Proposed Mussel Spat Catching Facility

Supplementary Ecology Report

Te Tahuna o Aotea Moana Marine Farms

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EXECUTIVE SUMMARY

This report supplements and supports an original report on the ecological impacts of a proposed mussel spat catching facility within Aotea Harbour. The location and operation of the proposed mussel spat catching facility are described and presented along with an examination of the seabed environment and biological communities in the immediate vicinity. The potential effects of the proposal on seabirds and marine mammals are discussed including the potential for habitat exclusion and entanglement effects.

The biosecurity risks associated with the proposal are presented and discussed along with suggestions for a Biosecurity Management Plan to manage those risks. The water column effects of the proposal are presented and discussed with an assessment of the likely overall effects based on current research and monitoring results from intensive mussel farming operations.

The location and the type and scale of operations for this proposed mussel spat catching farm appear to provide for the avoidance or minimisation of these potential adverse effects. Any adverse effects on seabirds are likely to be less than minor and there is the potential for mild positive effects in terms of roosting sites and for piscivorous seabirds. Adverse effects on marine mammals are unlikely and the potential for entanglement issues for both seabirds and marine mammals is extremely low.

Any potential biosecurity effects can be adequately addressed through the formulation and operation of a Biosecurity Management Plan. Any water column effects that might arise from the proposal are likely to be impossible to measure in the field.

1 INTRODUCTION

Te Tahuna o Aotea Moana Marine Farms ('the applicant') has made an application for resource consent for a mussel spat catching facility within Aotea Harbour. A technical report presenting the results of an investigation into the ecological implications of this application and an analysis of the effects that are likely to result from the proposal was prepared in January 2017 (White, 2017). This report is designed to supplement and support that original technical report by expanding upon some of the analysis and discussion, and by presenting and discussing further information to clarify the expected effects of the proposal should resource consents be granted.

1.1 Spat Catching

"Spat" is the term applied to larval and juvenile forms of, in this case, New Zealand greenshell mussel (*Perna canaliculus*). *P. canaliculus* is a native New Zealand species that occurs around the coastline of mainland New Zealand. *P. canaliculus* mostly occurs below the intertidal zone but can occasionally be found intertidally. *P. canaliculus* is a filter feeding, bivalve mollusc that feeds on planktonic organisms by filtering them from the seawater it pumps through its respiratory and feeding systems. *P. canaliculus* reproduces by broadcast spawning sperm and eggs into the water column where the eggs are fertilised and develop into microscopic, free-swimming, planktonic larvae that drift through the coastal currents until they find a suitable substratum to attach to, transform into a sessile phase and develop into mussels.

The New Zealand mussel aquaculture industry relies on a source of larvae, or spat, to provide the stock that is then on-grown or cultivated to a commercially harvestable size. To date the majority of spat (around 270 tonnes or 80% of the spat required for the mussel aquaculture industry) has come from beach-cast seaweed collected from Ninety Mile Beach in Northland. The entire industry is heavily dependent upon natural spat fall events and variation in timing and quantity of these natural spat fall events represents a significant commercial risk for the industry. A key alternative methodology for spat collection is the suspension of "hairy" ropes in the water column at strategic times to allow mussel larvae to settle on to the ropes.

One of the less recognised risks to the mussel aquaculture industry is the consequence of restricted genetic diversity. The propensity of *P. canaliculus* to genetic issues can be mitigated by high connectivity among mussel populations and by sourcing progeny from wild populations in multiple areas.

Mussels reproduce at different times of the year and to varying degrees however, the main spawning period is usually at the beginning of, or during, winter after which the mussels "hibernate" or experience a period of reduced activity and productivity due to the colder water temperatures. Accurate prediction of spawning activity is impossible, but spawning is usually triggered by changes in weather and cooling coastal water temperatures and close monitoring of these conditions can suggest when mussel spawning activity is likely to occur. The quantities of spat in an area will depend to a large extent upon the mature adult populations of mussels in the locality. The applicants are confident through local knowledge and experience of the existing mussel spat catching facility that there are sufficient populations of adult mussels in the area to support a additional spat catching facility of the size proposed.

With spat catching facilities, "hairy" spat catching ropes are suspended in the water column at times when it is predicted that a spawning event may occur. If, however, the ropes do not catch spat as anticipated, they are then removed from the water and re-set prior to the next predicted spawning event. By only setting ropes when mussel spawn are likely to be caught, the incidental fouling on the spat catching ropes is kept to a minimum. Excessive fouling of the spat catching ropes makes it impossible to slip the spat for reseeding without damage. While the buoys and backbones and their anchoring systems would be permanently established, the spat catching dropper lines would only be deployed as needed.

There is an established demand for mussel spat from Aotea Harbour, particularly for the mussel farmers of the Coromandel area. Spat from Aotea Harbour can be transported to Coromandel farms, stripped and re-seeded within relatively short timeframes and has a proven track record of low mortality. This lower mortality rate may be due to the minimal handling and short timeframes between harvest and re-seeding. Advantages of establishing an additional spat catching facility Aotea Harbour include the risk reduction through a diversified source of spat for the industry as well as considerably shorter handling and transportation timeframes for local mussel farmers. In the past few seasons there has been particularly high mortality of spat sourced from Northland with an almost total failure of Northland spat. The establishment of an alternative spat supply helps to reduce the reliance on a single source of spat and consequently reduces the risks to the viability of the whole mussel aquaculture industry. It has been shown that spat caught from Aotea Harbour are not only be more resilient than wild caught spat from beach cast seaweed but managed spat catching reduces biosecurity risks and provides more commercial certainty for the local industry.

The Gazette No. 10699 Fisheries (Declaration of Species as Spat Notice (No.2)) 1993 defines greenshell mussel spat as being of less than 40mm shell width. This accounts for both the microscopic larval forms of the mussel spat and the metamorphosed forms of the juvenile mussels up to a size whereby they can effectively be handled with a reasonable chance of survival. Once the spat have developed to a size of 35-40mm shell width, they can be slipped from the spat catching ropes and seeded onto growing ropes. At a size of less than 35mm shell width the mussel spat are not hardy enough to survive the slipping and handling processes required for re-seeding. The mussel spat can take from 6 to 9 months to develop to the 35mm size depending upon the time of year and conditions including phytoplankton productivity, water quality and ambient water temperatures.

While the aquaculture industry defines greenshell mussel spat in functional terms, the Waikato Regional Council has a different definition of mussel spat. From a resource management point of view, the Waikato Regional Council considers mussel spat to be the microscopic free swimming mussel larvae and the newly metamorphosed forms of juvenile mussels. In terms of resource management, Waikato Regional Council considers that the development of the newly settled mussel larvae to a size where they can be successfully slipped from the spat catching ropes and seeded onto growing ropes is the on growing of mussels, which is a separate activity from the catching of mussel spat.

In the area proposed for spat catching by the applicants, the on growing of mussels is a prohibited activity under the Waikato Regional Council's Regional Coastal Plan. This means that the proposal for spat catching must involve the short term deployment of spat catching ropes at times when mussel spawning events are predicted, assessment of the ropes for suitable spat collection and subsequent removal and relocation of the ropes to an area in which resource consents are held for the on growing of mussels. This shift in the proposal was made after the original ecological report was written.

The analysis contained within the original report was based upon the expected effects resulting from the collection of spat and development of the mussel larvae to a size suitable for slipping and reseeding (35-40mm shell width). The ecological effects of developing the mussel larvae to a size suitable for handling are likely to be considerably greater than for the deployment of spat catching ropes and relocation of ropes after a period of two weeks or so. The temporary deployment of spat catching ropes severely reduces or virtually eliminates the potential for ecological effects resulting from biological waste from the developing mussels, long term shading, hydrodynamic disturbance, planktonic depletion, etc and dramatically reduces potential interaction effects with seabirds and marine mammals.

1.2 Proposal

The applicants propose the establishment of a single, five-hectare block of mussel spat catching facility in the waters of Aotea Harbour. The proposed area for the spat catching facility includes all buoys, anchors and structures. It is proposed that screw anchors of a suitable size and construction would be established in the seabed with anchoring lines extending to the surface to buoys and backbone lines that would support spat catching dropper lines as required.

The proposed spat catching structures would be sited within Aotea Harbour, approximately 1km east of Aotea township and would be additional to the two small mussel spat catching facilities already operating in Aotea Harbour.

Figure 1: General location of proposed spat catching facility (yellow star) in relation to Aotea and Kawhia Harbours.

The main periods of spat catching are the months of September and October with a secondary period in March and April. The times of mussel spawning activity can vary each year, however, it is anticipated that spat catching will be undertaken mainly during these months. Initially it is anticipated that 5 spat catching long lines, or approximately 10,000 metres of catching rope, would be deployed. Once the ropes have been deployed, they would be checked on a weekly basis for spat fall. Ropes would then be transported to the Coromandel area for on growing of the juvenile mussels.

2 BENTHIC HABITAT

A full description of the benthic habitat was undertaken in the original ecology report, including sediment grain size distribution data, sediment chemistry and the results of a benthic biological sampling exercise (White, 2017). For the purposes of clarity, some of that information will be repeated here.

