
**Assessment of future expansion of
Pacific oyster (*Crassostrea gigas*)
farming in Northland**

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Assessment of future expansion of Pacific oyster (*Crassostrea gigas*) farming in Northland

Sean Handley
Andrew Jeffs

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National Institute of Water & Atmospheric Research Ltd
269 Khyber Pass Road, Newmarket, Auckland.
P O Box 109-695, Auckland, New Zealand
Phone +64-9-375-2050, Fax +64-9-375-2051
www.niwa.co.nz

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Executive Summary

Pacific oyster culture is a significant contributor to the Northland economy, with estimated production figures exceeding \$20M in revenue. With around a 1:1 regional flow on effect of the value of the oyster industry to Northland is more than double. Oyster farmers and processors currently employ about 400 people and support a further 140 indirect jobs. Northland is the best region in New Zealand to grow Pacific oysters due to the biology of the species and the region's large capacity of shallow intertidal harbours suitable for optimal intertidal culture systems.

Immediate expansion of Pacific oyster farming is at present restricted by the nationwide moratorium on marine farm developments. In the short term this offers opportunities to increase efficiencies within the industry, with revenue predicted to exceed \$41M. This will require surveys to highlight areas of overstocking, parasites and pests, and followed up by farm advice and information in areas where problems exist. This, and research to develop methods for controlling the density of oysters on sticks, could potentially double the economic returns from Northland oyster farms.

Maori currently own about 60% of oyster leases in Northland, with around 85% of the employees on these farms of Maori descent. They are also among leaders in the industry by forging and supplying new high value markets overseas and working to unite suppliers to provide the volumes needed to supply key export markets. With the impending allocation of \$111.5M in fisheries assets and earnings from the Treaty of Waitangi Fisheries Commission, iwi in Northland will be looking to invest in established growth sectors such as Pacific oyster farming, especially in areas of the far North.

The future expansion of the industry is heavily reliant on more farm space being made available in the processing of establishing new Aquaculture Management Areas (AMAs). Analysis of the constraint maps produced and publicly distributed by the Northland Regional Council and entitled "AMAs: Where should they NOT go?" shows that most existing intertidal oyster farms overlap or conflict with conservation and amenity buffer zones and sources of pollution. However, the basis of these "constraints" is unclear and requires more careful analyses. Previous research in Northland indicates that the environmental effects of oyster farms is minimal and research into public attitudes has found that the public is more concerned with oyster farms effecting harbour hydrology than the loss of amenity values. Unless shallow intertidal areas within Northland harbours can be set aside as part of the AMA establishment process, the future development of the Northland industry will be very limited.

In the longer term, the Northland oyster industry should be looking to develop subtidal methods for culturing Pacific oysters so future expansion can take place in coastal or offshore waters. Allowance for this development should be made in the AMAs, in strategically placed areas close to existing intertidal farms. However, subtidal cultivation poses more risks and biological challenges that need to be backed by sound research and market testing. In the short term, subtidal growing methods should be tested in intertidal leases containing water space too deep for rack construction.

Other threats to the industry that need to be addressed include;

- the “Aquaculture Law Reform Bill” threatening to re-tender existing leases;
- problems associated with pollution, especially as coastal urbanisation and development continues;
- lack of skilled staff and poor staff retention;
- limited active membership and attendance of educational Industry field-days and events;
- the general public seem ill informed of the benefits Pacific oyster farming generates for the region. There needs to be an education program to inform people about the true impacts and benefits of the industry;
- research funding to support future expansion is likely to be require heavy subscription from industry or development authorities rather than from the Public Good Science Fund;

Potential solutions to these and other issues are discussed further in this report.

Introduction

Pacific oysters are a lucrative aquaculture species currently fetching in excess of \$3.40/dozen to farmers in high value overseas markets. The Northland region currently produces around 3 million dozen Pacific oysters worth an estimated NZ\$20M of which 85% are exported (Jeffs 2003). Northland oyster farms total 106 leases covering 672.66 ha (Table 1). Currently the Kaipara Harbour, Bay of Islands, and Whangaroa Harbours dominate the allocated growing areas, however, many Kaipara farms are underdeveloped.

With the ideal growing conditions in Northland, this region is well placed to expand with current sales of Pacific oysters predicted to treble by 2020 (Hannah 2001). Expansion will come from full utilisation of undeveloped lease areas, expansion of new leases, and increases in the efficiency of production.

The rationale for this report is to explore the question, how can the economic returns from Pacific oyster production be increased in the Northland region? Our approach has been to investigate opportunities for the expansion to new areas and growing systems, and also evaluate management options to optimise returns.

What do the high value markets want?

Due to New Zealand's geographic isolation, production and marketing should focus on high value products and product differentiation. The most valued product from Pacific oysters is the "half shell oyster" (Fig. 1), which can be produced for less cost in time and effort than processing oyster meat (J. Nicholson pers. comm.).

The quality standards required to market Pacific oysters include:

- Meat creamy in appearance without streaks or granulation
- Meat full and creamy in flavour without bitter aftertaste or limp texture
- Shell even, rounded and deep cupped, and in a specific size range (75-85mm)
- Shell interior smooth and pearly white, without "mudworm" or unsightly markings
- Shell exterior clean and banded, without unnecessary frills, thinness, or oyster spat overcatch
- Health assured, free from phytoplankton toxins or human pathogens

Discerning markets in Europe, USA, and Japan offer premiums for uniformly shaped oysters with deep cup and consistent condition.



Figure 1. The desired product, deep-cupped and rounded, half-shell Pacific oysters with the meat filling up the shell.



Figure 2. Pacific oysters growing on traditional wooden racks constructed in the intertidal.

Table 1. Breakdown of oyster farms by location recorded by the Northland regional Council (Jeffs 2003), with rough estimates of potential production.

