Potential for artificial enhancement of scallops in Northland

NIWA Client Report: AKL2003-038
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Prepared for

Enterprise Northland

Aquaculture Development Group

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Executive Summary

This report was prepared in response to a request by Enterprise Northland for information on the feasibility and potential scale of various aquaculture ventures in Northland coastal waters. We deal here with the potential for enhancement of scallops (the artificial collection and release into the wild of large numbers of juveniles), but not with "conventional" aquaculture.

Scallops grow rapidly and to a large average size in northern New Zealand, and this makes them an attractive proposition for a fishery. However, both growth and recruitment are variable and this leads to an unpredictable fishery. Much of this unpredictability can be smoothed out by enhancement, because it can remove the recruitment "bottleneck" at the larval settlement stage.

Enhancement has been spectacularly successful in the Challenger scallop fishery in Tasman and Golden Bays. A highly variable wild fishery that was completely closed in the early 1980s has been converted to a larger and more consistent fishery with an annual catch close to 700 t (worth more than $10M at first sale). We believe a successfully enhanced Northland fishery could be of a similar size and directly support in the order of 300 Northland jobs.

Trials with enhancement in northern New Zealand have not met with the same initial success as did trials in the Challenger fishery, and have been beset by high mortality of juvenile scallops seeded onto commercial beds. We do not know the exact cause of this mortality but identifying and minimising the causes of initial mortality is probably the key to successful enhancement in Northland. We summarise the steps we believe necessary to move through pilot experimental stages to full scale production. This is likely to take at least 5 years and cost hundreds of thousands of dollars.

1. Introduction

This report was prepared in response to a request by Enterprise Northland for information on the feasibility and potential scale of various aquaculture ventures in Northland coastal waters. We deal here with the potential for enhancement of scallops, a wild fishery for which has existed in Northland since 1980. Enhancement in this context means the artificial collection and release into the wild of large numbers of juvenile scallops. We do not deal with "conventional" aquaculture of scallops in lantern cages or other devices. First, we summarise the biology of scallops in northern New Zealand, and the dependent Northland fishery. Next, we describe how enhancement is conducted and summarise some of the trials that have been conducted on northern populations of scallops. Finally, we consider how, given what has gone before, enhancement might work in Northland, its potential scale, and the steps we consider necessary to realise that potential.

2. General biology of scallops

The New Zealand scallop, *Pecten novaezelandiae*, is one of several species of "fan shell" bivalve molluscs found in New Zealand waters (Bull 1988). They have a characteristic round shell with a flat upper valve and a deeply concave lower valve. Scallops inhabit waters of up to about 60 m deep (up to 85 m in the Chatham Islands), but are more common in depths of 10 to 30 m. Growth rates are spatially and temporally variable, growth to 100 mm taking anything between 1.5 and 3.5 years. The maximum age of scallops in unexploited populations is thought to be about 6 or 7 years.

Scallops are hermaphroditic, that is each individual carries both male and female gonads at the same time. Most individuals are sexually mature at a size of about 60 mm, although larger individuals have disproportionately larger gonads and produce many more eggs than small scallops. They are extremely fecund and can spawn several times each year (although not all of these spawning events lead to successful spat settlement). Planktonic larval development lasts for about 3 weeks, depending on water temperature. Initial spat settlement is by byssus thread attachment to some surface free of sediment (shell hash, hydroids, spat bags etc.). The characteristic scallop shell does not develop until a few days after the spat loses the byssus thread and settles to the seabed.

Scallops grow rapidly (albeit with considerable variation), have high natural mortality, and exhibit highly variable recruitment. Such a life history results in fluctuating biomass, catch, and catch rate (sometimes called Catch Per Unit Effort, CPUE) in most fisheries for scallops, and reliance on relatively few year-classes (Caddy & Gulland 1983, Orensanz et al. 1991, Shumway & Sandifer 1991). New Zealand stocks are not an extreme example, though Cryer (1994) showed that recruited biomass in any given year could not be predicted from historical biomass estimates, nor even from the biomass in the previous year together with estimates of intervening removals by commercial fishing.

Growth of scallops in Northland has not been well-described, although work conducted by NIWA (Cryer & Parkinson 1999) suggests that, on average, scallop grow faster in Northland than they do in the Coromandel fishery. In the Coromandel fishery, scallops tagged and released into shallow water (less than about 15 m) grow much faster than those released into deeper water (depth ranges averaging 20 and 30 m, Figure 1). As well as being generally faster, growth in Northland seems less constrained by depth than it is further south. This accounts for the persistent populations of very large scallops (>120 mm shell length) with few smaller scallops found in deep water, especially in Rangaunu Bay and Spirits Bay.

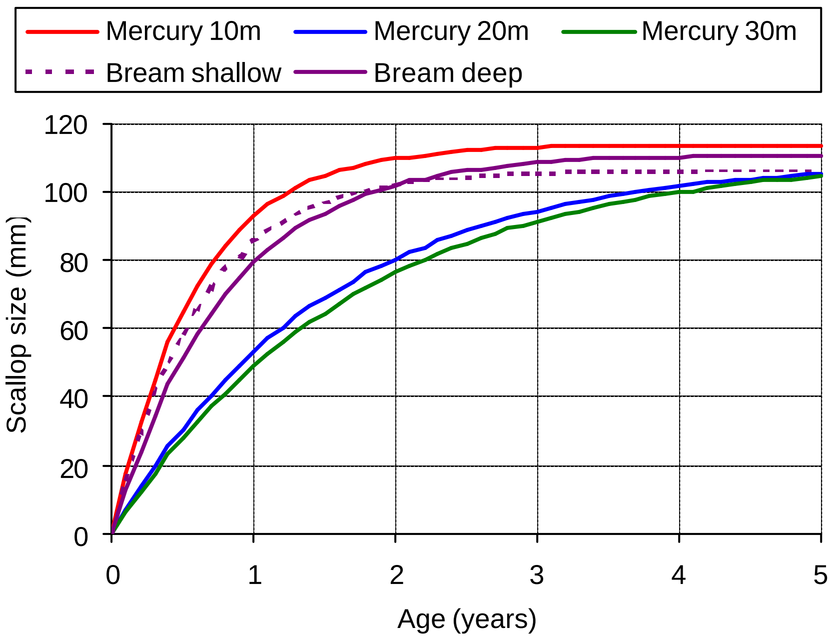

Figure 1: Average growth rates of scallops at various depths in the Mercury Island beds (Coromandel fishery) and in Bream Bay (deeper and shallower than 20 m). There is some evidence that growth in the Far North (especially Rangaunu and Spirits Bay) is faster.