Aotea Harbour is located on the west coast of the North Island within the Otorohanga and Waikato Districts of the Waikato Region, just north of Kawhia Harbour. Aotea Harbour is a semi-enclosed, tidal water body and is relatively sheltered from the high-energy environment of the exposed west coast. The Harbour comprises an area below mean high water springs (MHWS) of 31.9 km^2, or 3190 hectares, and of that 74% (or 2361 hectares) is intertidal (Lundquist et al, 2004). This leaves 829 hectares of Aotea Harbour as subtidal habitat. The proposed spat catching facility has a total footprint of 5 hectares, or 0.60% of the subtidal habitat within Aotea Harbour.

The entrance to Aotea Harbour has a mobile bar and the entrance channel shifts under complex coastal processes. The main channel within the inner harbour is relatively stable and remains fixed, however, a network of sub-channels within the harbour can shift over relatively short time periods. The water depth within the Harbour is relatively shallow and does not generally exceed 10 metres at low tide.

Aotea Village is located on the southern headland near the Harbour entrance. On the northern side of the main channel to the Harbour entrance (opposite Aotea Village) are large sand hills gazetted as the Aotea Scientific Reserve. The harbour margins and steep surrounding catchments have large tracts of native bush and exotic pine forest as well as developed farmland.

Two existing mussel spat catching facilities are located in the main channel of the inner Harbour between Pourewa and Tahuri Point, to the east of the Aotea township. At this location the channel is generally between 3 and 8 metres depth at low tide and is subject to relatively high tidal currents of up to three knots.

The proposed location for the mussel spat catching facility is shown in Figure 2. The five hectare block would be approximately 300m eastward of the nearest of the two existing spat catching facilities in a channel in about 4-6 metres depth over a seabed of sand and broken shell gravel. In this area of relatively shallow depth and moderate to high tidal currents, it is expected that there will be good circulation of water through Harbour tidal exchange and wind-driven currents. Flushing in this area is anticipated to be very good.

2.1 Seabed Survey

The seabed in the vicinity of the proposed spat catching facility appeared, from attempts to collect sediment samples, to be hard packed black sand armoured by broken shell gravel. The depth in the area of the proposal ranged from 4 to 6 metres at the time of survey (7 November 2016). Local knowledge suggests that no significant seabed features were located within the proposed marine farm sites (R. Dockery, pers comm, T. Awhitu, pers comm). The persistent turbidity of the Harbour waters and general very poor in-water visibility prevented any visual, photographic or videographic surveys of the seabed.

2.2 Sediment Quality

Samples of the sediments in the area proposed for the spat catching facility were collected using a boat operated box dredge. Samples were collected from the locations listed in Table 2.1 and are displayed on Figure 3. At each of the sampling locations a single sample was collected and each sample was chilled and despatched to Hill Laboratories for analysis. Each sample was analysed for grain size distribution, total nitrogen and total recoverable phosphorus concentrations.

Table 2.1: Locations of sediment sampling sites (lat/long**)**

Sampling Site	Latitude	Longitude
AH1	38° 00.280’ S	175° 50.578’ E
AH2	36° 00.424’ S	175° 50.369’ E
AH3	36° 00.502’ S	175° 50.141’ E

2.2.1 Sediment Grain Size

Each of the samples was analysed by Hill Laboratories for a seven grain size profile by wet sieving and gravimetry. The results are presented in Table 2.2 together with the classification based on the principle grain size fraction modified by the next most important grain sizes. This classification is given as letter codes. For example, a sample consisting mostly of sand with a significant proportion of gravel would be classified as **gS** (gravelly sand). If the sample had a mud component it would be classified as **(m)gS** (slightly muddy gravelly sand).

Figure 3: Locations of sediment sampling sites

Table 2.2: Results of sediment grain size analysis

Sediment Grain Size	Description	AH1	AH2	AH3
≥ 2mm	Gravel	20.9	0.8	<0.1
< 2mm, ≥ 1mm	Very Coarse Sand	0.6	0.4	<0.1
<1 mm, ≥ 0.50mm	Coarse Sand	0.4	2.1	<0.1
<0.50mm, ≥ 0.25mm	Medium Sand	11.9	63.6	35.0
<0.25mm, ≥ 0.125mm	Fine Sand	52.6	29.3	58.5
<0.125mm, ≥ 0.063mm	Very Fine Sand	9.4	1.3	3.5
< 0.063mm	Mud	4.1	2.5	2.9
Total		**100.0**	**100.0**	**100.0**
Classification		**gS**	**S**	**S**

The subtidal sediments in the area of the proposed spat catching facility are classified as gravelly sands or sands.

2.2.2 Sediment Chemistry

Each of the composite sediment samples was analysed by Hill Laboratories for total nitrogen and total recoverable phosphorus. The results are presented in Table 2.3.

Table 2.3: Results of the chemical analysis of composite sediment samples

Parameter	units	AH1	AH2	AH3	ANZECC	
					ISQG-Low	ISQG-High
Total nitrogen	g/100g dry weight	<0.05	<0.05	<0.05	-	-
Total recoverable phosphorus	mg/kg dry weight	640	570	640	-	-

No sediment quality guidelines exist for nutrients in marine sediments, however, these parameters were measured to determine the baseline nutrient concentrations in the area proposed for the spat catching facility. There is an accepted stoichiometric ratio of nitrogen to phosphorus, which has been determined from examination of oceanic phytoplankton to be 16:1 total Nitrogen to Phosphorus. The accepted argument is that at nitrogen to phosphorus ratios less than 16:1 that nitrogen is a limiting factor to algal growth while at ratios higher than 16:1 that phosphorus is the limiting factor in algal growth. Downing (1997) discusses this stoichiometric ratio and shows that while oceanic systems may adhere to the 16N:1P relationship, estuarine systems frequently vary quite considerably from this accepted ratio.

Given that the average total nitrogen concentration in the sediments examined was <0.05 g/100g dry weight (or <500 mg/kg dry weight) and the average total phosphorus concentration was 617 mg/kg dry weight, which resolves to a ratio of 0.81:1, the ratio of total nitrogen to phosphorus suggests that the sediments in this area of Aotea Harbour are highly nitrogen limited and that inputs of nitrogen to the system might stimulate algal proliferation.

Nitrogen inputs to coastal systems generally come from land-based sources such as partially treated wastewater discharges or diffuse run-off from farmland. The land in the catchment of Aotea Harbour is a mix of unvegetated sand dune, land with good vegetative cover (both native and exotic forest) with some developed farmland and a very small number of residential lots. The water quality in Aotea Harbour may be affected by future changes in land use practices in the surrounding catchment and as such the control of sediment and nutrient sources in the catchment of the Harbour should be carefully managed in order to avoid sediment and nutrient inputs into the coastal waters. Although it is possible that high-density mussel culture facilities might contribute nitrogen into the water column in quantities large enough to affect the water quality, the proposed spat catching activity is very unlikely to ever generate these large-scale nitrogen inputs. The proposal is unlikely to have any notable impact on the sediment nitrogen concentrations in the immediate or wider vicinity.

2.3 Benthic Biological Communities

One benthic sample was collected at the location of each of the three sampling sites indicated in Figure 3 using a boat operated box dredge with a gap of 250mm x 150mm and a depth of 350mm. Each of the samples was then sieved fresh through a 1mm mesh sieve and the material retained on the sieve was preserved in a 70% isopropyl alcohol solution. Each sample was then sorted in a white plastic tray and any organisms were picked out and stored in a 70% isopropyl alcohol solution before being identified and counted. The results of the benthic biological community sampling are presented in Table 2.4

To clarify, one benthic biological sample was collected from the approximate centre of the 400m by 125m rectangular area proposed for the spat catching facility, one sample was collected from a short distance to the southwest of the area proposed for spat catching and one sample was collected from a short distance to the northeast of the area proposed for spat catching. This spread of sampling was an effort to characterise the general benthic habitat in and around the area proposed for spat catching.

The benthic biological communities around the area proposed for the spat catching facility were not very diverse with only a small number of taxa found in each sampling location. The total numbers of individuals within each sample was also very low.

Amphipods, polychaete worms dominated the sediments at all three sampling locations, both in terms of numbers of taxa and numbers of individuals, while hermit crabs were found at the AH1 and AH3 sampling sites. Some organisms are more tolerant of organically enriched conditions and as such their presence in high numbers is potentially indicative of organic enrichment. Cirratulid and Capetellid polychaete worms in particular are known to be indicative of organic enrichment in sediments, however, neither of these polychaete worms were found at these sampling sites. The absence of Cirratulid and Capetellid worms, as well as the very low levels of diversity and abundance of organisms, suggest that it is unlikely that the sediments in the locations sampled have been subject to high levels of organic enrichment.

Table 2.4: Summary of the number of separate taxa found in each sample

Taxa	AH1	AH2	AH3
Polychaeta			
Heteromastus filiformis	4	4	6
Perinereis nuntia(?)	9	2	4
Amphipoda			
Paracorophium excavatum(?)	12	7	9
Decapoda			
Pagurus spp.	3	0	1
Total No of Taxa	**4**	**3**	**4**
Total No of Individuals	**28**	**13**	**20**

2.4 Intertidal Biota

The area proposed for spat catching is located close to extensive intertidal sandflat areas. Hillock and Rohan (2011) conducted intertidal habitat assessments for both Kawhia and Aotea Harbours. On the intertidal flat to the south and east of the proposed spat catching site, Hillock and Rohan (2011) found cockles (*Austrovenus stutchburyi*) in densities of 96-240 individuals per square metre with occasional patches of over 480 cockles per square metre. Those cockles sampled were classified as mostly being in the small to large or medium to large size ranges.