HARBOUR	LOCATION	MAF Licence /Lease	CPT Permit	Total Permits	MAF Area (ha)	CPT Area (ha)	Total Area (ha)	Estimage returns: 3 Dozen/stick	Estimated returns: 6 Dozen/stick
Parengarenga	North	5	4+7	16	52.5	22	74.5	\$ 2,279,700	\$ 4,559,400
	South	1	1	2	2	7.8	9.8	\$ 299,880	\$ 599,760
Houhora	Jacksons Bay	5	6	11	32.03	18.92	50.95	\$ 1,559,070	\$ 3,118,140
Rangaunu		3	1	4	22.46	9	31.46	\$ 962,676	\$ 1,925,352
Whangaroa	Waitapu Bay	3	"+1?"	4	11.2		11.2	\$ 342,720	\$ 685,440
	Touwai Bay	1		1	4.93		4.93	\$ 150,858	\$ 301,716
	Pumanawa Bay	1		1	2.92		2.92	\$ 89,352	\$ 178,704
	St Peters	5		5	95.19		95.19	\$ 2,912,814	\$ 5,825,628
Bay of Islands	Te Puna Inlet	5		5	23.4		23.4	\$ 716,040	\$ 1,432,080
	Kerikeri Inlet	7		7	41.43		41.43	\$ 1,267,758	\$ 2,535,516
	Parekura Bay	1		1	2.5		2.5	\$ 76,500	\$ 153,000
	Paroa Bay	1		1	2.1		2.1	\$ 64,260	\$ 128,520
	Orongo Bay	18		18	29.08		29.08	\$ 889,848	\$ 1,779,696
	Waikare Inlet	23		23	72.72		72.72	\$ 2,225,232	\$ 4,450,464
	Waikino Inlet	2		2	11.21		11.21	\$ 343,026	\$ 686,052
Whangarei	Parua Bay	1		1	2.83		2.83	\$ 86,598	\$ 173,196
Kaipara	Pahi River	5	5+4	9	13.17		13.17	\$ 403,002	\$ 806,004
	Paparoa Creek	3		5	19.34		19.34	\$ 591,804	\$ 1,183,608
	Arapaoa River	6		6	39.39		39.39	\$ 1,205,334	\$ 2,410,668
	Otamatea River	2		2	6.7		6.7	\$ 205,020	\$ 410,040
	Kirikiri Inlet	1		1	4		4	\$ 122,400	\$ 244,800
	Hargreaves Basin	4		4	100.9		100.9	\$ 3,087,540	\$ 6,175,080
Hokianga	Te Karaka	3		3	22.92		22.92	\$ 701,352	\$ 1,402,704
Totals		106	12(+20?)	32	585.14		672.66	\$ 20,583,396	\$ 41,166,792

Note: Estimated production figures are based on 3,000 sticks/ha and returns at \$3.40/dozen. These are likely to be overestimates as many leases in the Kaipara are used solely for spat catching and other leases will be partially developed eg. 40% undeveloped in 1993 (Jeffs 2003).

Exotic arrival provides opportunity

It is unknown when the Pacific oyster *Crassostrea gigas* was first established, but it was reported among native rock oyster *Saccostrea glomerata* cultivations in the Mahurangi Harbour, North Island in 1971 (Dinamani 1971). By the late 1970's the Pacific oyster was well established and had spread rapidly to Harbours on the east and west coasts of the North Island where it quickly dominated the native rock oyster by virtue of its faster growth, larger size, and multiple spawning events (Dinamani 1987).

Cultivation methods – intertidal growing

The majority of Pacific oyster cultivations in the North Island are based on intertidal (ie. between high and low tide) rack systems developed in Australia (Fig. 2, Roughly 1922). To avoid “mudworm” polychaete worm pests, the original native rock oyster cultivation industry restricted the depth at which oysters were grown intertidally. Mudworms cause the formation of unsightly shell blisters or “mudblisters” which result in the oysters being unsuitable for sale in the half shell (Handley 1992). Farm structures comprise wooden post and dual-rails constructed in orientation to maximise current flow and to allow barge access through the farm.

Juvenile oysters or “spat” are caught intertidally on artificial substrates in the wild, mostly in the Kaipara Harbour and are then transported to grow-out leases. Spat catching is carried out post-Christmas when water temperatures in the area has resulted in spawning of wild oysters. Growing substrates are dominated by 1.2 m wooden sticks, but fibrolite, plastic sticks, packaging tape and “Venetian blinds” have also been used to catch spat in the past. Spat can either be grown to harvest size on sticks, or stripped off their catching substrate for on-growing as individual oysters (“single-seed” oysters) where they can be placed in baskets or mesh trays or bags. Some farmers prefer to harvest sticks when the majority of oysters are an optimum size for harvest, retaining small oysters for further growing and fattening in mesh or basket containers.

Recently, some NZ growers have adopted single seed production techniques developed by Australian companies, for example the BST oyster system (<http://www.bstoysters.com/>) from South Australia (Fig. 4). These types of systems cater for single seed production and mechanisation of sorting and growing. Increased returns from more-uniform growth and shape offset the cost of such systems (Handley pers. comm.).

Hatchery production of oyster spat, which is common overseas, has only taken off in the last couple of years, driven largely by growers wanting to gear up for single-seed

production, and also the promise of faster growth rates and control over traits touted by hatcheries conducting breeding programs.

Cultivation methods – subtidal growing

Trials growing Pacific oysters on fully submerged longlines were first carried out in the North Island to assist the established intertidal industry to fatten oysters during poor condition months, following spawning, and to also achieve faster growth rates (Curtin 1982). These trials, although successful in terms of achieving faster growth rates and increased meat condition, were largely abandoned because of very high infestations of mudworm pests and shell blistering.

Incentives for diversification from diminished returns from Greenshell™ mussel sales in the early 1990's generated interest in growing Pacific oysters subtidally on mussel farm leases in the Marlborough Sounds, South Island. The Marlborough Sounds also lack suitable intertidal sites for the development of intertidal oyster racks. Initial trials with subtidal cultivation in the Marlborough Sounds produced very varied results. Some areas had high mudworm infestations, while other areas remained free of these pests (Hippolite, Edwards pers. comm.).

The mudworm species constraining subtidal cultivation of Pacific oysters in the Marlborough Sounds (Handley 1995), differed to those species found in North Island oysters (Handley & Bergquist 1997, Handley 2002). Management systems to avoid infestations were devised based on life-history studies of the dominant mudworm pest species (Handley 1997a,b). However, the subtidal oysters that were produced suffered from poor quality due to their clumped growth characteristics, brittle shells and odour problems associated with biofilms growing on the outside of the shell. These factors affected the processing and marketing of the oysters (Handley pers. observ.). Some limited subtidal production of Pacific oysters is still carried out in North and South Island growing areas, with further diversification into tray or barrel-type culture systems growing single-seed oysters. Subtidal culture is mainly used today for fattening and on-growing small oysters rejected from grading, with immersion times limited to several months to avoid mudworm infestations.



Figure 3. Experimental Pacific oysters grown on subtidal “plastic sticks” as part of trials in the Marlborough Sounds.