3. History of the Northland scallop fishery

The north-east coast of the North Island support two regionally important commercial scallop fisheries (the Northland and Coromandel fisheries) and are of intense non-commercial interest (Cryer 2002, Cryer & Parkinson 2002). The dividing line between the two commercial fisheries runs from Cape Rodney. The Northland fishery runs from a line between Cape Rodney and the northernmost tip of Great Barrier Island to Tauroa Point (Reef Point) at Ahipara at the southern end of Ninety Mile Beach (Figure 1). Until 1997, when it was introduced to the Quota Management System (QMS), the fishery supported about 38 vessels and their supporting processing factories. The number of vessels participating in the fishery has since declined, but the processing capacity depends on the size of the catch rather than the number of vessels involved. All commercial fishing is by dredge, fishers in both fisheries preferring self-tipping "box" dredges to the ring bag designs in common use in southern fisheries. A wide variety of effort controls and daily catch limits has been imposed in the past, but the fishery is now limited by explicit seasonal catch limits specified in meat weight, together with some additional controls on dredge size, fishing hours, and non-fishing days. The catch limit for the Northland fishery is now formally established as a TACC under the QMS, with a fishing year of 1 April to 31 March. Catch and catch rates are variable both within and among years, a characteristic typical of scallop fisheries worldwide (Shumway & Sandifer 1991). The main beds of the Northland fishery were historically found in Bream Bay, Rangaunu Bay, Doubtless Bay, and from Whangaroa to Matauri Bay. Since 1995, fisheries have developed in Spirits and Tom Bowling Bays, but the beds in Bream Bay and southwards have not been very productive.

Recreational and Maori customary fishing is undertaken in suitable areas throughout both fisheries, more especially in enclosed bays and harbours (Rangaunu Harbour, Whangaroa Harbour, the Bay of Islands, Whangarei Harbour, etc), most of which are closed to commercial fishing. Fishing for scallops by amateurs is by diving, small dredge or, in some circumstances, hand collection from intertidal areas. To an extent, management of northern scallop fisheries has concentrated on spatial separation of commercial and amateur fishers through the closure of harbours and enclosed waters to commercial dredging. There remain, however, areas of contention and conflict, some of which have been addressed through further voluntary or regulated closures. Bradford (1997) estimated the recreational fishers caught 40–60 t (green weight) of scallops in 1993–94 from the area covered by the Northland fishery. Commercial landings in the most comparable period (July 1994 to February 1995 scallop season) were about 1300 t, suggesting that, in that year, the recreational catch of scallops was less than 5% of total removals. This does not mean that the recreational fishery is "insignificant" and there may be significant resistance to any expansion of commercial dredging, even that designed to take advantage of additional enhancement.

The minimum legal size (MLS) for scallops for commercial and amateur fishers throughout the Northland fishery areas is 100 mm. Although commercial fishers in the Coromandel fishery have adopted a 90 mm MLS (to address concerns expressed by all user groups over the impact of scallop dredging on juvenile scallops), there seems little support for such a change in the Northland fishery.

Table 1: Catch limits and landings (t, green weight or meat weight as specified) from the Northland Scallop Fishery in the last 10 years. "W'rei" includes all beds south of Cape Brett, "Far North" includes all beds from Cape Brett to North Cape, and "Spirits Bay" includes all beds to the west of North Cape. –, no catch limits set, or no reported catch (for Spirits Bay)

	Catch limits (t)		Landed catch (t)		Estimated catch (t, green)		
Year	Meat	Approx. green	Meat	Green	W'rei	Far North	Spirits
1983	–	–	–	1 171	78	1 093	–
1984	–	–	–	541	183	358	–
1985	–	–	–	343	214	129	–
1986	–	–	–	675	583	92	–
1987	–	–	–	1 625	985	640	–
1988	–	–	–	1 121	1 071	50	–
1989	–	–	–	781	131	650	–
1990	–	–	–	519	341	178	–
1991	–	–	–	854	599	255	–
1992	–	–	–	741	447	294	–
1993	–	–	–	862	75	787	1
1994	–	–	–	1 634	429	1 064	142
1995	–	–	214	1 469	160	810	499
1996	189	1 508	132	954	55	387	512
1997	189	1 508	126	877	22	378	477
1998	98	785	31	233	0	102	130
1999	98	785	18	132	0	109	23

For poorly understood reasons, biomass and catches from both scallop fisheries have been very low since about 1998 (Cryer 2002). In the Coromandel fishery, low biomass has coincided with poor condition, "black gill" syndrome (Diggles et al. 2000), and a rapid increase (since 1996) of the filter-feeding tubeworm *Chaetopterus* sp. on many of the beds. *Chaetopterus* sp. builds large clumps of parchment-like tubes and renders dredging for scallops impossible (because the dredge fills with tubes and therefore cannot catch scallops). There may have been catastrophic mortality of scallops on some beds (Cryer 2001), but the role played by the expansion of *Chaetopterus* sp. is not known, despite anecdotal reports that scallops do not survive where *Chaetopterus* sp. is abundant. The causes of these apparently major changes to the ecology of the Coromandel fishery are far from clear, but broadly parallel trends in biomass in the Northland fishery suggests that they act on a very broad scale.