Berkenbusch and Neubauer (2016) sampled cockles within Aotea Harbour and estimated a total population of 34.99 million cockles in 2014-15 with a mean population density of 356 cockles per square metre. In 2014-15 there was an estimated 0.55 million large cockles (>= 30mm shell width) or 6 large cockles per square metre.

Hillock and Rohan (2011) also listed wedge shells (*Macomona liliana*) as being present in the same area in densities of 16-160 individuals per square metre and most of those wedge shells were in the small to medium, or small to large size range classifications. Other intertidal species recorded by Hillock and Rohan (2011) were *Diloma subrostrata*, *Zeacumantus lutulentus* and *Cominella glandiformis*. Only one pipi (*Paphies australis*) was found on the intertidal flat area to the south and east of the proposed spat catching facility, and very few pipi were recorded from throughout Aotea Harbour as a result of the sampling. Patches of seagrass (*Zostera* spp) were recorded by Hillock and Rohan (2011) on the same intertidal flat, ranging in cover from 1 to 75 percent cover with a very small patch recorded as being 96 to 100% cover.

Hillock and Rohan (2011) also recorded the presence of Asian date mussel (*Musculista senhousia*) in two discrete locations some distance to the south west of the area proposed for spat catching, adjacent to a mostly sheltered, large channel. The two beds of *Musculista* were described as dense and raised and appeared to exclude other bivalve species.

Sediments on the intertidal flat to the south and east of the proposed spat catching facility were classified by Hillock and Rohan (2011) as sandy.

2.5 Fish Species

Beach seine tows carried out by NIWA in 2001 showed 14 fish species caught within Aotea Harbour with the most common species being anchovy, flounder and yellow-eyed mullet (Francis and Morrison, unpublished data; reported in Lundquist et al 2004).

3 SEABIRD INTERACTIONS

In New Zealand, the generally perceived negative effects of aquaculture have centered on entanglement (resulting in birds drowning) as well as habitat exclusion and displacement from feeding grounds by physical structures, disturbance and changes to the food web. Potential negative effects may also include disturbance of breeding colonies and bird's feeding, blockage of the digestive tract following ingestion of foreign objects, injury or death following collision with farm structures and the spread of pathogens or pest species. In contrast, a potential beneficial effect includes the provision of roost sites closer to foraging areas, thus saving energy in flying to and from more traditional roosting sites and so enabling more efficient foraging. Likewise, the attraction and aggregation of small fish around marine farm structures may provide enhanced feeding opportunities for piscivorous seabirds (Sagar, 2013).

The location of marine farms within the range of seabirds and the conservation status of those seabird species (a measure of the risk of extinction) are the main factors that may lead to issues of sustainability and conservation concern. Of particular concern are the location of farms in relation to breeding and feeding sites and the operational procedures of regular farm activities. Siting of farms close to breeding and feeding sites may lead to disturbance of the seabirds, the consequence of which will depend upon the conservation status of the species affected (Sagar, 2013).

There are significant knowledge gaps concerning almost all seabird species in New Zealand. While overall distribution of most species is well documented, detailed information on the time-specific distribution, abundance and critical habitats is lacking (Sagar, 2013).

Several New Zealand and overseas studies discuss the potential ecological effects of shellfish aquaculture on seabird populations, but only a few direct studies have been conducted (Roycroft et al. 2004; Zydelis et al. 2006; Kirk et al. 2007). Based on these studies, mussel aquaculture has the potential to affect some seabirds by altering their food resources, causing physical disturbances (e.g. noise) and/or being a possible entanglement risk. Sagar (2013) presents a review of the literature with regard to seabird interactions with both feed-added aquaculture (e.g.

salmon, kingfish, hapuku) and filter feeder aquaculture structures. Sagar (2013) notes that while perceived negative effects of both feed added and filter feeder aquaculture have centered on entanglement issues, there have been no reports of seabird deaths as a result of entanglement in aquaculture facilities in New Zealand (Butler, 2003; Lloyd, 2003).

Sagar (2013) considers the potential effects of habitat exclusion and considers the effects to be insignificant given the small area occupied by filter-feeder aquaculture in New Zealand in relation to the large total area of suitable habitat available for foraging seabirds. Given the small physical presence of the anchor lines, buoys and backbone lines proposed for the spat catching facility and the short term temporary deployment of spat catching lines involved in this proposal, the actual physical area occupied by the proposed structures are very small in terms of both areal and temporal extent. Effective management options for the minimisation of habitat exclusion effects can be achieved by careful site selection that avoids key foraging areas of seabird species with restricted habitat requirements (Sagar, 2013).

The potential effects of smothering of seabed by debris from mussel ropes, including shell drop and nutrient enrichment as a result of psuedofaeces and faeces production from mussel stock, leading to changes in the seabed fauna are considered by Sagar (2013) to be insignificant given the small area occupied by filter feeder aquaculture in New Zealand in relation to the large total area of suitable habitat available for foraging seabirds. Given that this proposal does not include the development or on growing of juvenile mussels, the potential for changes in seabed fauna of this nature is essentially eliminated.

Increases in the abundance and diversity of some small fish species around aquaculture facilities have been documented (Grange, 2002). These fish species were probably attracted by shelter under the farm structures and to feed on organisms inhabiting the ropes and farm structures. As a consequence, piscivorous seabirds, such as shags, terns and penguins, may be attracted to, and benefit from, enhanced feeding opportunities provided by these farm structures (Sagar, 2013).

Filter feeder aquaculture facilities provide new roosting sites, usually on buoys supporting backbone and dropper ropes. This may benefit some seabird species (Lalas, 2001) with shags, gulls and terns most likely to benefit from additional roosting sites close to enhanced feeding opportunities. Use of such new roosting sites may reduce the energy expenditure of the birds because they do not have to fly to and from their natural land-based roosting sites, which may be some distance from their foraging area (Sagar, 2013).

Increased human activity associated with filter feeder aquaculture facilities can have significant detrimental effects on the feeding and breeding of seabirds. For example, small boat traffic, or noise associated with aquaculture facilities, may disturb birds that are feeding or breeding in the vicinity (Sagar, 2013). The most obvious means of avoiding significant effects on colonial nesting species, such as shags, gulls and terns, is careful site selection for aquaculture facilities.

Little is known about the distances over which foraging and feeding seabirds may become disturbed, however, it is likely to be species specific. Literature about disturbance distances for king shags in the Marlborough Sounds is ambiguous. For example, Davidson et al (1995) proposed buffer zones of 300 metres around roosting sites and 1000 metres around breeding colonies, but Taylor (2000) recommended that small boats do not approach breeding colonies closer than 100 metres. More recently, Lalas (2001) noted that king shags resting ashore or on emergent objects only flew off (exhibited avoidance behaviour) when approached to within 30 metres.

Ingestion of marine litter, particularly plastics, is common among seabirds and can cause death by dehydration, blockage of the digestive tract, or toxins released in the intestines. In addition, large numbers of seabirds have ben reported to have died as a result of becoming entangled in plastic debris (Derraik, 2002). Among seabirds, the ingestion of plastics is directly related to foraging behaviour and diet (Ryan, 1987). For example, species that feed on surface or near-surface dwelling invertebrates are more likely to confuse pieces of plastic with their prey than are piscivores and therefore have a higher incidence of ingested plastics (Azzarello & Van Vleet, 1987). Piscivorous seabirds, however, have been recorded to consume plastic bags and food-handling gloves (Sagar, 2013). It should be noted that the harm caused by the ingestion of plastics may not be restricted to the individual seabird that consumed them because adults that regurgitate food to their chicks could pass plastics on to their offspring (Fry et al, 1987).

Entanglement in plastic debris, especially in discarded fishing gear (nets), is also a very serious threat to seabirds. For example, entanglement accounted for 13 percent to 29 percent of the observed mortality of gannets (*Sula bassana*) in the German Bight (Schrey & Vauk, 1987). Marine litter arising from aquaculture operations, however, can be minimised by sensible management practices.

Seabirds flying at night may become attracted to artificial lighting and have been recorded colliding with fishing vessels and lighthouses (Montevecchi, 2006). The attraction of seabirds to artificial lighting appears to be more pronounced when mist or light rain prevails (Sagar, 2013). The results of such collisions include death as a result of injury. Feeding of some seabirds, particularly species of petrels, shearwaters and shags, is related to the phase of the moon. Shags, for example, have been recorded foraging at night, with their absences from breeding colonies (presumably on feeding trips) coinciding with a half or full moon, although the great majority of feeding occurs during the day (Saptoznikow & Qunitana, 2002; White et al. 2008). Mitigation of these potential effects includes site selection to avoid being on the flight path between foraging areas and breeding colonies, minimising the use of lights and downward-pointing and shaded lights.

3.1 <u>Seabird Species</u>

There are around 10,400 species of birds worldwide, however, only about 359 of those species are "seabirds", i.e. they breed on land but spend the majority of their lives at sea. They are essentially marine creatures and possess unique physiological and morphological adaptations to a life dominated by the sea. They can be highly mobile, and in some cases the whole population of a species can travel from one side of an ocean to another. They come in all shapes and sizes and are highly specialised.

Important Bird Areas (IBAs) are the sites needed to ensure the survival of viable populations of the world's bird species. They are recognised as internationally important for bird conservation and known to support key bird species and other biodiversity. An IBA has been identified at Gannet Island, 11 nautical miles west of Aotea Harbour mouth. This site has been identified as being important for Australasian gannets (*Morus serrator*; Not Threatened). New Zealand Conservation Threat status designations are those applied by Robertson et al (2016).