Figure 4. The BST system developed in South Australia for growing Pacific oysters (www.oysa.com.au)

Growing biology

The optimum salinity for Pacific oyster larval development is 15-29‰ but at least some eggs develop normally at 36‰ (Amemiya 1928). Various authors' state that oysters have been spawned at salinities ranging from 30-36‰ (Coleman 1996) and King (1977) found one successfully settled spat in a hypersaline pond. Spawning of Pacific oysters has been recorded at temperatures of 18-22°C cultured in Canada, US, and UK (Quale 1969, Askew 1972, Dinamani 1974) and Ruiz *et al.* (1992) reported Pacific oysters spawning at 16°C coinciding with a major phytoplankton bloom in Spain. Imai (1980) however stated that there are cold and warm water strains of Pacific oysters, and that fertilisation occurs at temperatures 19-27°C. At the lower end of the temperature range, the setting (settlement) of larvae is impaired.

A review of the biological risks of importing Pacific oysters in Victoria Australia states that although the salinity of growing waters in South Australia were supposed to be too high for wild population to become established, since 1990 four of the six areas in South Australia where oysters are cultivated wild populations have become established (Coleman 1996, Hone & Clark 1997). Vandeppeer (1995) tested the salinity tolerances of developing larvae sourced from oysters from hatcheries in Tasmania, and found that some D-stage larvae were found even at the highest salinity tested of 44‰. The salinity tolerances of Pacific oyster thus appears to be broader than early studies suggest. The Pacific oyster is thus tolerant of a wide range of salinities and temperatures and is ideally suited for growing in most coastal and estuarine waters found in the Northland region.

Future development of the Pacific oyster (*Crassostrea gigas*) farming in Northland

Regulatory background governing expansion of growing areas

With the need recognised for reform of the regulatory framework governing the allocation of marine farms, the Ministry of Fisheries proposed new aquaculture legislation in 2001. With the rapid expansion of particularly the Greenshell mussel farming industry in the previous five years, considerable planning difficulties and conflicts over resource use arose. In March 2002, the government recognised this impending "bottleneck" of marine farm applications and implemented a two-year moratorium on the granting of all marine farm consents. The moratorium puts on hold applications for coastal permits for aquaculture activities that had not been notified by 28 November 2001 and applies until March 2004. The "breathing space" provided by the moratorium was to provide Central Government and Regional Councils time to finalise legislation and management systems at a regional level respectively.

The Northland Regional Council's role ("Project Aquaculture") is to define areas within the region that are suitable for the development of marine farming, and these areas are termed Aquaculture Management Areas (AMAs, <http://www.nrc.govt.nz>). Under proposed new aquaculture legislation, new aquaculture activities will only be able to be established within Aquaculture Management Areas (AMAs). The law will prohibit aquaculture activities outside these areas. The size and location of an AMA will be designed to avoid, remedy or mitigate the adverse effects of aquaculture on the environment, and on fishing, as well as other users of the coastal marine area. A consultation process with the community, iwi, and the aquaculture industry is being implemented to define the AMAs and address conflicts and issues.

The Northland Regional Council has prepared and published 24 draft maps covering the region showing areas suitable for aquaculture activities and mapping "potential aquaculture constraints". Most of existing Pacific oyster farming sites overlap or are included with the existing potential aquaculture constraints. This brings into question the validity and relevance of these "constraints" and the processes used to identify them and then map them. The most common conflict identified between the constraint maps and existing farm sites are those relating to landscape and conservation values (Table 2). For example, landscape values are cited as a major feature of the oyster farms in the Parengarenga Harbour, however, most of these farms are remote and out of sight of the highly frequented tourist and visitor routes. In most instances there is an extremely small resident population affected by the loss of landscape values, and in many instances these people are benefiting from the farm activity. Another example, is the assertion by these maps that the proximity of land based parks or reserves somehow exerts a constraint on marine farming activities in nearby marine waters. Of significant note from the constraint maps are the potential problems associated with marine farms overlapping buffer areas of poor water quality and proximity of sewage discharges to water highlighted by this analysis (see later).

Expansion of intertidal farm areas

Suitable areas for intertidal oyster farms usually have water depths ranging from 0.5 m below extreme low water neap and up to about 1.5 m depth at low tide. This is to keep rack structures off the bottom at their shallowest to prevent the build up of sediments on farm structures and to aid the feeding of the oysters which can be hindered by high sediment loads. It also allows the farms to be serviced by walking around the racks with barges at low tide. Water flow through the farm should be maximised to allow adequate food to reach the oysters and to reduce the build-up of sediment directly beneath the rack structures. Shelter from extremes of wave climate is also desirable, so exposed sites experiencing more than about 0.25 m high waves may require some form of buffering to prevent damage to the racks and allow

servicing during rough weather conditions. Water quality is also a significant issue, not only from bacterial contamination, but also from nuisance marine micro-algae that can cause illness (see later). New oyster farm developments should therefore avoid areas draining from residential and commercial areas, sewage and landfill plants, and areas of intensive livestock production.

Table 2 Analysis of aquaculture constraints adjoining/overlapping existing marine farm leases published in draft maps by the Northland Regional Council as part of “Project Aquaculture” (www.nrc.govt.nz, Feb 2003)

Harbour location	Landscape buffer	Area of significant Conservation value	Poor water quality	Sewage discharge to water buffer	DOC parks reserve buffer	Sewage discharge to	Landfill buffer	Shellfish gathering	Popular beach buffer	Stormwater discharge tow water buffer
Parengarenga	13	18			3				1	
Houhora	<i>Incomplete</i>									
Karikari Bay	5				1				1	
Rangaunu		4								
Whangaroa				1		1	1	1		
Bay of Islands	22		15	5		4	3			
Whangarei				1	1	1		1		
Kaipara	5	4		4			1	1		1
Hokianga					2					
Total:	41	26	15	11	7	6	4	3	2	1

Note: figures are only a guide as it was not possible to distinguish individual marine farm lease areas when farms boundaries were not demarcated on the maps provided eg. the large block of marine farms in the Whangaroa represented several leases

operated by a range of companies. Subtidal leases are also included as they are relevant to future expansion of the industry.

An analysis of the “Draft Potential Constraints to Aquaculture Maps,” indicates that on the basis of these maps there is very limited scope for expansion for any intertidal oyster farming, save for possibly areas in the Whangaroa Harbour, upper areas of the Kaipara Harbour, and in the Hokianga Harbour. There could be some opposition to further expansion of oyster farming in parts of the Whangaroa Harbour due to the localised reduction of natural shellfish food in the waters (see later). The Kaipara Harbour suffers from problems of over-catch with oyster spat, mudworm pests, and flatworm predation, but this area has potential for future development with technological advances of growing systems (see later). Also, if in the future technical advances improve the purification of sewage or stormwater discharged to the sea, the current pollution buffer zones to marine farming may be removed and made available for farming activities. Highly suitable areas for Pacific oyster farm development, such as areas of the Parengarenga Harbour, have been blanketed with a range of constraints in the constraint maps.