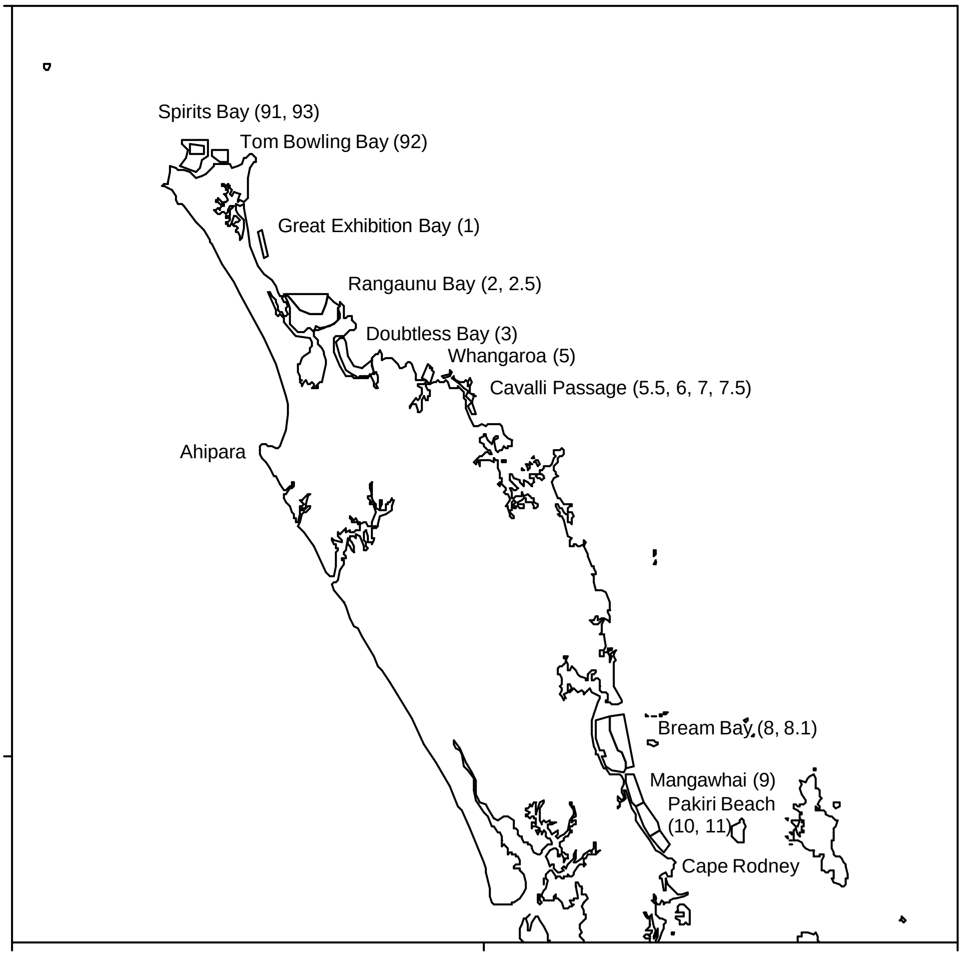

Figure 2: Location of strata for the survey of the Northland scallop fishery 1998. Code numbers for strata are given in parentheses (see Appendix 1 for details and stratum areas).

4. How does scallop enhancement work?

Scallop enhancement involves the provision of large numbers of juvenile scallops to areas of the seafloor that would not normally have received such a number, removing potential natural bottlenecks in juvenile production (Morrison 1999). It can involve both the seeding of areas known to support scallop populations through natural recruitment, and areas where scallop are able to live, but which may have features about them that stop juvenile recruitment (such as lack of larval supply, or lack of larval settlement surfaces).

To collect juvenile scallops for seeding, artificial larval collectors ("spat bags") are suspended in the water column during the season when scallop larvae are abundant in the plankton (summer months). On an experimental scale, spat bags can be suspended from simple "droppers" (single ropes with a float and an anchor), but commercial operations require much more substantial sub-surface long-line systems supporting hundreds of bags each (Figures 3 and 4). Typically, long-lines are 200 m long and support 100 droppers, each with 20 or more spat bags (Bartrom 1990).

Scallop larvae naturally settle from the plankton onto various foliose surfaces (such as red seaweeds and hydroids, (feather-like animal colonies)) as they move from a pelagic to a benthic existence. Spat bags mimic these natural settlement surfaces, and can attract hundreds or a few thousand scallop larvae. Once scallops settle, they are known as 'spat', and remain attached to these surfaces using byssus threads (like mussels). They remain byssus attached until around 3–5 mm, when they release themselves and adopt a free-living existence.

Spat bags are constructed of double bags of fine plastic mesh; the outer is a sock of finer mesh small enough to retain scallops after their byssus release, the inner is composed of a coarser mesh sock that is bunched up to provide a large surface area for settlement. Scallop spat grow quickly inside the bags, feeding on the passing plankton. As they release their byssus threads, they are retained inside the spat bags by the finer outer mesh.

When the spat reach a suitable size for seeding, the bags are retrieved from the long-lines, and the small scallops removed from them and released to the seafloor at densities that aim to gain the best harvest per unit area of seafloor. Experience in the Challenger fishery suggests that about 6 spat per square metre of seafloor is acceptable and leads to good growth and survival. After one or more years of growth, scallops can be harvested by dredging.

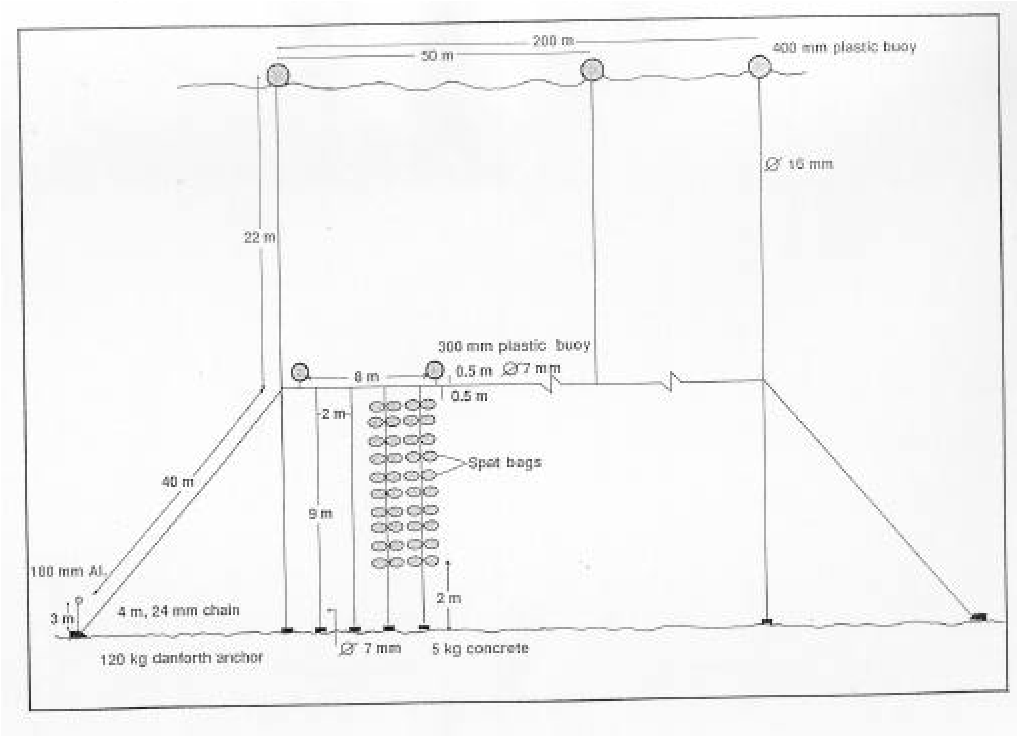

Figure 3: Long-line structure for deploying spat catching bags on a commercial-scale

