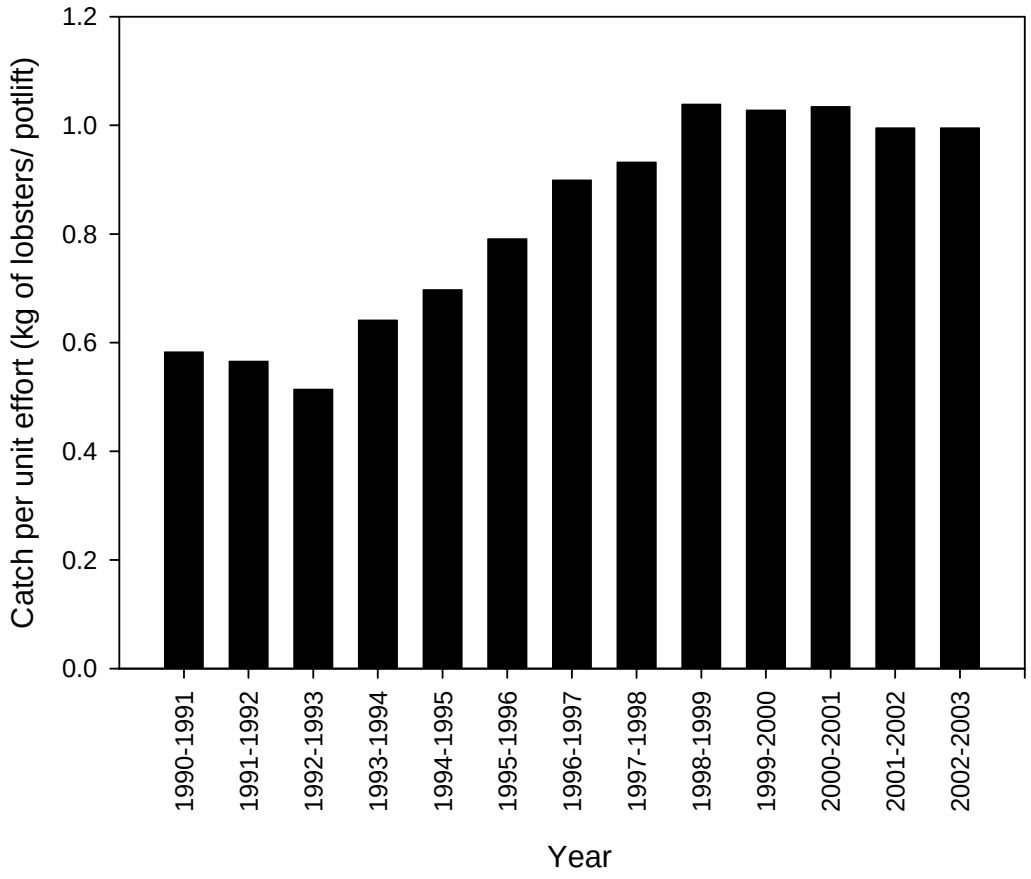
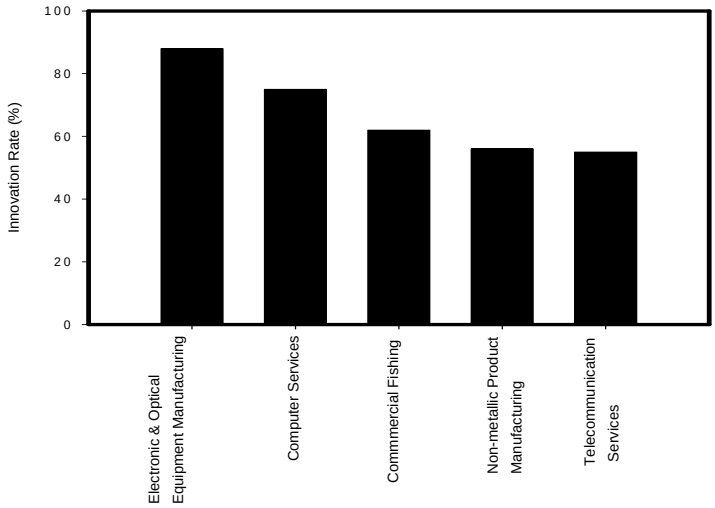


Figure 3 Increase in catch per unit effort in New Zealand's commercial rock lobster fishing industry due to innovation in catching following the introduction of the QMS



Source: Sharp & Jeffs [10]

Figure 4 Comparison of the top five levels of innovation from a survey of sectors of the New Zealand economy



Source: New Zealand Statistics [33,34]