A recent development that may also aid in intertidal industry expansion is the use of Australian single-seed growing systems in the Kaipara Harbour, mentioned earlier. This system suspends mesh bags containing oysters beneath adjustable plastic wire lines supported by posts. As the suspended bags can swing in wave action, this and similar systems are more suited to areas where there is a greater wave climate that are otherwise unsuitable for traditional fixed rack systems. As the oysters are regularly handled, problems of mudworm, flatworms and over-spawning can be addressed as part of management of the farms. Thus shallow tidal banks like those occurring in the Kaipara Harbour can be more readily utilised for growing intertidal single seed oysters and this has been recognised by the Auckland Regional Council, which has included some of these areas in the Kaipara Harbour among its notified AMA areas.

Expansion of subtidal growing areas

The subtidal production of Pacific oysters is common in many overseas countries including Australia, United States and Canada. It is commonly thought by oyster farmers that if you give oysters more time to feed, by lowering their growing level vertically in the water column, the oysters should grow faster and have greater condition (fatness). However, when oysters grown at a range of levels within the same farm in the Houhora Harbour were tested for variations in growth and condition, maximum growth was recorded at extreme low water neap (ELWN), with reduced growth below that level (Handley 2002). Condition did not vary significantly with level, but was only recorded during peak condition. Thus, oysters may grow faster

when placed subtidally, but this effect is likely to be a “site effect” rather than an effect of submersion, with greater water flow and food resources available in deeper water than in the intertidal. Hence, although Pacific oysters appear better “adapted” for growing in the intertidal, in harbours restricted for intertidal development, adjacent subtidal sea space offers opportunities for expansion for the industry, but the optimum growth and quality of oyster product is still likely to come from intertidal production methods.

The companies that successfully utilise subtidal leases mostly use these for on-growing small oysters graded off during the harvest and processing of oysters from traditional intertidal stick culture. These are stocked into trays that are suspended in stacks below the backbone of the longline marine farm. However, with the increasing interest in hatchery spat and breeding programs, and the move by some of the more successful companies towards single-seed growing methods, there is significant opportunity to expand into systems that utilise subtidal growing as part of the crop production cycle. A very successful system used in South Australia, relies on starting off seed oysters subtidally and growing them at twice the speed of neighbouring intertidal oysters farms, and then finishing or “hardening off” the oysters in the intertidal once they reached marketable size, to increase their shelf life (Handley pers. observ.). This system was highly efficient in terms of lease space due to the vertical stocking densities of the subtidal lease. Increased labour cost required to grade the oysters every 4-6 weeks, was more than offset by halving the production times and making more efficient use of the valuable intertidal farm space. Such systems, which appear attractive for oligotrophic (food poor) waters of South Australia, need to be tested in comparatively highly productive waters in New Zealand that may suffer more from fouling and pests/predators. Likewise, provision needs to be made in the AMA process for developing and expanding the potential of these alternative on-growing methods which may ultimately reduce the pressure for more extensive areas of intertidal farm space.

Growing oysters subtidally poses greater risks to fouling, predators and pests, but such risks could be overcome with a combination of research, education and management skills that will be discussed further in a later section. Ideally, if investing in offshore marine farm lease areas, oysters should be grown at the site for a period of at least a year to determine potential problems of pest and predators like mudworms and flatworms. However, current approaches to allocating marine farm space do not test the sites for the biology of the species suitable for development at that site. Parasites and pests will therefore have to be managed once a lease is granted, adding to the risk of investment and expansion of the industry, particularly in any new unfarmed areas allotted through the AMA process.

A potential model for subtidal production

The Northland Regional Councils' draft constraints to aquaculture maps offer greater opportunity for development of subtidal oyster farm leases. This is in part due to the reduced water space needed in deeper water to grow equivalent volumes of oysters that can be stacked vertically in the water column than for intertidal farms that are grown at one level. Criteria for situating subtidal leases are again dependant on water quality, and also exposure regimes governed by wave climates and currents. As longline marine farms grow their crop below the surface, some applications for mussel farms well offshore, particularly in the South Island, have proposed to sink their backbone lines beneath the surface to avoid the major impacts of surface swells when placing marine farms offshore in areas like Cloudy Bay, Marlborough and Pegasus Bay, Canterbury. It remains to be tested whether these structures can weather extremes of storm events, and continue to grow shellfish.

For the purposes of this report, we will construct a model for growing oysters utilizing both intertidal and subtidal water space synergistically. To start, hatchery spat are deployed to some form of intertidal or subtidal nursery system to raise the spat to a size for on-growing on the farm. When the juvenile oysters have grown to an adequate size they can be transferred to grow-out bags or trays, for example, at 25 mm oysters can easily be stocked into 12 mm BST bags for on-growing. At which stage, the oysters will be transferred to a subtidal lease for on-growing. These oysters will be periodically cleaned, graded and managed for pests (4-6 weekly). It has been shown that frequently rumbling of oysters can actually enhance their growth (Loosanoff & Nomenjko 1955, Jakob & Wang 1984). When the oysters have reached a marketable size, the oysters will then be "hardened off" in the intertidal (about 2 weeks) before being processed for sale in the half shell, with 100% acceptance of pre-graded size and conditioned oysters.

In terms of maximising efficiency of production (reducing labour and transport costs), the most appropriate place to site a subtidal oyster farm is adjacent to and offshore from the intertidal farm. The intertidal lease can be used primarily for nursery systems and for the "hardening off" of stock for sale. The term "hardening off" refers to the "teaching" of the oysters to close their shells during low tide. The muscle that holds the oyster closed during low tide becomes weak if grown subtidally, so placing them in the intertidal for several weeks improves their "shelf life". This "hardening-off" can also kill off any unwanted odour associated with biofilms and algae growing on the outside of the shell that can affect marketing (Handley pers. observ.).

Those leases currently with undeveloped deep water due to its unsuitability for rack construction could initially be used to test the economics of such a growing model.

The success of this model will largely depend on knowledgeable management and mechanisation required to grow single seed oysters. Luckily, many sorting and grading systems can be readily purchased from the South Australians who have been growing single seed oysters for more than a decade. Despite oysters taking twice as long to grow in South Australia, their farmers can afford to handle their oysters about every 6 weeks as their average returns from their product are higher. Growing areas in Northland that do not have constraints to aquaculture development identified for them adjacent and offshore to existing farms are in the Whangaroa, Kaipara and Hokianga Harbours. If such systems prove efficient, and lucrative, transport costs could be factored into cost benefit analysis of on-growing oysters in coastal areas close to harbour entrances like in the Houhora, and even in less sheltered offshore locations proved suitable for longline mussel farm development.