The feeding habits of seabirds vary. Some species regularly feed over land (gulls) or in freshwater (shags), others feed in tidal harbours and inshore water (gulls, terns, shags, gannets) and the rest feed on the continental shelf and beyond in deep oceanic waters (petrels, shearwaters and gannets). Flight for many species (i.e. petrels, shearwaters, gannets) is extremely efficient due to dynamic soaring (Pennycuick, 1982), while other species, such as penguins, shags, diving petrels and shearwaters fly underwater using their wings. Seabirds can find food over large distances using excellent vision to keep them alert to the activities of other seabirds, fishes and cetaceans (Au & Pitman, 1986) and a strong sense of smell is enhanced by large olfactory bulbs (Hutchinson & Wenzel, 1980). All of this allows seabirds to exploit such prey as fish, crustaceans (krill) often in association with fish schools, cephalopods (squid), plankton and zooplankton from the surface to depths of 60 metres or more (Brooke, 2004; Rayner et al, 2008; Taylor, 2008; Rayner et al 2011b).

Only the Australasian gannet is known to have a breeding site in reasonably close proximity to the area proposed for spat catching activity (Gannet Island) but it is reasonable to assume that seabird species like pied shags (*Phalacrocorax varius varius*; At Risk Recovering), Southern black-backed gulls (*Larus dominicanus dominicanus*; Not Threatened) and red-billed gulls (*Larus novaehollandiae scopulinus*; At Risk Declining) as well as Australasian gannets would be found in or around the area proposed for mussel spat catching on a regular basis. Field notes recorded during benthic biological sampling in the area in November 2016 show the presence of gannets, pied shags, black-backed gulls and red-billed gulls (S White, pers obs).

While the spat catching lines are deployed it is possible that the facility may have some exclusion effects on seabird foraging habitat, however, such deployment of lines would be short-term and temporary and would be seasonal. The 5 hectare area proposed for spat catching would leave over 99% of the subtidal habitat within Aotea Harbour completely unaffected and available for seabird foraging.

Approximately 60% of NZ seabird species regularly forage more than 50km offshore while the remaining species feed over inshore waters and only occasionally are found well away from land (Taylor 2000a). Other species such as gulls, terns, shags, penguins and gannets (to some degree) feed close to the shorelines of the mainland and harbours. Shearwaters and petrels forage predominantly in continental shelf waters (Gaskin & Rayner, 2013) and, as such, would be extremely unlikely to come into contact with the proposed spat catching facility. Given that the known breeding site for these Australasian gannet is around 12 nautical miles from the proposed spat catching facility, it is highly improbable that any activity at or around the spat catching facility would disturb seabird breeding.

3.2 Management of Seabird Interactions

As discussed, there is potential for interactions between seabirds and the proposed spat catching facility and associated activity. It is possible to manage these potential interactions to avoid or minimise adverse effects and to mitigate any potential adverse effects with possible positive effects. While entanglement is perceived to be a central issue with regard to seabirds, there have been no reports of seabird deaths as a result of entanglement in aquaculture facilities in New Zealand (Butler, 2003; Lloyd, 2003).

Habitat exclusion effects on seabirds are best managed by careful site selection and appropriate scales of operation of filter feeding aquaculture facilities in order to avoid or minimise effects on key foraging areas for species with limited or restricted foraging requirements (Sagar, 2013). Seabird species identified as potentially being affected by the proposal (gannets, shags, black-backed gulls and red-billed gulls) are not likely to be excluded from key foraging areas as a result of the proposed spat catching facility. All of those species have been observed foraging and/or resting on or around mussel farms in the Hauraki Gulf area without any reported exclusion or other adverse effects. Due to the seasonal nature and short-term deployment of ropes, the proposal for a mussel spat catching operation would have significantly fewer exclusion effects on seabirds than mussel cultivation facilities and as such it is considered unlikely that a spat catching facility would have negative impacts on these seabird species.

Disturbance of seabirds is a potential adverse effect resulting from aquaculture activity and the most effective means of managing disturbance is careful site selection for aquaculture facilities to avoid disturbance of known seabird breeding areas (Sagar, 2013). As discussed, the closest known breeding site to the proposed spat catching facility is Australasian gannet breeding site on Gannet Island, 12 nautical miles to the west. It is highly unlikely that the proposed spat catching facility would have any disturbance effects on this breeding site.

Marine litter is a potential problem for all seabird species and the most effective means of avoiding litter, particularly plastic litter, generated from an aquaculture facility is to instigate sensible management practices in and around the facility to prevent the introduction of litter into the sea. This is a required practice in the New Zealand aquaculture environmental protocols.

Artificial lighting associated with aquaculture facilities has the potential to have adverse effects on seabirds. The most effective method of managing this potential includes careful site selection to avoid having aquaculture facilities on the flight path between foraging areas and breeding colonies, minimising the use of lights and using downward-pointing and shaded lights where such lighting is necessary (Sagar, 2013). The proposed spat catching facility avoids major flight paths between foraging areas and breeding sites of seabirds known to be breeding in the area. The proposed facility may require appropriate navigation lighting to ensure the safe navigation of vessels in and around the area, however, beyond that, it is unlikely that the spat catching facility would require or show any significant artificial lighting. There may be a potential for deck spot lights or other lighting to be used on vessels working at the spat catching facility on occasion, however, this is not expected to be a regular occurrence as most activity at the facility is expected to be undertaken during daylight hours.

There is a small potential for small fish to be attracted to the spat catching facility and this may provide a potential benefit for piscivorous seabirds that may forage in and around the proposed facility. Given that it is unlikely that the facility will have much more than anchor lines, backbone lines and buoys for much of the time and will only have spat catching dropper ropes on a short term temporary basis, as and when mussel spawning events are expected, the potential for fish attraction is admittedly limited. The presence of buoys and backbone lines, however, does provide a potential benefit for shags, terns and gulls as potential roosting sites.

Managing seabird interactions is mostly undertaken by careful site selection of aquaculture facilities to avoid adverse effects and by sensible management practices to avoid the introduction of litter, or unnecessary artificial lighting. The proposed spat catching facility is sited in an area that avoids disturbance of known seabird breeding sites and avoids flight paths between seabird breeding sites and foraging areas. While perceived negative effects of aquaculture have centered on entanglement issues, there have been no reports of seabird deaths as a result of entanglement in aquaculture facilities in New Zealand.

Noting the presence, activity and interactions of seabirds at the facility where possible may be sensible in order to monitor or record the specific effects of the facility on the seabirds found in the area.

4 MARINE MAMMAL INTERACTIONS

Interactions between marine mammals and aquaculture usually result from an overlap between the spatial location of the facilities and the breeding, feeding and/or migrating habitat of the marine mammal species. To date, issues such as habitat exclusion, underwater noise and entanglement appear to be minor for New Zealand mussel farming with no recorded instances of any marine mammals having become entangled in mussel farms in New Zealand (Clement, 2013).

Several overseas studies (Wursig & Gailey, 2002; Kemper et al, 2003; Wright, 2008) have characterised the possible interactions between marine mammals and aquaculture facilities, which include competition for space (habitat modification or exclusion), potential for entanglement, underwater noise or disturbance and possible flow-on effects due to alterations in trophic pathways. The physical location of the marine farm within important habitats or migration routes of New Zealand marine mammal species is the main factor that then leads on to potentially adverse interactions or avoidance issues. Once a marine farm is within the distribution range of a species, the types of gear and equipment employed, as well as operational procedures around regular farm activities, influence the probability and scale of impacts on marine mammals (Clement, 2013).

Overseas research highlights that the nature of habitat exclusion effects on marine mammals greatly depends on the type of aquaculture facility and the particular species of marine mammal present in the area (Kemper et al, 2003; Watson-Capps & Mann, 2005; Heinrich, 2006; Ribeiro et al, 2007). Mussel farm cultivation ropes typically extend vertically from floats at the surface through the water column to within a short distance above the seabed. Markowitz et al (2004) demonstrated with sonar that these vertical structures can appear as visual or acoustic barriers that can potentially exclude marine mammals from habitats previously used for feeding, calving and/or migration activities. Studies in New Zealand have so far addressed interactions between mussel farms and Hector's (Slooten et al, 2001) and dusky dolphins (Markowitz et al, 2004; Vaughan & Wursig, 2006; Duprey, 2007; Pearson et al, 2007). Collectively, these studies suggest that while some marine mammal species are not completely displaced from regions as a whole, they do not appear to be utilising habitats occupied by shellfish farms in the same manner as prior to the farm's establishment. Pinnipeds appear to be the one group of marine mammals that will not be excluded from habitats by mussel farming (Clement, 2013).

4.1 <u>Marine Mammal Species</u>

Berkenbusch et al (2013) lists the primary marine mammal species likely to be encountered on the upper west coast of the North Island as including Maui's dolphin (*Cephalorhynchus hectori maui*), short-beaked common dolphin (*Delphinus, delphinus*), Bottlenose dolphin (*Tursiops truncatus*), Orca (*Orcinus orca*) and New Zealand fur seal (*Arctocephalus forsteri*). Other possible marine mammal species that might be encountered include humpback whales (*Megaptera novaeangliae*), Southern right whales (*Eubalaena australis*), blue whales (*Balaenoptera musculus*), Sperm whales (*Physeter macrocephalus*), Minke whales (*Balaenoptera bonaerensis* or *Balaenoptera acutorostrata*), Sei whales (*Balaenoptera borealis*), Fin whales (*Balaenoptera physalus*) and possibly Bryde's whales (Balaenoptera edeni/brydei).

