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LYTTELTON PORT OF CHRISTCHURCH COAL STOCKYARD EXPANSION PROJECT: RESPONSE TO FURTHER INFORMATION REQUEST – MARINE ECOLOGICAL MATTERS.

Purpose: Lyttelton Port Company has applied for a suite of resource consents to expand the coal stockyard and the quarrying at Gollans Bay.

In a letter dated 10 March 2010, the Canterbury Regional Council has requested further information under Section 92 of the Resource Management Act, 1991. The purpose of this report is to provide answers to those questions (or parts thereof) relating to the marine ecological effects potentially resulting from the proposed reclamation. These are questions 38 to 40 (marine mammals and fisheries resources), questions 42-43 (biosecurity and marine pest species), questions 55, 67, 68, 69, 70 and 71 (stormwater discharges). This report answers the questions in the order contained in the Request but divided into five broad categories.

1. Marine mammals

Question 38 *A detailed description of benthic ecology in the harbour has been provided. Please also provide information on marine mammals, seabirds (including shorebirds), fish and other pelagic biological resources of the harbour that may utilise the area of immediate influence of the proposed works.*

Cawthron is providing information on marine mammals and benthic and pelagic ecological resources within the area of potential influence of the proposed works. Boffa Miskell Ltd (Annexure E) is providing information on seabirds/shorebirds.

Out of the more than 50 species of cetaceans (whales, dolphins and porpoises) and pinnipeds (seals and sea lions) known to live or migrate through New Zealand waters, only seven cetaceans and one pinniped species were found to frequent Lyttelton Harbour and/or its entrance waters. A list of these species is given below (Table 1).

NOTE: Detailed information on distribution and/or habitat usage is only available for a handful of New Zealand's marine mammals, despite recent advances in survey techniques and large-scale improvement in data quality from remote sensing technology. Much of the information that is known has come from marine mammal strandings –a dead or live marine mammal that washes on to the shore and is unable to return by itself. Until more systemic and dedicated research surveys are completed, species' residency within Lyttelton Harbour can only be estimated from opportunistic sightings and strandings (*e.g.* Department of Conservation-DoC), tourism reports and any past/present research in nearby areas.

Table 1. The residency patterns of marine mammal species known to frequent Pegasus Bay and nearby waters of Lyttelton Harbour. Species' conservation threat status is listed for both the New Zealand system and international IUCN system.

Common Name	**Species Name**	**NZ Threat Classification**		**IUCN Red Listing**	**Residency Category in Pegasus Bay Waters**
RESIDENTS					
Hector's dolphin	*Cephalorhynchus hectori hectori*	NZ native & resident, evaluated, threatened	Nationally Endangered	Endangered	Year-Round Resident
NZ fur seal	*Arctocephalus forsteri*	NZ native & resident, evaluated	Not Threatened	Least Concern	Seasonal to Year-Round Resident
MIGRANTS					
Southern right whale	*Eubalaena australis*	NZ native & resident, evaluated, threatened	Nationally Endangered	Least Concern	Seasonal Migrant
Humpback whale (Oceanic population only)	*Megaptera novaeangliae*	NZ native, evaluated,	Migrant (Threatened)	Endangered	Seasonal Migrant
VISITORS					
Dusky dolphin	*Lagenorhynchus obscurus*	NZ native & resident, evaluated	Not Threatened	Data Deficient	Seasonal to Infrequent Visitor
Common dolphin	*Delphinus delphis/capensis*	NZ native & resident, evaluated	Not Threatened	Data Deficient to Least Concern	Seasonal to Infrequent Visitor
Orca (killer whales)	*Orcinus orca*	NZ native & resident, evaluated, threatened	Nationally Critical	Data Deficient	Seasonal to Infrequent Visitor
Bottlenose dolphin	*Tursiops truncatus*	NZ native & resident, evaluated	Range Restricted	Least Concern	Infrequent to Rare Visitor

The marine mammal species potentially found in the vicinity of the proposed reclamation activities, include the residential communities of Hector's dolphin and New Zealand fur seals, and to a much lesser extent, any visiting southern right whales. As such, a brief summary of each species is given below.