Increasing efficiency and returns from current production areas

There is a feeling by the more experienced oyster farmers in the industry that oysters could be farmed far more efficiently with more attention to producing a higher quality product. The incentives are now present for farmers to spend the time producing such oysters are coming from companies such as JEMCO (www.oystersnz.com) who offer premiums not only for good quality product in optimum condition, but also incentives for lack of reject oysters supplied to their processors. Such incentives reduce product waste, processing labour costs, and increase the sustainable management of growing areas by encouraging growers to grow fewer oysters on sticks to maximise their quality. In most growing areas, the optimum density to grow oysters is 4-5 dozen on a 1.2 m stick (J. Nicholson pers. comm., Handey 2002).

The density trap

Some growers do not endeavour to control the density of spat they catch on their sticks, and the resulting oysters produced from 10-12 dozen on a stick are often elongate and are slower to condition due to overstocking of the farm (Handley 2002). As a result, these growers are the last to harvest their oysters and are thus at the whim of the processors later in the season who can choose oysters of better shape and condition. If the grower cannot sell these oysters, they can remain on the lease and become infested with mudworm. Valuable farm space is taken up holding low grade oysters, infested with mudworm and the farmer is often forced to sell the stock at discount in order to clear space on the farm to re-stock with spat for the coming year.

The experienced growers know the way out of the density trap is attention to detail at the start of the oyster cycle. These growers remove their spat sticks from the Kaipara as soon as they have caught an even low-density settlement, which requires the farmer

to be on site, or within easy travelling distance with a hand lens or microscope. As a result of their isolation many far north growers of Northland, find this difficult. If the spat sticks are left too long in the Kaipara, they become overgrown with successive settlement events resulting in a wide range of spat sizes that will grow at variable rates leading to variation in oyster size at harvest. The Kaipara is also infested with flatworm predators, and entire spat bundles can be eaten out if left too long (N. Wiki pers. comm.). Or, flatworm infested spat bundles are then transferred to the growing harbours throughout Northland, which then become a menace to larger oysters on the farms. A few days of work during spat catching with attention to detail, can thus:

- reduce the density of oysters growing on the sticks
- improve the resulting shape and condition of the oysters
- improve economic returns from the oysters grown with less labour cost
- reduce the risk of losing all the spat from flatworm predation
- and, reduce the risk of infesting Northland Harbours with flatworms

Many Northland oyster farmers at best average about 3 dozen premium oysters per stick (V. Sydall pers. comm.), whereas those that control the density of their spat on their sticks can average about 6 dozen premium oysters per stick (B. & J. Jessop-Whangaei). Rough production estimates based on these figures for Northland show that current revenue is close to the \$NZ20M estimated by Jeffs (2003), and if all oyster farmers in Northland produced 6 dozen oyster per stick, revenue from production could exceed \$NZ40M if spat density can be controlled (Table 2).

Human resource and economic development

Whilst Pacific oyster production is very labour intensive, the future innovation and move of some in the industry into single seed culture systems requiring mechanisation to improve product quality, may reduce labour costs. The industry is estimated to currently employ about 400 people directly both part time and full time, in both growing and processing operations. With around a 1:1 flow on effect creating indirect economic activities, the industry currently generates approximately \$40M for the Northland economy with a further 140 indirect flow on jobs supported (Jeffs 2003). Given that the Northland oyster industry has more than doubled in the past decade, and the South Australian industry which grows high value single seed oysters has

almost doubled in the last three years, with continued focus on quality of production, it is realistic to expect the Northland industry could sustain up to a 20% increase in total production value per year for the next 10 years, taking it over \$100M per annum. An industry of this size could be expected to produce over \$100M in flow-on economic benefits within the region and employ about 2,500 people with a further 850 flow-on jobs. Critical to the continued development of this industry is the availability of farm space for expansion.

Opportunities for Maori

Maori are well placed to be part of the future development of Northland's Pacific oyster farming industry. One of the largest oyster farming companies, Pacific Marine Farms (1996) Ltd., owned and operated by Te Ohu Kaimoana (Maori Fisheries Commission), owns around 60% of Northland oyster farms, and has around 85% employees of Maori descent (D. Moana pers. comm.). Pacific Marine Farms (1996) Ltd. are also part of the JEMCO group, who through some aggressive marketing overseas, have established some lucrative export markets, especially in Asia. A greater proportion of Maori also live close to or adjoining areas likely to sustain future development of this industry, especially in the far north in the Parengarenga Harbour and offshore of Houhora Harbour. With the impending allocation of around \$111.5M in fisheries assets and earnings from the Treaty of Waitangi Fisheries Commission, iwi in Northland region will be looking to invest in established growth sectors such as Pacific oyster farming.

Diversification of products and production

Alternative measures to increase revenue from production is to focus on developing saleable products from the industries waste streams. Apart from potential production of sauces, dips, and dried oysters sold in Asian markets, there are also potential markets for:

- health products made from waste shell.

- waste shell and plastics.

- hydrated lime production from waste shell, requiring less energy to form than cement eg. for roading and eco-building materials (e.g. earth building etc.- North G. 2003.). Cement kilns currently account for around 6-8% of world carbon dioxide emissions.

Another means of increasing the value of oysters sold from Northland is the potential for "Organic certification" (Handley 2000). Product demarcation that can give marketers the edge on production could be very valuable if such certification is recognised by importing countries. In New Zealand, as far as we are aware, "BioGro" certification is IFOAM (International Federation of Organic Agriculture Movements) accredited, giving access to most EU markets. New Zealand organic certification is however not yet compatible with USFDA standards recently released (B. Hearn, MIC). There needs to be some market testing of the value of organic certification for oysters sold from Northland and the benefits analysed against certification costs for the whole of the Northland industry. To get Biogro certification would take a minimum of one year to achieve (www.Biogro.co.nz).

Polyculture, or the farming of more than one species together should also be investigated. Oysters have been used overseas as a means of stripping organic waste material from fish and shrimp farming systems (Jones & Iwama 1991, Ingram et al 2000, Wurts 2000). Such systems could be either land or sea based and would help to reduce waste outputs and increase public perceptions of such systems. The oysters produced however have the potential to accumulate any antibiotics or chemicals used in the production of some fish species as has been reported overseas (Jones & Iwama 1991).

Research, education and management to enhance development

The following section addresses research, education and management measures that could be implemented to address specific constraints hindering future development of the industry.