Table 4.1 Marine mammals possibly encountered on the upper west coast of the North Island or near Aotea Harbour

Common Name	Scientific Name	Conservation Status[1]
Maui's dolphin	*Cephalorhynchus hectori maui*	Nationally Critical
Short-beaked common dolphin	*Delphinus delphinus*	Not Threatened
Bottle-nosed dolphin	*Tursiops truncatus*	Nationally Endangered Least Concern
Orca/killer whale	*Orcinus orca*	Nationally Critical Data Deficient
NZ fur seal	*Arctocephalus forsteri*	Not Threatened
Humpback whale	*Megaptera novaeangliae*	Migrant Least Concern
Southern right whale	*Eubalaena australis*	Nationally Vulnerable Least Concern
Blue whale	*Balaenoptera musculus*	Migrant Critically Endangered
Sperm whale	*Globicephala melas*	Not Threatened Vulnerable
Minke whale	*Balaenoptera bonaerensis* or *Balaenoptera acutorostrata*	Not Threatened Data Deficient
Sei whale	*Balaenoptera borealis*	Migrant Endangered
Fin whale	*Balaenoptera physalus*	Migrant Endangered
Bryde's whale	*Balaenoptera edeni/brydei*	Nationally Critical Data Deficient

Of the marine mammals listed in Table 4.1, the baleen whales (blue, humpback, Southern right, Minke, Sei, Fin and Bryde's whales) are generally of greatest danger of

[1] Baker et al (2013)

entanglement with man-made objects in the water due to their inability to echolocate. All of these whales, however, while spending some time in coastal waters would not enter Aotea Harbour and would therefore never encounter the proposed mussel spat catching facility. Similarly, while sperm whales are found in coastal waters, their key foraging habitat is deep water and these whales would not enter Aotea Harbour or encounter a spat catching facility such as the one proposed.

Humpback whales can occasionally be seen off New Zealand's west coast on their migratory journeys from Antarctica to the tropical waters of the South Pacific. While migrating humpback whales may occasionally travel close to the coast during either the northern or southern migrations between tropical and sub-Antarctic waters they would not enter Aotea Harbour and therefore would never encounter a mussel spat catching facility sited in the proposed location.

Historically, Southern right whales were widely distributed in New Zealand waters around the mainland and sub Antarctic islands. Southern right whales calve in coastal waters in winter months and tend to migrate offshore to feeding grounds in summer months, with their distribution in summer linked to copepods and euphausids, their primary prey species (Patenaude, 2003). Southern right whales underwent a catastrophic decline in numbers around mainland New Zealand as a result of shore-based and pelagic whaling activity. Demographic modelling based on historical whale catch data suggest that prior to exploitation Southern right whales in New Zealand waters likely numbered more than 16,000 (Patenaude 2000). Despite 65 years of protection, Southern right whales in New Zealand waters still number less than 5% of their historical abundance. There are few published reports of sightings of right whales around mainland New Zealand and little information is available about the mainland New Zealand Southern right whale population (Patenaude, 2003).

Although Southern right whales are sometimes found in coastal mainland New Zealand waters, they would not enter a shallow harbour such as Aotea Harbour and would therefore never encounter a mussel spat catching facility sited in the proposed location.

Prime foraging habitat for blue whales and Minke whales are cold current upwellings where accumulations of food occur for these whales. They are essentially oceanic species and would not enter a shallow harbour like Aotea Harbour and would therefore never encounter a spat catching facility sited in the proposed location.

Fin whales and Sei whales are cosmopolitan baleen whale species that pass through New Zealand waters on their migrations between the tropics and summer feeding habitat in the southern Pacific. While these whales may be encountered in coastal New Zealand waters, they would not enter a shallow harbour like Aotea Harbour and would therefore never encounter a spat catching facility sited in the proposed location.

Bryde's whales are a coastal baleen whale found between Cape Brett and East Cape in New Zealand, with a resident population of about 46 Bryde's whales within the Hauraki Gulf, and another 159 whales thought to use the Gulf for part of the year (Wiseman et al, 2011). Although Berkenbusch et al (2013) show a possible sighting of a Bryde's whale near Raglan, the paper does include the disclaimer that reported sightings are from a variety of sources and should be considered indicative only as misidentifications with some other baleen whale species have been made. Aotea Harbour is outside the recognised range of Bryde's whales in New Zealand and it is extremely unlikely that any Bryde's whales would encounter a spat catching facility sited in the proposed location.

Maui's dolphin is on the edge of extinction with a recent population estimate indicating approximately 63 individual Maui dolphins over one year of age remain. The Department of Conservation sighting database for Maui dolphin shows three reported sightings near Aotea Harbour. The first, from August 1985 was recorded by an Otago University research team and recorded two adult dolphins 100-200 metres offshore from the mouth of Aotea Harbour. The second recorded sighting, from February 2006, was by WWF staff and was of two adult dolphin 300 metres south of the mouth of Aotea Harbour. The third recorded sighting was made by DoC staff and was of one adult dolphin off the rocks to the south of Aotea Harbour. Only the Otago University sighting is listed as having been validated. No sightings of Maui dolphins have been recorded from inside Aotea Harbour.

Maui's dolphin are piscivorous and echolocate. They are known to prey on a range of benthic and free-swimming fish species including red cod, ahuru and sole. The area proposed for the spat catching facility would not be within key foraging habitat for Maui's dolphin, and given the lack of sightings from inside Aotea Harbour it seems unlikely that Maui's dolphin is a regular visitor to Aotea Harbour itself. It would appear to be unlikely that a spat catching facility, such as that proposed, would result in entanglement risk, habitat exclusion, disturbance or displacement effects on Maui's dolphin.

Both bottlenose and common dolphin hunt fish species and may, on occasion, utilise this area of Aotea Harbour and it is therefore possible that both species may encounter a mussel spat catching facility sited in the proposed location. Despite the long-term existence and operation of mussel farms in many coastal locations in New Zealand there have been no recorded entanglement events or other immediately adverse effects on dolphins caused by mussel farming. There have been studies that have documented the habitat exclusion of Dusky dolphin from some areas of the Marlborough Sounds as a result of the relatively intense mussel farming activity within some embayments, however, this proposal does not represent a level of development approaching that level of intensity.

There are potentially three sub populations of Orca in New Zealand waters: North and South Island populations; and an additional group that appears to travel between the two islands (Visser, 2000). Some Orca have been known to travel an average of 170 km per day, covering up to 4000 km. The New Zealand Orca population is thought to number around 200 individuals (Suisted and Neal, 2004). Figure 4.3, taken from Berkenbusch et al (2013), shows sighting locations of Orca in New Zealand waters between 1970 and 2013. While there are "hot spots" of sightings around centres of human activity, this is not likely to reflect the true distribution patterns. It does, however, give a general indication that Orca may occasionally visit Aotea Harbour.