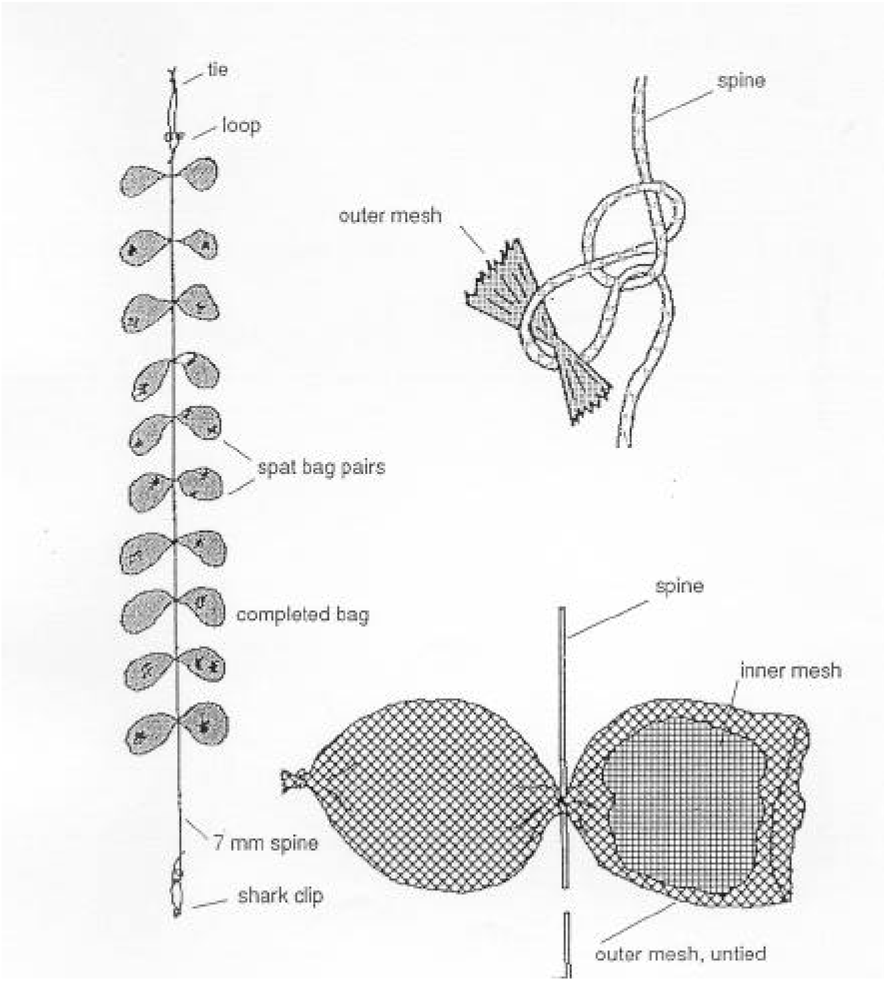

Figure 4: Details of spat catching bags for scallops showing structure and deployment from droppers.

Although the above methods seem straightforward, there are many factors that need to be taken into account for each of the steps involved, to get the best returns from the system. Examples include appropriate selection of spat catching and bottom release sites, handling of spat to minimise mortality, and minimising the loss of scallops to benthic predators. We will cover these areas in following sections.

In New Zealand, successful commercial scale scallop enhancement has been carried out in the Challenger fishery (Golden and Tasman Bays) since 1983, and supports a healthy and productive fishery (which is a mixture of seeded and wild settled stock). However, past attempts to transfer these technologies and their successes to the North Island have not been entirely successful; spat were caught, sometimes in large numbers, but the survival of seeded juveniles was poor. We discuss these efforts, and possible reasons for their failure, below.

5. Trials with scallop enhancement in northern New Zealand

Following successful scallop enhancement of the Challenger fishery, scallop spat catching trials were undertaken in the Coromandel fishery in 1986–87 and 1987–88. These trials were designed to assess where, when and how many spat could be caught in different areas of the Coromandel Peninsula (on both the Firth of Thames side, and the Whitianga side). Spat catches were variable in space and time (a universal feature of such spat studies), but showed that commercial levels of scallop spat catch could be achieved. Spat numbers per bag ranged from 10s to the high 100s but, overall, were lower than those caught per bag in Golden Bay.

Based on these findings, large-scale scallop enhancement trials were run over two summers, from 1987–1989, by the then MAF Fisheries (the fisheries arm of the Ministry of Agriculture and Fisheries). Bulk spat collectors (long-lines) were set to provide sufficient scallop spat for the trials (Bartrom 1990).

About 6 million spat were released in the Firth of Thames in March 1988; their survival by September 1988 was estimated at 3.6%. In 1989, 13.7 million spat were released in Mercury Bay, Whitianga; their survival rate by June 1989 was effectively zero (Bartrom 1990). The reasons for these failures were not clear, but contributing factors appeared to be poor handling of spat during seeding, bad weather (including cyclone Bola), poor selection of release sites, and loss of badly stressed spat to bottom predators. The lack of detailed monitoring of spat mortality and stress throughout each of the different steps (in spat bags, during release operations, immediately post-release, and subsequently on the seafloor) does not allow us to pinpoint the stage at which most mortality occurred. These large-scale trials clearly failed, but we do not know precisely why, and failure with one approach (the Challenger approach) doesn't mean that enhancement of northern scallop populations is impossible. Indeed, we are confident that enhancement of northern scallop fisheries is feasible if mortality at the critical time(s) can be reduced. This means that future work should be directed more at assessing the scallop survival rates during each of the steps, and avoid simply releasing large numbers of spat to the seafloor and "hoping for the best".

Limited work looking at fish predation was also undertaken in tandem with the large-scale Coromandel release (Davies 1989). In a wild setting, scallop spat released to the seafloor at Cooks Beach (near Whitianga) were seen to be eaten by several snapper, a trevally and a goatfish. In a controlled aquarium setting, spat released into Kelly Tarlton's Marine Aquarium in Auckland were eaten by a wide range of fish species, although it should be born in mind these fish were habituated to taking food dropped from the surface, and included several reef fishes that would not be present in (soft-sediment) seeding areas.

Following on from these trials, during 1991–92, the Department of Marine Studies, Bay of Plenty Polytechnic, in association with the Coromandel Scallop Fishermans Association (CSFA), undertook some small-scale spat catching trials close to Whitianga (Brownell et al 1992). Unfortunately, severe problems with their gear set-up, and a new design of collector, resulted in much entanglement, and touching of droppers to the seafloor (giving hermit crabs and other predators access to the spat). The results of this work were limited, but the average catch was only 1.5 scallops per bag (from 745 collectors). These results should not be taken as a good estimate of spat catch rates at that time, as artefacts in the sampling methods were quite substantial.

During 1992–94, spat catching trials were carried out further north, in Greater Omaha and Kawau Bays, in the northern Hauraki Gulf (Morrison 1999). In 1992, high catches were taken across all five sites assessed, with catches ranging from 100 to 3000 spat per bag. In 1993, there was an almost complete recruitment failure to the spatbags, and few spat were caught. This coincided with a large-scale algal bloom event, and heavy scallop mortalities throughout large parts of the Hauraki Gulf. In 1994, higher spatfalls were again recorded, though lower than in 1992. Following this, limited scallop spat catching trials were carried out by northern scallop fishers in the mid 1990's, giving returns of 100s to 1000s per bag.