Biological and ecological constraints

Mudworm

Intertidal growing: Mudworms are small polychaete worms that can bore into the outside or settle on the inside of Pacific oysters and thrive in warm waters generally breeding at temperatures above 20°C. There are at least five species of mudworms which can attack Pacific oysters in Northland (Handley 1992, 2002), with each having

their own unique biological characteristics which can affect their resulting designation as pests for oyster growers. These polychaete worms are called mudworms due to the nature of the shell blisters (“mudblisters”) that often contain sediment (Fig. 5). Mudworms live and breed within these blisters, which are produced by the oyster as a defence mechanism to an irritation within their shell. The presence of mudblisters within the shells can affect the health of heavily blistered oysters (Handley 1998), and can render them unsuitable for sale in the half shell. In the early stages of development, the oysters lay down a nacreous material over the irritation caused by the worm either boring in from the outside of the shell, or in the case of some species, settling as larvae on the inside edge of the shell. Depending on the health of the oyster and the degree of infestation, the oyster then lays down shell material over the nacreous blister and fills in the depressions around the blister in an effort to restore a uniform shape within its shell. All these blister secretions cost the oyster valuable energy. If the mudworm dies or cannot aerate the blister, the contents can become anaerobic leading to the production of hydrogen sulphide inside the blisters which smells of “rotten eggs”. Newly formed blisters can easily be perforated during shucking of the oyster during processing, or worse still, by a customer. When the blister is broken the oyster meat gets contaminated with the often-putrid content of the mud blister.

In the intertidal growing environment research has demonstrated that growing oysters at or above extreme low water neap (ELWN), can avoid most mudworm infestations (Handley 1992, Handley & Bergquist 1997). However, in extreme cases, where mudworm infestations are very high within harbours, infestations can move higher up the shore (Handley 2002, Curtin 1986). The primary cause of these outbreaks is from poor management of farms, especially the removal of wild oysters “rail oysters” that settle on the racks during the growout cycle (Handley pers. observ.). These oysters are situated below the recommended ELWN and easily become infested with mudworms. As these oysters are growing off the bottom, the mudworms breed prolifically in these oysters and become a liability if left on the farm racks for more than one season. Experienced growers remove rail oysters during the harvest of their stick oysters, and



can sell them as they are often in good condition.

Figure 5. Mudworm induced shell blisters “mudblisters” in the shell of this Pacific oyster



Figure 6. Flatworms like that in the bottom right hand corner (reddish colour) can devour healthy oysters, and oyster spat.

One cultural constraint of some growers in Northland, is that some farmers consider these rail oysters the property of the “whanau” (M. Robertson pers. comm.). and as a result, are not removed as part of the management of the farm. There needs to be education to change this, or perhaps an annual event organised for the “whanau” to remove these oysters and place them at a level at or above ELWN, so they can be utilised at the whanau’s leisure. Moving infested oysters above ELWN has been shown to control the infestations and prevent the worms breeding and spreading (Handley & Bergquist 1997).

Derelict leases within harbours can also be a source of mudworms while the racks are still standing free off the mud bottom. Mudworms generally do not breed well when growing inside oysters on the seafloor, as these oysters and mudworms are being constantly covered by resuspended mud, which hinders their feeding as the tide covers and uncovers them (Handley pers. observ.). Derelict leases or neighbouring poorly managed farms riddled with rail oysters can be a liability for all concerned within a Harbour, as mudworms can continually re-infest once established in an area. This is an important issue for improving the quality and product value of Northland oyster farms, as the clean up of derelict oyster farms has been an ongoing issue for many years.

Subtidal growing: Growing oysters subtidally, whilst not biologically optimum (Handley 2002), is likely to be necessary if this industry is to expand in the future. Without intertidal exposure, mudworms can proliferate rapidly in subtidal oysters (Handley 1995). In the subtidal environment, the species infesting the oysters can be very site specific (Handley pers. observ.). Thus, the research and management requirements to avoid or control mudworms needs to be evaluated on a site-by-site basis. Avoidance of mudworm infestations is recommended rather than direct and costly intervention once an outbreak occurs (Handley 1997b). This is a very important consideration for establishing potential AMAs for subtidal oyster farming, i.e. that it would be highly advantageous to have some experience of the prevalence of mudworm on site before allocating or developing it for subtidal oyster production.

Lessons on how to avoid mudworm infestations in oysters grown below ELWN or subtidally can be taken from a minority of South Australians who have mastered the management of mudworms infesting single seed culture systems which are advocated as part of the subtidal growing model above. South Australian growers are forced by very high summer temperatures to lower their oysters on their adjustable intertidal growing systems to avoid heat stress and death of their stocks (S. & G. Tonkin pers. comm.). Because these growers handle their single-seed oysters regularly, to grade and rumble them to enhance their shape, some growers prevent outbreaks of mudworms by placing them in a freshwater bath overnight whenever they bring their

oysters in for grading. Once an outbreak of mudworm has occurred, however, the freshwater bath does not work to control the pest, as the larger worms can survive up to a day submerged in freshwater inside the oyster shells. A similar control method could be the use of hypersaline baths in combination with drying the oysters out to kill the juvenile worms.

It may be found that in some locations, little or no mudworm infestations occur, as is still the case in parts of Croisilles Harbour in the Marlborough Sounds (Handley pers. observ.). Or, like in the outer Marlborough Sounds, a single species may dominate infestations (Handley 1995). In this case, subtidal oysters were infested by a species not previously recorded as a pest of oysters before. It was the growing of oysters outside their “ecological range”- subtidally which created the problem. The solution to this problem was a thorough investigation of the life-cycle and the timing of the infestations of this species (1997). It was subsequently revealed that the dispersive or planktonic larval stage of this worm only occurred during spring, so infestations could be avoided by harvesting oysters on an annual rotation before spring (Handley 1997b). Juvenile oysters are not infested by this species until they reach approximately 40-50 mm in size

Flatworms

“Wafer worms”, “oyster leaches” or flatworms are a primitive but efficient group of predators that can have a devastating effect on shellfish aquaculture (Fig 6.). Little is known about the biology of flatworm species in New Zealand, apart from provisional identifications of three species sent to an Australian flatworm researcher. Many oyster farmers think that flatworms are just scavengers, as they often appear to congregate in dead oyster shells once the oyster meat has been removed from the shell. This myth however has been dispelled, with evidence of flatworms entering and eating living and healthy oysters (Handley 1999, 2000).

Many oyster-eating flatworms are hermaphrodite, and can produce thousands of eggs even after undergoing long periods of starvation (Chintala 1993). For these reasons, they pose a high risk to oyster culture ventures, if they are given the right environment to flourish. Flatworms appear to do best in single seed culture systems in New Zealand, rather than stick culture systems. They prefer crevices and damp silty areas in which to hide during low tide. They can often be found congregating en-mass in dead oyster shells, stacked on top of each other, seemingly in an effort to prevent drying out. Flatworms can last up to five days out of water in this manner in Western Australia (K. Jennings pers. comm.). Flatworms appear to be predated on by fish (Handley pers. observ.), and this may provide clues as to why they do better in single seed culture systems, inside trays of mesh bags that exclude fish.