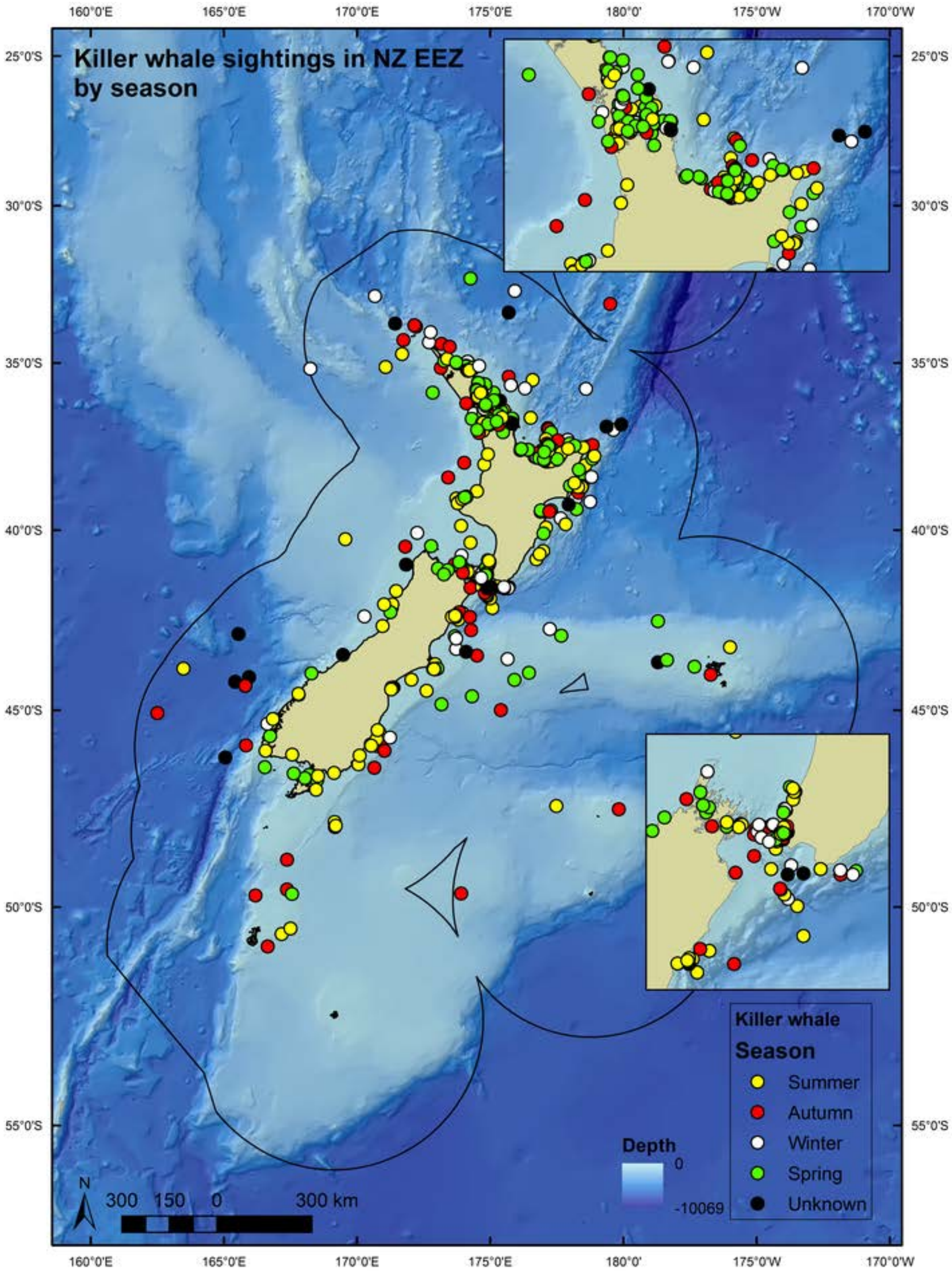

Figure 4.3 Locations of killer whale (*Orcinus orca*) sightings in New Zealand waters between 1970 – 2013. (from Berkenbusch et al, 2013)

It is, therefore, quite feasible that Orca may encounter a mussel spat catching facility sited in the proposed location. Orca in New Zealand appear to forage on rays, sharks and finfish, as well as marine mammals (Visser, 2000). Despite the long-term existence and operation of mussel farms in many coastal locations in New Zealand, and in particular density around the Coromandel Peninsula and Firth of Thames areas, there have been no adverse effects on Orca recorded as a result of mussel farming. This proposal is likely to have a smaller fish aggregation effect than a full-scale mussel cultivation farm and is therefore less likely to attract Orca and dolphin.

New Zealand fur seals are known to breed on Gannet Island, 11 nautical miles west of the mouth of Aotea Harbour. As such, it is quite likely that NZ fur seals occasionally venture into Aotea Harbour. These seals tend to be inquisitive and are likely to be attracted to a mussel spat catching facility rather than excluded by the structures and activity associated with aquaculture. As with other marine mammals, and despite the long established marine farms around the country, there have been no adverse effects on fur seals recorded as a result of mussel farming and pinnipeds (seals) are the one group of marine mammal species least likely to be excluded from habitats by mussel farming (Clement, 2013).

4.2 Management of Marine Mammal Interactions

Siting mussel farms in areas to minimise or avoid the likelihood of spatial overlap with species' home ranges, critical breeding and foraging habitats or migration routes is likely to be the most effective management option to prevent habitat exclusion effects on marine mammals. Although the proposed spat catching facility will have anchor lines, backbone lines and buoys as mussel farms do, it will not have permanent, or long term deployment of vertical mussel cultivation ropes to present the same vertical visual or acoustic barrier effect. Spat catching lines will be deployed on a short term, temporary basis and will be relocated for development and on growing of the juvenile mussels in a suitable area for mussel cultivation. It is likely that the proposed spat catching facility would result in considerably reduced habitat exclusion effects on marine mammals compared with those that might occur with a conventional mussel farm in the same location and it could be argued that habitat exclusion effects would probably be minimal.

Mussel farming structures can occupy a large portion of the water column, effectively creating three-dimensional structures that marine mammals have to actively navigate or maneuver around. The proposed spat catching facility will not have permanent or long term deployment of vertical dropper lines as found at mussel cultivation farms. There have only been three cases of whales entangling in shellfish farms in Australia and New Zealand, with no known fatal entanglements of pinnipeds or dolphins (Clement, 2013).

Many species of marine mammals are known for their curious nature and they are often attracted to novel objects, such as floating debris and/or lines. While some incidences of dolphin entanglement in thin lines have been reported from overseas, none have been associated with shellfish aquaculture. On other occasions, New Zealand marine mammals have become entangled in non-biological marine waste or debris (Mattlin & Cawthorn, 1986; Derraik, 2002). These reports, as well as reports from overseas, indicate that loose, thin lines or buoys and floats pose the greatest entanglement threat to marine mammals. As such, potential entanglement risks at the proposed spat catching facility are likely to be low because anchor and backbone lines are kept under tension and management of the spat catching activity will ensure that there are no loose lines associated with the facility.

Because they don't echolocate (Tyack & Clark, 2000), baleen whales, such as Bryde's, southern right and humpback whales, are more prone to entanglement issues. Over 60% of northern right whales in the North Atlantic have entanglement scars on them (Hamilton et al, 1998). There has been one documented case of a Bryde's whale (*Balaenoptera brydei*) entangled in a single rope used to buoy an isolated spat catching structure at Great Barrier Island in the Hauraki Gulf (Seafood New Zealand, 1996) and five instances of humpback whales (*Megaptera novaeangliae*) found entangled in crayfish pots near Kaikoura. Because of their echolocation abilities and smaller size, there is a lower risk of dolphins becoming entangled in lines, and while there have been instances of dolphins, including Maui's dolphin, entangled in fishing gear, there have been no reported cases of dolphins entangled in aquaculture lines in New Zealand (Lloyd, 2003; Clement, 2013).

The risks of entanglement are thought to be greater with thinner or untensioned ropes such as buoy lines used to mark crayfish pots (Lloyd, 2003). The proposed spat catching facility does not include untensioned lines, small lines or isolated structures of this type as stand alone elements of the facility. Rather the proposed spat catching facility is a relatively robustly structured collection of buoys, backbones and mooring lines with suspended dropper ropes deployed only at times of expected spat fall. The "hairy" mussel spat catching dropper lines are around 25mm diameter and would be relatively obvious underwater to visually or acoustically orienting animals. Dropper lines would be deployed clustered in groups within the overall footprint of the proposed facility, rather than spread out as individual dropper lines in a low density distribution. These measures, together with the specific location of the proposed facility away from known locations, key foraging areas or migration routes of baleen whales or Maui's dolphin should avoid or minimise the risks of marine mammal entanglement.

Underwater noise in the oceans is a fairly widespread, yet largely unknown problem for marine mammals, particularly the larger whale species (Nowacek et al, 2007;Weilgart, 2007; Wright, 2008). The level and persistence of any underwater noises associated with mussel farming may be minimal relative to other underwater noise sources, such as commercial vessels, but will vary according to farm features (type, size), habitat characteristics (location, water depth, types of bottom sediments, shape of coastline, background noise levels) and activities within the farm management. Due to the nature of the proposed spat catching facility and its operational procedures, the levels of underwater noise that are likely to result from the proposal would be considerably less than those generated by an active mussel cultivation facility, and it could be argued that underwater noise generation from the proposed facility would be less than minor.

Overseas research has demonstrated that whales may be more sensitive to increased noise production in their habitats or along migration routes (Gard, 1974; Herman, 1979; Bryant et al, 1984; Glockner-Ferrari & Ferrari, 1990), however, most odontocete (toothed whales and dolphins) and pinniped species demonstrate few avoidance behaviours and considerable tolerance of most underwater noises with a few exceptions (Richardson, 1995). The curiosity and temporary attraction of dolphins to boat noise will be familiar to most recreational or commercial vessel users and this has been recognised in the literature (Carwardine, 1995; Dawson et al, 2000). The siting of the proposed spat catching facility would result in no overlap with known baleen whale habitat and is outside key foraging, breeding or migratory habitat for known whale species in New Zealand.

The potential for wider, more indirect ecosystem effects on marine mammals due to mussel aquaculture, including food-web interactions (Black, 2001; Kaiser, 2001; Wursig & Gailey, 2002; Kemper et al, 2003), biotoxin and pathogen (disease) outbreaks (Geraci et al, 1999; Kaiser, 2001) and antibiotic use (Buschmann et al, 1996; Kaiser, 2001) have been considered in the literature, however, no actual research or any indirect effects have yet been documented or demonstrated resulting from full-scale mussel farms. Due to the seasonal and short term nature of operations, the proposed spat catching activity should have considerably fewer effects on marine mammals than a conventional mussel farm in the same location. The proposed activity is likely to have unmeasurable effects on water quality, planktonic supply, hydrodynamics, currents, sediment quality, or food-web interactions. With careful and sensible biosecurity management measures, the proposal should have no impact on biosecurity in the area and is unlikely to introduce biotoxins or pathogen outbreaks. There is no intention to use antibiotics or other biocontrol agents at the proposed spat catching facility. The expected effects on marine mammals would be less than minor.

Noting the presence, activity and interactions of marine mammals at the facility, where possible, may be sensible in order to monitor or record the specific effects of the facility on the marine mammals found in the area

5 BIOSECURITY

Biosecurity, in the context of the proposed spat catching facility, refers to the introduction to New Zealand waters of foreign, invasive or pest species and the movement (spread) of such species from any area in which they may be established to areas within New Zealand waters that do not have these species present. For a country like New Zealand that relies so heavily on primary productivity and, in this context, the aquaculture industry, for much of the country's GDP, biosecurity is a constant and real threat both economically and environmentally. The primary focus of agencies responsible for biosecurity in New Zealand has been to prevent the introduction of foreign organisms into New Zealand, however, with the volume of international shipping that is essential for the country there has inevitably been accidental introductions of foreign species.