Morrison (1999) also undertook small-scale spat release trials in Greater Omaha Bay. Because of the scarcity of spat at that time (because single droppers were used rather than bulk long-lines), spat were removed from the spat bags, placed in plastic bags, and released by divers to the seafloor. Spat seemed stressed by this process and, on release to the seafloor, assumed a "gaping" behaviour, and did not exhibit their normal "escape" responses. The release sites were over fine to coarse sand, in 7–16 m depth. Upon release, large numbers of invertebrate predators were immediately seen to erupt from the sediment surface and move towards the seeded spat. These predators included whelks, hermit crabs and two species of starfish. In their stressed state, the spat were unable to avoid the predators, and mortality was high. Some predators were seen to consume more than one spat, and the scent plume seemed to attract predators from downstream of the release site. These observations show that predation of scallops immediately following seeding can be very substantial, and that careful treatment of spat during seeding, and selection of appropriate seafloor release areas, are probably central to maximising survival.

Finally, further research work in Omaha and Kawau Bays was undertaken by Nesbit (1998). Spat catching was carried out at two of the locations monitored by Morrison (1999), using the same collection methods. Spat catches were very low, averaging 6–10 per bag. Release trials were undertaken with these spat onto two sites, one of sand, the other of shell gravel. Almost all of the spat had disappeared from both sites after 2 months. Aquarium trials using invertebrate predators occurring at these sites showed that hermit crabs and starfish could successfully attack and consume most sizes of scallop spat used in the field experiments, resulting in up to 100% mortality over 2 weeks. However, scallops of around 30–40 mm (depending on the predator) seemed much less vulnerable to predation.

In conclusion, studies in northern New Zealand show that spat can be caught at commercial numbers at a range of sites, although spatial, monthly and annual variability is large and needs to be allowed for. One of the major issues yet to be resolved, however, is identifying how to ensure good survival and growth of scallops once they are seeded onto the seafloor. Invertebrate predators seem to be a very important component of initial mortality, and we think that work should be directed at how their impacts can be minimised. Other important factors that we think worthy of investigation are the effects of handling procedures on spat stress and survival, the selection of appropriate release sites, and predation by fish.

6. Potential for scallop enhancement in Northland

Parts of the Northland coastline are well suited to potential scallop enhancement because they have shallow, coastal embayments, and sandy subtidal flats. Two types of factors need to be considered when assessing areas of seafloor for their suitability for enhancement operations. The first is biological suitability — whether scallops can be successfully seeded and grown to harvestable size on the seafloor, and the second is social (human) suitability — whether enhancement operations can be integrated with other uses and functions of the marine environment without undue conflict.

Two types of area are required for scallop enhancement; these are spat catching areas, and bottom seeding areas. The two need not be the same, but do have to be close enough to allow for the transport of scallop spat without too great a stress being imposed on them. The greater the distance between the spat catching and seeding areas, the more problems are likely to be encountered.

Spat catching areas

Spat catching sites need to be identified through deployment of spat monitoring droppers, ideally based on predictions from hydrodynamic models that identify areas where larval retention is likely to be high (e.g. gyres and eddies). Logistics also need to be considered: water needs to be deep enough to allow sufficient numbers of spat bags to be set on long-lines, but not so deep that excessive amounts of long-line gear are required. Spat catching areas also need to avoid exposed sea conditions, and areas of high current flow, as these will damage or destroy the long-lines, as well as cause problems to spat survival. Fouling of spat-bags also needs to be kept to a minimum, to avoid problems of spat being overgrown and smothered, and reductions in scallop growth rates due to reductions in water flow, and food competition with fouling organisms.

From a human perspective, spat catching areas need to avoid areas of high human use. "Socially unsuitable" areas might include sheltered embayments used by pleasure boats, areas where boat traffic is high and navigation might be impeded, and no-anchoring zones such as undersea cable areas. The long-lines needed for commercial scale spat catching need to be in the water from November to about March, coinciding with the peak recreational usage of coastal waters during the holiday season. Visual impacts also need to be considered, although since much of the long-lines are sub-tidal, this is not quite such the problem as encountered in oyster and mussel farming. Finally, areas need to be close enough to the associated land-based operations required to build the long-lines, and store the gear between spat-catching seasons, so that transport of equipment to the spat catching sites is not too onerous.

Areas that will produce good levels of spat supply are not well known in Northland, and trials would need to run across a range of geographically spread sites to identify good collecting areas.

Spat seeding areas

Depth

Scallop growth and maximum sizes can be strongly affected by water depth, although this can vary greatly depending on water clarity and other factors. For instance, in Greater Omaha Bay, Hauraki Gulf (Morrison 1999) and around the Mercury Islands (Cryer & Parkinson 1999), scallop growth and maximum sizes are higher in shallow water (14–24 m depth) than in deep water (deeper than 25 m). In contrast, in many parts of Northland (but especially in the far north), commercial sized scallops are dredged from as deep as 60–70 m water depth, presumably because the waters are less turbid, allowing algal productivity to extend deeper into the water column.

In very shallow water, growth rates may be good, but the probability of stranding from storm events is greatly increased at exposed locations. Wave exposure may set the shallower depth limits for naturally occurring scallop beds, although in very sheltered areas, scallops may be found right up to the inter-tidal mark (e.g. in areas of the Manukau Harbour).

Therefore seeding water depths need to be selected based on local conditions, but in general are likely to range from around 15 to 30 m in depth.

Bottom type

The main soft sediment bottom types likely to be encountered in Northland are sands, muds, and shell gravel/grits. Wild scallop beds can be found on all three, but are generally less common on mud. Sand habitats are probably the most widespread in the shallow waters (less than 28 m) most likely to be used for scallop enhancement. Muds are likely to be less suitable for enhancement because the finer sediments are more likely to be re-suspended during storm events, and this can affect scallops feeding, and may even smother smaller scallops.

Benthic predator assemblages

Predation on seeded scallops is one of the central hurdles to overcome for successful scallop enhancement. Predation losses will be strongly related to the predator assemblages present at a seeding site, integrated with how stressed scallop spat are at the time of release. Seeding sites need to be chosen that minimise the numbers of potential scallop predators present. We already have some knowledge of what species are involved (whelks, hermit crabs, and starfish), and potential release sites should be assessed for the abundance of these predators before selection. Fish predation is much more poorly known, and problematic to address at this time without more knowledge of fish foraging abilities and preferences for small scallops.