In the intertidal, flatworms are generally not a huge issue, as long as single-seed oysters are contained at low densities in trays or baskets to reduce the chance of flatworms becoming established by letting the oysters dry out adequately. Subtidally, however, flatworms pose a significant constraint to the future development of the industry if the industry is forced to use subtidal growing leases in the absence of room to expand intertidally.

Experience from Australian oyster growers may once again help here. O'Connor and Newman (2001) found brine baths and freshwater baths were effective in killing related flatworm species found in Port Stephens in Western Australia. These solutions could thus be implemented as part routine grading of the crop as mentioned previously as a measure to control the outbreak of mudworms. Some South Australian growers however consider that the regular rumbling and grading process of the oysters is enough to remove most flatworms from their crop (G. Zippel pers. comm.). Research needs to be undertaken to test avoidance or control measures for Northland subtidal growing environments as part of any subtidal developments.

Sustainability

Sustainability in the context of this report is used to refer to localised reduction of phytoplankton upon which shellfish such as oysters feed. Overstocking of shellfish farms, or the presence of too many farms in an embayment can reduce the production of the farms due to localised reductions in phytoplankton due to the effectiveness of the filter feeding of the shellfish. Avoiding this effect in shellfish farming is referred to as “sustainability.”

The sustainability of oyster farming in Northland's harbours is poorly researched, but a recent, yet to be published study of the Mahurangi and Coromandel Harbours can provide some generalised insight into environmental and climatic forces influencing the sustainability of these growing areas. There is a feeling from some oyster farmers that some farm areas may have already reached or exceeded their carrying capacity, for example in the Houhora Harbour (H. Petera pers. comm.). and in the Whangaroa Harbour (L. Boyd pers. comm.). This is because oysters appear to take longer to grow and fatten than when these areas were carrying fewer farmed oysters. To some extent, mitigating the density at which the oysters are grown, and encouraging the removal of feral oysters and derelict farms could in some cases help to improve the sustainability of some growing areas.

Riverine harbours fed by large catchments are generally highly productive as long as there is regular input of freshwater from the catchment. The nature of the catchment use can however impact greatly on the type and extent of nutrient discharge from the

watershed (Quinn & Stroud 2002). As can the soil moisture content which is dictated by the season in the year (Handley et al. unpublished data). Nutrients largely build up in the pastures and soil over summer when evaporation and transpiration from plants can exceed rainfall inputs. As autumn approaches, the soil moisture balance is often tipped, so that discharge occurs, flushing nutrients from the catchment. If there are adequate temperatures and light in the sea, marine plants or phytoplankton bloom and provide food for oysters. Generally speaking, nutrient levels in harbours are at their greatest in winter when light levels are low, limiting their utilisation by phytoplankton, and are at their ebb during summer, when phytoplankton production outstrips the supply of nutrients. Climate driven rainfall patterns can have significant impacts on the sustainability of riverine harbours. For example, we might expect that in El-Niño climate conditions, elevated rainfall predicted for north-eastern New Zealand (Mullan 1996) might increase nutrient supply to riverine harbours, as long as there is not excessive rainfall flushing nutrients out of the system and destabilising phytoplankton blooms.

Nutrients can also be “advected” into harbours by the passage of fresh or low salinity water over the top of saline water below. This creates a positive inflow of water beneath the freshwater above (freshwater is less dense than saline water). If conditions offshore are favourable (see later), nutrients from offshore can through advection be supplied to the harbour as the result of consistent rainfall events.

Harbours characterised by small catchments and close to the coast like the Parengarenga and Houhora are more likely to be prone to nutrient limitation when there are consistent onshore winds that are characteristic of La-Niña climate conditions (Zeldis et al. 2000). This is because surface offshore waters that have been stripped of their nutrients are forced onshore. As there is nowhere for this water to go, it is downwelled, forcing nutrient rich deep water away from the coast. Nutrients within the harbours then become depleted with little replenishment from reduced rainfall levels predicted during La-Niña conditions (Mullan 1996).

As many oyster farmers find it difficult to manage the density of their farms already, it is premature to hope that they might try and manage their densities to match forecast climate predictions as some agriculturalists now do. In the future, however, with more research into factors governing sustainability patterns and with research into methods for controlling the density of oysters grown on sticks, such management may be possible. It is important therefore that the Northland Regional Council take into account the understanding of the full range of nutrient dynamics within the region across the extremes of La-Niña and El-Niño cycle and how this might affect the production and continuity of supply to important shellfish markets. Ensuring

expansion of growing activities in a range of harbour systems will be important to safeguarding the interests of this important industry to the regional economy.

With the infilling of marine farms in the Marlborough Sounds in the South Island, consortiums of marine farming companies are being encouraged to combine research initiatives to address issues of sustainability. Especially as the Ministry of Fisheries develop and clarify what level of research and surveys they require as part of new marine farming applications in already heavily stocked areas (MFish 2002). If the same were to happen in Northland, these consortia should be proactive in supporting long term nutrient monitoring and research into how climate affects sustainability of the harbours of concern.

Pollution

The analysis of potential aquaculture constraints adjoining and overlapping with existing marine farm leases in Northland is disheartening as it shows many areas already conflict with desired discharge and landfill buffer zones (Table 2). Whilst future research initiatives might mitigate the control of discharge of pollution to growing areas, increasing urbanisation and development is likely to counteract such efforts.

Oyster farmers have long been touted as watchdogs over water quality for their growing areas and already work closely with area health authorities to ensure that oyster products are sold free of contamination, especially in contentious areas like the Bay of Islands.

The practice of “relaying” of oysters initially grown in contaminated waters, to areas with clean water so that the oysters can be purified, could help to utilise waters that are otherwise unavailable to marine farming activities due to the effects of pollution. The adoption of single-seed growing techniques could also help alleviate pollution related problems, with these areas used perhaps as nursery farms. The stigma associated with pollution and downstream disease outbreaks need to be managed well by the industry as a whole, as they can affect all within the industry. Depuration in tanks, or by transferring oysters grown in polluted waters to clean waters is feasible, but research would be needed to establish a reliable methodology under local conditions. Also, very high hydrostatic pressure treatment plants have been developed overseas to sterilize oysters and other shellfish. These are unlikely to be economically feasible to be operated in New Zealand in the medium term, as they are very expensive to set up and operate. Such product treatment may also detract from the market value of the product, with the leaders in the industry marketing their products from “pure NZ waters”. Ultimately, it is important that greater emphasis is put on controlling coastal

water pollution sources in Northland, for the benefit of not only marine farmers, but the community as a whole. In the long term maintaining high water quality standards in Northland is the key to retaining and increasing the returns on premium shellfish aquaculture product, when competing oyster growing countries are increasingly troubled by pollution.