Some of those species are more serious in terms of economic and environmental implications than others, for example, Pacific oyster (Crassostrea gigas) was accidentally introduced to New Zealand in the 1950's. It has in some areas completely supplanted the native rock oyster *Saccostrea glomerata* and has modified and dominates some habitat as it has formed biogenic reef structures of significant size and extent. Since the 1970's the Pacific oyster has been cultivated and is now one of the three main aquaculture species in New Zealand along with king salmon and greenshell mussels.

Most introduced species, however, do not provide positive benefits to the aquaculture industry with increased fouling of lines, buoys, structures and vessels and the active competition for space and/or food resources with cultivated shellfish being common adverse effects for mussel farmers. The additional time and resources required to prevent the spread of these organisms, monitor for them or to report and control them if discovered presents a cost to the aquaculture industry, however, it is in the best interests of the industry and of New Zealand in general that the introduction of pest species is prevented and any established pests are controlled and contained.

While there is a long list of foreign species that New Zealand agencies are constantly vigilant for, the main organisms of concern in the Auckland and Waikato Regions appear to be Mediterranean fanworm (*Sabella spallanzanii*), the Asian kelp *Undaria pinnatafida*, Asian paddle crab (*Charybdis japonica*), Northern Pacific seastar (*Asterias amurensis*), the clubbed sea squirt (*Styella clava*) and the sea squirts *Eudistoma elongatum* and *Pyura doppelgangera*. In particular, controlling the spread of these species from areas where they have become established (e.g. the Waitemata Harbour) to areas that are currently free from these organisms (e.g. Coromandel) is of principal concern.

Table 5.1 Principal marine pest species of concern

Common Name	Scientific Name	Habitat	Impact
Mediterranean fanworm	*Sabella spallanzanii*	• Low tide to 30m • Sheltered harbours to semi-exposed coasts and reefs • Wharves, pontoons, structures, boat hulls	• Fouling organism • Can form dense colonies • Highly efficient filter feeder • Disrupts natural ecological balance
Asian kelp	*Undaria pinnatafida*	• Intertidal to 40m • Sheltered harbours to semi-exposed coasts and reefs • Wharves, pontoons, structures, boat hulls	• Fouling organism • Can form dense colonies • Very fast growing
Asian paddle crab	*Charybdis japonica*	• Low tide to 15m • Sand and mud in most coastal habitats	• Very aggressive predator • Detrimental to aquaculture
Northern Pacific seastar	*Asterias amurensis*	• Low intertidal to 25m • Sheltered harbours to semi-exposed coasts and reefs • Wharves, pontoons, structures, boat hulls	• Very fast growing • Can form dense colonies • Voracious predator
Clubbed seasquirt	*Styella clava*	• Low intertidal to 25m • Sheltered harbours to semi-exposed coasts and reefs • Wharves, pontoons, structures, boat hulls	• Fouling organism • Can form dense colonies • Disrupts natural ecological balance • Highly efficient filter feeder
Droplet seasquirt	*Eudistoma elongatum*	• Intertidal to subtidal • Sheltered harbours to semi-exposed coasts and reefs • Wharves, pontoons, structures, boat hulls	• Fouling organism • Can form dense colonies • Disrupts natural ecological balance

Seasquirt	*Pyura doppelgangera*	• Intertidal to subtidal • Hard surfaces	• Fouling organism • Can form dense colonies • Disrupts natural ecological balance

The main vectors for spread for these organisms appears to be vessels and equipment used in the marine environment that have not been properly cleaned prior to movement between areas. Northland Regional Council, for example, are attempting to prevent the spread of Mediterranean fanworm from Auckland's Waitemata Harbour to wider Northland through targeting of vessels moving between these areas. There are requirements to demonstrate appropriate cleaning and antifouling of vessels entering Northland waters from Auckland, as well as underwater inspections of vessels where the risks of unwanted transfer of organisms are deemed to be high. These measures are applied to both recreational and commercial vessels.

Where invasive species are found to be spreading, early detection and rapid action to control or eliminate the organisms is key to preventing the wide scale spread of pest species.

So far as is known, Aotea Harbour is free of all of the species listed in Table 5.1. Asian date mussel (*Musculista senhousia*) is known to be present within Aotea Harbour, though its location is some distance from the proposed spat catching facility. Clearly, biosecurity measures to be undertaken for the proposed spat catching facility would need to consider measures that prevent the spread of *Musculista* both within, and from, Aotea Harbour.

At present, the best means of managing biosecurity issues associated with aquaculture facilities is to instigate a Biosecurity Management Plan (BMP) that covers equipment and vessels, people management, staff training and education and biosecurity risk assessments and management, etc. Table 5.2 outlines examples of the aspects of the Biosecurity Management Plan that should be considered and covered.

One of the key aspects of biosecurity and pest species control involves the maintenance of vessels moved between areas. While the proposal does not involve vessel movements between Aotea Harbour and anywhere else for the purposes of moving spat, there may be a requirement for vessels to move to and from Kawhia Harbour on occasion. Prior to any movement of vessels between areas, an assessment for biosecurity threats would need to be undertaken, in addition to regular assessments for biosecurity threats and scheduled maintenance and hull cleaning to prevent pest species spread. This would normally include out of water cleaning and potentially antifouling treatment, if necessary, on an annual basis. The vessel's hull and underwater structures, with particular emphasis on crevices, through hull apertures, sea chest or water intakes, or wet areas (e.g. anchor wells, live bait tanks, etc) should be assessed for biosecurity risk via visual inspection (e.g. diver, video and/or stills camera, etc). Should any pest species be found, appropriate measures should then be taken to remove or eliminate the pests prior to vessel movement.

Table 5.2 Example Aspects of an Aquaculture Facility Biosecurity Management Plan

Biosecurity Risk Management	• Regular contact with Biosecurity agencies to maintain awareness of latest threats and changes to policy and direction • Annual in-water survey of marine farm structures and seabed footprint to identify any of the marine pests listed in the RPMP or on the MPI UO's register
Equipment, Vehicles and Vessels	• Assessment of all equipment, vehicles and vessels entering and leaving the aquaculture facility for biosecurity risk and appropriate actions taken • Standard Operating Procedures for the regular cleaning and disinfection of all equipment, vehicles and vessels • Dedicated delivery and loading areas
People Management	• Assessment of all staff and visitors entering the aquaculture facility for biosecurity risk and appropriate actions taken • Manage farm access • All visitors to be briefed regarding on-farm biosecurity issues • Preventative measures for pest and disease entry and spread applied
Staff Training & Education	• Staff to understand biosecurity plans and responsibilities • Staff to be trained on aspects of biosecurity and contingency plans including identification of pests and biosecurity risks in association with pests and diseases
Record Keeping	• Maintain records of all aspects of biosecurity management (e.g. maintenance, cleaning, staff training, visitor logs, etc)
Waste Management	• All waste assessed for biosecurity risk to farm and environment and appropriate actions taken • Containment, handling and disposal of waste in biosecure manner
Contingency Plans	• Contingency plans should be prepared for direct (e.g. disease outbreak, pest discovery) and indirect (e.g. storms, tsunamis, etc) incidences that may influence on-farm biosecurity

Greenshell mussels are not highly prone to disease. Hine (1989) found no disease-associated mortalities in greenshell mussels or the presence of potentially serious pathogens within the mussels. A review on mytilids with particular emphasis on *P. canaliculus* (Webb 2007) indicated that there have been no particularly destructive diseases of mussel species identified in New Zealand, with the exception of a digestive viral disease. Jones *et al.* (1996) reported mortalities in cultured greenshell mussels in the outer Marlborough Sounds as a result of digestive viral disease (digestive epithelial virosis). The majority of these mortalities were associated with virus-like particles and digestive tubule damage. The condition also affects scallops and clams in New Zealand and other bivalve molluscs elsewhere. Viruses producing similar digestive tissue effects on bivalve molluscs have been reported in Australia, Scotland, Denmark, and elsewhere (Bower 2001). This digestive viral disease has not been reported in the Coromandel area. Due to the relatively short time in the water potentially exposed to viruses, the spat are less likely to be affected than cultivated mussels and any trans-shipment of stock is unlikely to impact on new locations.

Another pathogen that poses potential environmental risk is the parasite APX, which is reported from New Zealand only (Diggles *et al.* 2002; Hine 2002b) and has been found in mussels from the Marlborough Sounds and also occurs commonly in dredge oysters *O. chilensis* (also known as flat oyster) from all around the coast (Diggles *et al.* 2002; Hine 2002b). In oysters, APX can cause a significant condition referred to as coccidiosis (Hine & Jones 1994), however, its effect on mussels is less noteworthy. Cultured greenshell mussels appear to present no major threat to wild molluscs, as wild greenshell stocks can harbour all known pathogens with the exception of APX. Since APX is also found in dredge oysters, however, there would remain a reservoir of infection even in the absence of greenshell mussel culture.

The threat to wild mussels and other bivalve species from farmed mussels carrying indigenous diseases/parasites is therefore low. Known pathogens in New Zealand occur in a range of other wild bivalve species, often at a greater prevalence and intensity than in cultured mussels. Farmed mussels could pose a threat if they were vehicles for introduction of an exotic disease but this is a possibility only if *P. canaliculus* is susceptible and if appropriate intermediate hosts (if required) are available. The catching of spat in the manner proposed is unlikely to represent any threat to wild or cultivated populations of mussels in New Zealand.