Environmental conditions

Scallops are sensitive to effects such as large sedimentation events, significant freshwater run-off (reduced salinities), and reduced dissolved oxygen. Sites need to be chosen that reduce the likelihood of such impacts. This means avoiding areas where run-off from rivers may be significant (particularly during large storm events), or where sediment run-off from the land may result in large plumes extending out to sea.

Existing known areas of scallop abundance in Northland, and their potential suitability for enhancement

Spirits Bay and Tom Bowling Bay

Scallops grow rapidly and to a large size in Spirits Bay and Tom Bowling Bay, and the commercial fishery has sometimes been extremely successful there. The scallops are found mostly between 20 and 60 m depth, but there is a regulated closure in most areas deeper than about 50 m. However, several factors suggest that this is not likely to be a suitable area for routine enhancement. The area is very exposed to strong winds and large ocean swells, has exceedingly powerful tidal flows, and is frequently unfishable for most scallop dredgers. Spirits Bay, especially, is remote and is several hours steam from the closest port (Houhora). The area previously surveyed for scallops is quite large, but there are many obstructions including patchy rocky reefs and coral “knobs” that can damage fishing gear. Finally, the area has great cultural significance for Maori and has many highly unusual and fragile “epifauna”, including corals, sponges, colonial hydroids, and bryozoans (Cryer et al. 2000). Increasing fishing pressure in this area though enhancement could be detrimental to this unique fauna.

Great Exhibition Bay

Great Exhibition Bay has occasionally produced reasonable catches of large scallops in the past, and the available area is of a reasonable size (probably larger than the area surveyed in the past). The bottom is mostly of flat sand with few obstructions. Great Exhibition Bay is readily accessible from Houhora.

Rangaunu Bay

Rangaunu Bay consistently produces good catches of large scallops, and the available area is large. The bottom is mostly of flat sand with few obstructions, although there is a reefy area in the middle of the bay and an area of small islands, rocky outcrops, and red seaweeds to the east of the bay that may not be suitable for increased fishing effort. Rangaunu Bay is readily accessible from Houhora.

Doubtless Bay

Doubtless Bay has occasionally produced catches of large scallops and, in one year in the late 1980s, supported much of the commercial fleet for several weeks. had and the available area is of a reasonable size (probably larger than the area surveyed in the past). The bottom is mostly of flat sand with few obstructions. Doubtless Bay is readily accessible from Mangonui.

Stevenson Island and Whangaroa Harbour

The area between the mouth of the Whangaroa Harbour and Stevenson Islands produces good catches in many years, though they tend to be rather small by Northland standards. The area is relatively small and is a mixture of flat sand, shell hash, and dog cockle beds. It is readily accessible from Whangaroa.

Cavalli Passage

The several scallop beds of the Cavalli Passage (between about Stevenson Island and Takou Bay) are all quite small, and sporadically produce scallops of variable size. Sometimes the scallops are very large, but they are rarely dense. There bottom is highly variable in substrate type and depth, and there are some obstructions to fishing. The area is accessible from Whangaroa, though with a moderate steam. There is an intense amateur interest in scallops inside the Cavalli Islands.

Bay of Islands

The Bay of Islands supports a significant amateur fishery for scallops, but is closed to commercial dredging. There would probably be significant resistance to any relaxation of this closure.

Bream Bay

Bream Bay has, in the past, supported an excellent commercial dredge fishery for scallops, although the scallops tend to be small by Northland standards. Biomass and commercial catches of scallops from Bream Bay have been very low for several years. There is a large area of flat sands and the bay is readily accessible from Whangarei.

Mangawai and Pakiri Beach

The area between Bream Tail and Cape Rodney has, in the past, supported reasonable fishing, although the scallops tend to be small by Northland standards. Biomass and commercial catches of scallops from this area have been very low for several years. There is a reasonable area of flat sands, and the area accessible from Whangarei or Leigh with a moderate steam.

Little Barrier Island

There is a small area to the north of Little Barrier Island that is within the Northland scallop fishery (as defined for Quota Management purposes) that supports scallops, but the area is so small and so remote that it is probably not worthwhile considering this as a site for enhancement. However, if "Northland" is interpreted more liberally, then reasonably extensive scallop beds can be found along the western and southern sides of the island, even though these are within the Coromandel scallop fishery. If some sort of collaboration between the two fisheries can be organised, then this distinction becomes less relevant.

West Coast (Cape Reinga to Tauroa Point)

The west coast is largely an unknown quantity as far as wild scallop resources are concerned. There has undoubtedly been some exploratory fishing there, but there is no published information on the distribution, density, or growth of scallops. Many factors combine to suggest that the area is not a good candidate for enhancement; the whole west coast is highly exposed to New Zealand's prevailing south-westerly wind and subject to large southern ocean swells, there is no good access for vessels tending spat catching equipment or dredging the mature scallops, and there is no good evidence that the area is biologically suitable for scallops in the necessary high densities.

7. Potential scale of scallop development in Northland

It is not easy to assess the potential scale of an enhanced Northland scallop fishery, but we offer a few projections based on what we know of suitable seabed areas, the historical performance of the fishery, and the price of scallops.

The most suitable areas would appear to be Rangaunu Bay and Bream Bay, both of which have supported substantial scallop dredge fisheries in the past. Their combined area is close to 400 km^2 so, assuming a three year rotation (seed one year, leave fallow the following year, and harvest in the third year) and the exclusion of about one-quarter of the area as in some way unsuitable, the fished area each year would be about 100 km^2. If an enhanced density of 0.5 harvestable scallops per square metre of seabed can be achieved, and the average recovered weight of meats from a scallop (at the current minimum legal size of 100 mm) is 15 g, the fished area could provide up to 50 million scallops annually, generating 750 t of processed product with a first-sale value (at \$15 kg^{-1}) of over \$11M. Some or all of these figures may be optimistic, but they serve to demonstrate that an enhanced Northland scallop fishery could be on a similar scale to the current (enhanced) Challenger fishery, where the TACC (Total Allowable Commercial Catch) is 720 t (of processed product). At a survival rate of 20% from seeding to harvest (e.g., Bull 1991, using early figures from the Challenger fishery), 250 million spat would be required, probably from something like half a million spat catching bags. Bartrom (1990) reported that 12 subsurface long-lines were required to catch 40 million spat in the Challenger fishery, suggesting that something in the order of 70 long-lines would be required for a full, commercial-scale enhanced Northland fishery. None of these numbers is precise, but they are based on the development of just two of the several bays supporting the current commercial fishery.