Research & Development

The future growth and development of oyster aquaculture in Northland is partly dependent on research and development, especially in terms of improving farming methods and efficiency, and developing new growing areas. Despite the importance of the oyster industry as part of New Zealand's aquaculture industry, it has invested relatively little in research and development. Likewise, the industry has failed to capture much of the main government research funding the Public Good Science and Technology Fund (PGST). The PGST fund provided by government, which has supported some valuable research used by the oyster industry in the past, has shrunk in real terms over the last 56 years. More recently research and development for specific projects has been made available through Technology New Zealand (TechNZ) and a number of oyster farmers have taken advantage of this funding in recent years. Research grants available to industry through TechNZ's schemes can cater for answering simple technical questions, market research through to large multimillion-dollar R&D programs. Industry however, has to provide a minimum of 50% contribution, of which 20% is cash. The scope of these grants requires that they focus on research related to technological innovation, with proprietary rights over intellectual property usually owned by the company lodging the application. The result being that research results that could be for the public good are owned and can in turn be marketed by industry. The scope of the grant criteria can also limit the types of research undertaken, unless the applicants can prove some technological innovation.

Social & management constraints

Significant growth in the value of the oyster industry, especially in recent years, can be attributed to some of the more senior and experienced of the oyster growers investing large amounts of time, money and effort in focussing on developing valuable overseas markets. Many of these growers are, however, approaching retirement age, and unless they impart their wisdom as mentors to newcomers, it will be lost. Many of the more successful companies have recognised that one of their most valuable assets is their staff, in which they invest wisely. Some Northland farmers speak of difficulties attracting or retaining skilled workers. With New Zealand growers competing on overseas markets with comparatively high labour costs, they need to

develop ways of mechanising to reduce costs and developing innovative ways of retaining good staff. Investment in training and retaining valuable skilled staff should not be overlooked if this sector is to expand in the future.

Another social constraint to development is the seemingly unfounded negative public attitudes to oyster farming and aquaculture generally in Northland. Most of these concerns relate to unfounded perceptions of environmental impact and visual amenity. Studies of the impacts of oyster farming in Auckland and Northland have indicated that impacts are very localised to within tens of metres of the racks, and result in some increased sedimentation and some shell drop beneath the racks (Forrest 1991, 1994). Positive effects such as enrichment adding to food resources for other species and racks acting as potential aggregation devices for fish species were also identified (Forrest 1994). Pacific oysters, although an exotic species in New Zealand, have been shown like most bivalves, to be an essential part of most estuarine ecosystems. They help stabilise estuaries and contribute significantly to the cycling of nutrients within these ecosystems (Dame & Libes 1993, Dame et al. 1994), and have even been advocated for introduction to improve environmental quality in parts of the US (Gottlieb & Schweighofer 1996.). The hydrological effects intertidal rack farms may have on shallow harbours is likely to be trivial in terms of the impacts of sedimentation from land based erosion, and farm effects are likely be reversible with their removal.

Legislation

Draft aquaculture legislation is proposing to re-tender marine farm sites at the end of their consent tenure (Chappel 2003). This approach is very likely to be difficult for many small farm operators who may not be able to afford such a process, but could be good for the industry overall by increasing efficiency of poorly managed leases. This process is going to cost the industry valuable earnings which otherwise should be going into expansion of the industry, not re-purchasing existing farm space. The infrastructure of the farms and job opportunities however will also be at the whim of the companies that tender for the leases.

Summary and recommendations

Northland is well placed to provide for the expansion of Pacific oyster aquaculture as the region contains some of the most desirable shallow harbours in the country. Short-

term expansion of the industry is likely to come from the full utilisation of underdeveloped existing farm areas as the current moratorium prevents the granting of new marine farm sites. Increased economic returns are also very likely with increases in efficiency with a trend of companies switching to growing single-seed oysters, and new export markets, which both have the potential to increase returns.

The allocation of further farm space through the AMA process is absolutely critical to the future growth of the oyster farming industry in Northland. The industry is well placed to make good use of new farm space and the industry is relatively environmentally benign. It is important therefore that the AMA process carefully considers the benefits of oyster farming expansion, rather than dismiss the opportunities through generalised or unfounded geographical constraints.

It is also important that consideration be given subtidal oyster culture techniques by the AMA process and the oyster industry, as a means of expanding production in new areas, and making better use of existing intertidal farm space. The development of these farming methods will pose more risks and biological challenges that will require industry backed research.

Recommendations

- New intertidal oyster farming areas in a range of Northland harbours need to be established in AMAs to allow for the future expansion of this important industry. A range of areas suitable for the development of subtidal oyster farming also need to be established, preferably in close proximity to existing intertidal farms. Before the oyster industry invests heavily in commercially developing these subtidal areas, they should be tested with oysters for at least a year to determine the oyster pest profile.
- New legislative arrangements for allocating existing and new farm space have the potential to destabilise the existing oyster industry in Northland. Opportunities to comment on the final arrangements will be available through the select committee process and could be pursued further.
- Educational material on the actual impacts of oyster farming as well as the social and economic benefits of oyster farming for the region needs to be prepared and promoted to dispel the myths associated with this activity.
- To improve the efficiency and economic returns of oyster farming in Northland, a survey of oyster densities, and parasites and pests should be conducted, to highlight growing areas where significant education of growers

is required. Such surveys are routinely carried out in Tasmania by their Fisheries department to monitor stocks for unwanted diseases and parasites and pests. A similar system should be advocated in Northland in conjunction with MFish biosecurity surveys.

- In growing areas where there are concerns over shellfish farm sustainability, monitoring and research to evaluate how weather and climatic events affect productivity would be invaluable. Annual variations in productivity should be measured over several years to understand how extremes of climate can affect oyster productivity and stocking densities. This information will be invaluable in the future for managing farms sustainably and maximizing production in good and bad years.
- The oyster industry in Northland needs to lift its skill base and this could be achieved by providing greater opportunities for in-house training, and through stronger linkages between industry and local training providers. One means of retaining educated or industry-trained workers in the industry is to subsidise their training and bond them to the employer for a period so that they impart their knowledge to fellow workers.
- Increased membership of the New Zealand Oyster Industry Association should be encouraged along with regular attendance to industry events and field days to empower the oyster farmers and farm workers to feel a part of their industry and to enhance their education.
- Oyster processors should provide more incentives to lift the quality of the product sent for processing, eg. bonuses for reduced volumes of reject oysters should be more important than for producing large volumes of poor quality oysters.

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