6 WATER COLUMN EFFECTS

For the purposes of this supplementary report on the ecological impacts of the proposed mussel spat catching facility, water column effects has been used a catch-all phrase to cover such issues as potential impacts to seston, water quality, currents and hydrodynamics. Strictly speaking, the issues of coastal currents and hydrodynamics are specialist areas of study that are outside the scope of an ecological report, except perhaps, in broad terms regarding the ecological implications, such as planktonic depletion and nutrient or discharge dispersion and dilution. In that regard, any discussion of water column effects within this report will be restricted to general terms and where appropriate the limitations of expertise will be acknowledged.

Keeley et al (2009) contains a good discussion regarding the water column effects of mussel farms and while there is no benefit in reproducing that discussion in its entirety within this report, some aspects of the Keeley et al (2009) discussion will be highlighted here and discussed in relation to the spat catching proposal.

Currents generated by tides and waves play an important role in the transportation of plankton and dissolved nutrients and gases as well as the flushing of wastes and associated nutrients into and out of the marine system. Currents may be affected by marine farming structures due to drag forces created by the interaction of a moving fluid with anchored submarine structures. These forces have been well studied for a range of engineering applications, but little research has been conducted in relation to marine farms (Keeley et al, 2009).

Of the studies conducted, the two main approaches taken have been to directly measure current speeds and compare the differences within and outside of existing marine farms or to estimate macro-scale changes using hydrodynamic modelling techniques. Boyd and Heasman (1998) showed decreases in current speeds within mussel farms to be as little as 10% of ambient flow. This study also investigated how changes in structural density affected currents within the farms revealing that increased rope density lead to decreased current velocities. The effects of this 'structural porosity' have particular relevance to the proposal being considered.

A more recent study by Plew et al. (2005) investigated changes in currents at a long-line mussel farm in New Zealand and found a 38% decrease in current speed and a reorientation of water flow parallel to the alignment of the mussel lines at peak velocities. Currents below the farm structure are often not affected by the longline structures and dropper lines.

Despite evidence for local modification of currents and waves by farm structures, coastal ribbon development of marine farms in New Zealand is unlikely to significantly affect bay-wide hydrodynamic characteristics (Plew et al 2005). While alteration of the wave climate shoreward of farms could theoretically affect ecologically important intertidal and shallow subtidal habitats (Davidson & Richards 2005), observations at farm sites in the Marlborough Sounds provide no evidence to suggest that this is an issue at present levels of development (Keeley et al, 2009).

The 'structural porosity' of a marine farm is an important factor. High rope densities produce greater hydrodynamic drag factors and therefore have a higher influence on currents. The proposal presents a farm structure that for the majority of the time has minimal structures and very low rope density and is therefore likely to have minimal effect on currents and waves. At the times of spat rope deployment, the density of the dropper lines may have a greater influence on currents, however, these influences would be a fraction of those produced by a single full-scale mussel cultivation facility. Research suggests that multiple mussel cultivation facilities in close proximity do not have significant hydrodynamic effects and it is therefore expected that this proposal would have hydrodynamic effects on a local and wider scale that would be unmeasurable.

The location has a high exposure to strong tidal currents with a relatively minor effect from wind-driven currents. On that basis, tidal currents are likely to be highly influential and will result in rapid exchange of water through the proposed facility.

Mussels, as filter feeders, remove organic material, including phytoplankton, from the water column and release dissolved nutrients and particulates back into the water column. Dense curtains of mussels suspended in the water column represented by the crop of a mussel cultivation facility can potentially lead to a halo of water depleted of phytoplankton and enriched by released nutrients that extends beyond the farm area. The scale, duration and ecological significance of these beyond-farm effects in the Firth of Thames have been the subject of modelling studies and field research over the last 15 years or so.

The Wilson Bay aquaculture zone in the Firth of Thames, when established, was the largest concentration of mussel farms in one location (Sea Change, October 2014) and totalled about 1200ha of farmable space in a total marine farm zone of about 2500ha. Comprehensive and quantitative monitoring requirements were imposed and multiple physical and biophysical models were developed. Citing NIWA research (Stenton-Dozey et al, 2012) the Marine Spatial Plan document reported that from 12 years of monitoring data supported by synoptic surveys, NIWA concluded that no significant depletion of phytoplankton has occurred from mussel farming in the Firth of Thames. Given the lack of phytoplankton depletion in a dense mussel cultivation area, the short term temporary presence of mussel larvae and microscopic juvenile mussels of the proposed spat farm is unlikely to result in any measurable planktonic depletion effects.

During feeding mussels excrete ammonia into the water column, which is then oxidised through the action of heterotrophic bacteria. Fouling organisms also contribute to the dissolved nitrogen pool, however, in the New Zealand situation where most mussel farms are situated in well-flushed areas, nutrient enrichment beyond the farm boundaries is difficult to detect (Zeldis, 2008; Stenton-Dozey, 2013). Given the difficulties in measuring nutrient enrichment as a result of full-scale mussel cultivation, the likely effects of nutrient contribution from the short term and temporary presence of mussel larvae and microscopic juvenile mussels of the proposed spat farm in this situation would be so small as to be impossible to quantify in the field. As a result of the immeasurable impacts the proposed activity would have, the measurement or monitoring of these parameters is pointless.

7 DISCUSSION

The most important management tools for preventing adverse effects as a result of mussel aquaculture appears to be the appropriate location of mussel farming structures and an appropriate scale of activity. This applies to all manner of potential adverse effects from seabed and water column impacts to seabirds and marine mammals and includes fisheries impacts on humans. The location and the type and scale of operations for this proposed mussel spat catching facility provide for the avoidance or minimisation of these potential adverse effects.

The seabed in the proposed location is mostly sand and broken shell and is not known to have any biogenic reef structures present. The biological communities present within and around the site, both intertidally and subtidally, were of moderate to low diversity and did not represent high value habitat or show unique or unusual characteristics that might preclude the proposed activity.

The main periods of spat catching are the months of September and October with a secondary period in March and April. The times of mussel spawning activity can vary each year, however, it is proposed that spat catching at this site will be undertaken mainly during these months. The proposed site would have approximately 10,000 metres of catching rope over the time of expected spat fall. Once the ropes have been deployed, they would be checked on a weekly basis for spat fall and relocated once sufficient mussel spat density has been achieved.

The proposed location is sufficiently separated from known breeding sites of seabirds to avoid disturbance effects and is likely to have less than minor effects on seabird foraging habitat. Coastal seabirds are unlikely to be adversely affected as a result of key foraging habitat exclusion and the proposal may provide some mild positive benefits in terms of enhanced roosting habitat and the potential for the attraction of small fish that might benefit piscivorous seabirds. Marine litter is an issue that can be adequately managed through farm management practices and artificial lighting associated with the proposal would be minimal and is unlikely to be an issue for seabirds. While entanglement issues may be perceived to be a potential threat to seabirds, the reality is that aquaculture in

New Zealand does not result in seabird entanglement, unlike commercial and recreational fishing.

The location of the proposal is clearly removed from known habitats and likely locations of baleen whales such as humpback, Southern right, blue, Minke, Sei, Fin or Bryde's whales. These baleen whale species would be at the highest risk of entanglement with the proposed spat catching facility due to their inability to echolocate, however, given the extremely unlikely interaction of these species with the proposed facility, those risks appear to be less than minor. Similarly, sperm whales are not likely to encounter the proposed spat catching facility as they do not enter shallow harbours such as Aotea Harbour. Maui's dolphin, while occasionally sighted outside Aotea Harbour, do not appear to utilise the Harbour itself as key habitat, and as the area proposed for spat catching is 4-6 metres deep it is therefore unlikely that the proposed facility would have any adverse effects on Maui's dolphin. Common dolphin, Bottle-nosed dolphin and Orca may be occasional visitors to Aotea Harbour and, as such, may encounter the proposed spat catching facility, but the agility, intelligence and echolocation abilities of these marine mammals, together with the shallow nature of the area proposed and the scale of operations of the facility would suggest that any adverse effects are likely to be less than minor. New Zealand fur seal are quite likely to enter Aotea Harbour and may encounter the proposed facility as a result. They are, however, unlikely to be adversely affected by this proposal.

While the potential for biosecurity issues exists and the consequences of pest species expansion may be significant, these risks can be adequately managed, as they are elsewhere in the country, through the development and activation of a Biosecurity Management Plan. The risks of pest species being spread via commercial or recreational vessels and equipment exist whether this proposed spat catching facility is granted consent or not and this proposal, with its attendant biosecurity management, is unlikely to change that risk profile. The risks of the introduction or spread of disease as a result of the proposed activity are extremely low.

The water column effects resulting from mussel farming are highly localised and difficult to measure even in full-scale and high-density cultivation situations. Given the location and scale and the seasonal nature of operations, this proposal is extremely unlikely to have any measureable effects on the water column in terms of either plankton depletion or nutrient release and therefore there is no ecological value in monitoring these parameters. The proposal is equally unlikely to have adverse effects on existing subtidal or intertidal biological communities within or outside the Harbour through water column effects. Given the high structural porosity and the short term and temporary deployment of spat catching lines, the hydrodynamic effects of the proposed spat catching facility are unlikely to be anything more than minor. As a result of the minimal effects on tidal or wind generated currents and the wave environment within Aotea Harbour, the proposal is not likely to have any measurable effects on coastal processes within the local or wider area.

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