Historically, the Northland fishery averaged a little over 100 t of processed product annually, supporting more than 30 boats. In a good year, the total catch would be closer to 200 t, and the "share" for a vessel would be about 6 t. Based on these figures, an enhanced Northland fishery might support over 100 (relatively small) dredge boats, generating catches similar to the "good" years of the wild fishery, but with a good deal more certainty and less variability between years. If each of these small boats has a skipper and one other crew member, and also requires one other person in a processing factory (to "shuck" the scallops), the enhanced fishery would directly support more than 300 jobs in Northland. There would undoubtedly be downstream benefits for supporting industries and employment. This development might occur as an expansion of existing catching and processing facilities, or the development of new facilities and jobs, probably in and around Houhora and Whangarei.

8. Identification of risks and steps towards commercial profitability

Given our fragmentary knowledge of the reasons for the failure of direct seeding trials in the late 1980s, we think that several years of trials and experiments are required to assess the feasibility of large-scale commercial operations and address potential production bottlenecks. We suggest the following time-line to develop large-scale scallop enhancement in Northland.

Year 1

Desk-top study to identify potential areas for scallop spat catching, and seeding

The spatial nature of scallop enhancement suits the use of Geographic Information Systems (GIS) to identify preferred areas for commercial operations. Spatial data that are likely to already exist, and that will be of use, include bathymetry, existing scallop beds and associated commercial fishing activity, zoning restrictions, undersea obstructions such as power cables, and human usage of different areas (i.e. navigation channels, mooring areas). Much of this data may already by held by regulatory bodies such as the Northland Regional Council, the Ministry of Fisheries, and the Department of Conservation. Using this data, and incorporating other factors such as distance from servicing ports, wave exposure, bottom types, and current dynamics, a range of locations can be selected for investigation as spat catching and/or seeding sites. Regulatory restrictions will need to be explicitly incorporated into this analysis. The use of GIS will also allow for factors such as travelling times between spat catching and seeding areas, and the potential area of seafloor available for seeding (binned by factors such as water depth) to be assessed and used in the area selection process.

It will be vital to consult widely with potentially affected or involved groups during this process, to ensure that locations are chosen for investigation that will be available for use, should full-scale enhancement proceed. There is little value in assessing locations that will not be usable.

Ideally this work should be completed over the autumn/winter months, allowing for sufficient time to plan and implement field trials the following spring/summer (spat bags need to be in the water around early December at the latest).

Spat catching trials

Based on the findings from the desktop analysis, up to a dozen locations along Northlands east coast should be chosen for assessment as spat catching areas. These locations should be sufficiently geographically spread to support a range of potential seeding locations (also selected through the desk-top analysis). Such a geographic spread also allows for spat catching sites to cover the range of known scallop aggregations occurring along the Northland coast, which logically provide the spawning populations needed to produce scallop larvae.

Individual spat droppers should be set at each of these locations (in clusters of 4 or more to allow for statistical replication, and potential gear losses), to assess when and how many spat can be collected. This assessment process is well established, and has been used widely elsewhere, both in New Zealand and internationally. These droppers are readily deployed and retrieved from small coastal vessels with winching capacity. The droppers should be set over overlapping time periods during the spat season, to assess where and when the highest numbers of spat can be collected. These results can be used to assess the relative spat collecting value of different locations, and to determine how many spat bags need to be set to achieve a desired number of spat for seeding (and associated gear costs)

Year 2 and beyond

Continue spat collecting trials

Spat numbers often vary considerably from year to year at any given location, and it is important to allow for this variability in large-scale spat production operations. A subset of the year 1 sites (those with the best catches) should continue to be monitored for spat catches, using the same deployment periods as established in year 1.

Deployment of small scale bulk spat long-lines

At several of the best sites identified for spat collection from year 1, sufficient spat-bags should be set to provide a supply of spat for bottom seeding trials, using bulk long-lines. The number of bags required will be determined by the catch per bag, and the extent of seafloor proposed to be seeded. Monitoring of the spat collecting long-lines should also be undertaken, to assess survival and growth of spat on the long-line, and the impacts of any fouling from other marine organisms, through time. This information will assist in determining the optimal trade-off between getting spat to the largest size possible before seeding, versus potentially increasing mortality due to crowding in the bags, and competition or predation effects from other organisms in the bags. Generally, the larger the spat upon release, the better their chances of survival.

Small scale seeding trials

Using locations selected from the GIS analysis, small release plots should be chosen for seeding. The size of the plots will depend on the number of spat available, but should be of sufficient size to avoid scale effects (such as swamping of seeded scallops by predators from outside the seeding plot) i.e. of at least 250 x 250 m extent (62 500 m^2). Plots should be spread across different bottom types and depths, and replicated (more than 1 plot per habitat/depth combination). Scallop survival will need to be assessed during all phases of the seeding operation (in the spat-bags, during retrieval and transport, immediately after seeding, and until commercial harvest size is reached). This should include the relative effects of different predators, or environmental events, on seeded scallop losses. This will avoid the situation encountered at the end of the 1987–89 Coromandel seeding trials, where the relative contributions of one or more factors to the eventual failure of the trails was not able to be assessed. It may prove that only one or two factors play a pivotal role in determining whether seeding ultimately succeeds or fails; we need to identify these factors if we are to mitigate or eliminate them.

Monitoring will need to continue through until the seeded scallops reach a harvestable size. It will need to include an assessment of the possible movement of scallops out of the release plots (due to the plots relatively small sizes, as opposed to full scale operations, which may extend over several kilometres). Seeded scallops can be distinguished from natural spat through a disturbance ring that is laid down in the shell at the time of seeding.

Harvesting by dredges of each of the plots (assuming that sufficient scallops remain to allow for harvesting) will provide an economic assessment of yield versus production costs by plot (habitat/depth combination).

The results from these small-scale seeding trials can then be used to identify what the most suitable release sites are, what the likely economic returns will be, and what factors might be actively managed to improve the survivorship and growth of seeded scallops. The overall time scale of this work is likely to be around 5 years, but results will become available on the likely success or failure of scallop seeding around the end of year 3; allowing for commercial decisions to be made on whether to step up spat production and the extent of seeding efforts. Limits on this time scale are all biological (Table 2) because scallops may take up to 3 years to grow to harvestable size).

Table 2: Likely timescale for development of enhancement capability for Northland.

Year	Desk-top	Spat trials	Bulk spat collecting	Seeded scallop monitoring	Harvest
Year 1	Undertake desk-top study	Nov–March: deploy/retrieve spat droppers			
Year 2		Nov–March: deploy/retrieve spat droppers	December: Deploy bulk spat long-lines	Feb–March Seed scallops Ongoing benthic monitoring	
Year 3		Nov–March: deploy/retrieve spat droppers	December: Deploy bulk spat long-lines	Feb–March Seed scallops Ongoing benthic monitoring	
Year 4				Ongoing benthic monitoring	Dredge year 2 plots for harvest
Year 5	Assess economic viability based on all data available			Ongoing benthic monitoring	Dredge year 3 plots for harvest

9. Potential planning, regulatory and treaty obstacles

Commercial scale scallop enhancement at the top of the South Island is managed by the Challenger Scallop Enhancement Company Ltd. The company consists of all of the scallop fishery quota owners for the fishery as shareholders on the basis of one share per person. Voting rights in the company are on the basis of the size of the quota holding. Through a commodity levy on the production from the fishery commercial revenue is derived to run the company. The company takes responsibility for the seeding operations as well as much of the research to develop and manage the enhanced scallop fishery. The company holds a resource consent which allows them to deploy spat catching equipment which is moored on the seabed. A spat catching permit has also been obtained from the Ministry of Fisheries to allow the catching of scallop spat for relaying onto other areas of the seabed. A special permit from the Ministry of Fisheries also allows the company to use dredges below and around the spat catching equipment to recover large numbers of juvenile scallops that fall from the spat catching equipment onto the seabed. The special permit also allows the company to conduct dredge surveys which are an important component of assessing and managing the fishery.

The scallop fishery in Northland also runs an enhancement company in the same manner that the Challenger fishery does. The Northland Scallop Enhancement Company Ltd was formed in the 1990's as part of the introduction of the fishery into the quota system. The current focus of the company is to represent the quota holder's interests in the management of the fishery, including biotoxin monitoring of the scallop beds. An informal levy is collected from scallop processing sheds with the consent of every fisher and used to fund the activities of the company. The company is currently considering establishing a commodity levy for the quota holders which may include an increased levy to fund greater enhancement activities for the fishery. To establish a commodity levy in Northland in order to finance a similar scallop enhancement programme would require over 50% of the scallop quota holders by number and by quota holding to agree to the introduction of the levy. The commodity levy could be collected directly from quota holders by the Seafood Industry Council. The company is also currently looking to appoint a professional manager to manage the affairs of the company which may also help to focus the development efforts of the fishery.

10. Needs for education, training and skill development

The infrastructure required for large-scale scallop bottom enhancement already exists (in part) for the Northland region, as a result of the existing scallop fishery, and aquaculture operations involving mussels and oysters.

If it were shown that commercial scale operations are viable, and funding is available to proceed, then it would be appropriate to appoint a Project Leader to oversee and be responsible for the various tasks and operations required. People appropriate for such a role already exist in the fisheries and aquaculture sectors. Perhaps the biggest challenges in such an operation are the logistics required to assemble the large amounts of gear required, to deploy it into the field under tight, biologically set deadlines (periods of spatfall), and to release the spat from the bags at an appropriate size. Thus choosing the right person for this role would be a critical and central step in getting a successful operation running.

Construction of the long-lines backbones and the spat-bags will require dedicated labour over a period of several months, but is comparatively unskilled work and can be taught to staff relatively easily.

Setting of the gears in the field is a less straightforward task, and required vessel skippers and crews with appropriate skills. Given the scallop fishers and others who already operate in Northland and Coromandel, the best way forward would be to utilise their skills and vessels. Mussel and oyster aquaculture barges and staff would also be useful for setting out the gear required.

Once scallops are seeded to the seafloor, ongoing monitoring of their survival and growth is an important element of refining operations and improving final yields over the longer term. This could be part of the Project Leaders responsibilities, assisted at times by others well versed in sampling and monitoring shellfish population dynamics.

At the time of harvest, scallops will need to be retrieved by dredging. The wild scallop fishery already has a fleet of such dredging vessels; integration with them for harvesting would be the most efficient option. Processing of scallops would best be done by existing processing factories, who not only have the staff and facilities to handle the catch, but also the marketing and transportation networks required to get the best returns on the final product.

In conclusion, the most effective way forward for large-scale scallop enhancement in Northland should involve integration with existing seafood sector operators. Given the highly seasonal nature of the work required, contracting in of appropriate staff and facilities when required would be the preferred option.

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Appendix 1: Parameters of length based von Bertalanffy growth equations estimated by the GROTAG method (Francis 1988) using tag-recapture data from the Northland and Coromandel fisheries between 1992 and 1997, and subsets from the Mercury Islands and Bream Bay at different depths. g40 and g95 are the estimated average annual increments (mm) for scallops of 40 and 95 mm at tagging, and L_∞ and K are the estimated parameters of von Bertalanffy growth equations. After Cryer & Parkinson 1999.

Data	g40	g95	L_∞	K
1992–97 all data	51.4	11.1	109.8	1.392
Coromandel only	49.9	10.3	108.8	1.366
Northland only	52.9	11.7	110.6	1.382
Mercury, 10 m depth	60.1	15.1	113.5	1.700
Mercury, 20 m depth	33.7	6.8	109.0	0.669
Mercury, 30 m depth	31.2	6.8	110.3	0.588
Bream Bay, 18 m depth	53.0	8.8	106.0	1.626
Bream Bay, 21 m depth	50.6	11.4	111.0	1.247

Appendix 2: Approximate biomass of scallops at the time of survey in the Northland fishery since 1992. Total includes data from beds not mentioned specifically. *, unreliable results; –,no survey.

Year	Spirits	Rangaunu	Doubtless	Whangaroa	Cavalli	Bream	Pakiri	Total
1992	–	750	100	–	50	1 700	400	3 050
1993	–	–	100	150	50	550	–	1 050
1994	–	950	150	50	–	400	0	1 550
1995	–	1 000	100	250	150	350	0	1 900
1996	2 800	850	50	100	100	200	–	4 100
1997	1 800	1 100	100	100	100	–	50	3 700
1998	550	650	50	50	100	0	–	1 450
1999	–	–	–	–	–	–	–	–
2000	–	–	–	–	–	–	–	–
2001	600	750	0	0	–	100	–	1 450
2002	1 200	1 000	–	0	–	550	–	2 750

Appendix 3: Stratum definitions from NIWA survey of Northland scallops, 1998 (after Cryer & Parkinson 1999)

Stratum	Location	Area (km^2)
91	Spirits Bay (Low density area)	61.8
93	Spirits Bay (High density area)	12.6
92	Tom Bowling Bay	22.1
1	Great Exhibition Bay	64.1
2	Rangaunu Bay (Inner)	111.6
2.1	Rangaunu Bay (Outer)	72.3
3	Doubtless Bay	52.9
5	Whangaroa Bay (Stevenson Island)	12.3
5.5	Flat Island	3.6
6	Cavalli Passage	9.1
7	Matauri Bay	4.9
7.5	Takou Bay	5.9
8	Bream Bay (Inner)	102.7
8.1	Bream Bay (Outer)	73.7
9	Mangawhai	36.5
10	Pakiri (North)	42.5
11	Pakiri (South)	25.3