Hector's dolphin

Hector's dolphin is the only dolphin species endemic solely to New Zealand waters. This species occurs around the South Island, with approximately 1,500 dolphins out of the estimated total population (*c.* 7,000-8,000 animals) found within Banks Peninsula waters. The Banks Peninsula animals are considered to be part of a semi-residential and fairly isolated community that are not thought to intermix with other regional communities to the north or south.

During the warmer summer and autumn months, dolphins move close to the shore and spread into the Peninsula's bays and harbours, including Lyttelton Harbour. It is over this time period that most Hector's dolphin calves are born (October to March). While calves have been regularly sighted within particular areas of Akaroa and Lyttelton Harbours and some southern bays, no distinct calving and/or nursery areas have been clearly identified. Over the colder months animals generally move further offshore and mainly out of the bays and inner harbour regions, with only a few animals continuing to remain in mid-harbour and entrance waters. Particular areas of the Peninsula appear to be important to this community. Large densities and several individual home ranges are based among the northern bays between Baleine Point (eastern most headland of Port Levy) and Stony Beach (west of Okains Bay). However, there is not enough information on animal movements within Lyttelton Harbour to specify any particular habitats or geographic locations that may be more important to this local population.

As these dolphins are highly clumped in their regional distribution, do not migrate long distances (>106 km) and have a fairly low total abundance, they have been listed as a *nationally endangered* New Zealand species. The main threat to this species is entanglement in gillnets (commercial and recreational), and to a lesser extent the trawling fisheries, but also includes increased eco-tourism and boat strikes on newborn calves. Thus far, this species appears to be fairly resilient to a range of coastal developments.

New Zealand fur seals

Current estimates of fur seals around New Zealand number around 100,000 animals and they are well established along the South Island's eastern coastline. Despite seals being observed year-round within Peninsula waters, only two distinct breeding colonies are found and these are southern Peninsula bays rather than Lyttelton Harbour. Seals tend to be more densely clumped within breeding colonies from late spring to summer, and pups generally leave colonies around late winter/spring months. This species is considered non-migratory and generally thought to return to the same breeding colony once they are sexually mature.

However, fur seals are known to travel long distances to find food. Some adults will travel out to open waters over winter while younger animals remain in shelf waters. Fur seals are the most common pinniped species observed within New Zealand waters today. Due to their general abundance and sustained growth, New Zealand fur seals are considered *not threatened* by the New Zealand Threat Classification System. Current threats at sea include entanglement in trawl fisheries and pollution such as oil spills. On land, fur seals are susceptible to disturbance from humans and domestic animals, such as dogs.

Southern right whales

Regular sightings of southern right whales occur off Banks Peninsula, in particular the northern bays and Lyttelton Harbour coastline, each year as whales migrate back to their traditional wintering grounds around New Zealand. The majority of whales are sighted along New Zealand's eastern coastal shores, and Banks Peninsula is considered one of their preferred habitats. It is not unusual for these whales or humpback to enter shallow, enclosed harbours such as Otago, Akaroa or Lyttelton Harbours, and remain for several hours or the course of a day. However, based on historical whaling data and a review of sightings, Banks Peninsula does not appear to be a final destination point for right whales. At the current sighting rate, at least one, and more likely two, right whales are expected to appear near or within Lyttelton Harbour entrance waters each winter where they will remain for a few days and up to a week. These whales are fairly solitary animals that usually travel alone or in small groups of 2-3 individuals.

Due to their low numbers around mainland New Zealand (less than 50 animals), southern right whales are listed as *nationally endangered*. While researchers believe whales around mainland New Zealand are potentially increasing, as of 2002 there has been no increase in the number of cow/calf pairs sighted in the last 25 years. Instead, the recent increase in sighting numbers is attributed to the increase in public awareness. Right whales' tendency to remain within coastal surface waters while feeding and migrating, and their natural curiosity places them at greater risk of interactions with human activities.

Question 40 *Lyttelton Harbour is part of the Banks Peninsula Marine Mammal Protection area. Please assess the potential effects of the reclamation activities on marine mammals in the harbour, particularly Hectors Dolphins*

Assessment of the potential effects of reclamation activities on marine mammals in the harbour, particularly Hector's dolphins

Further discussions about potential reclamation effects on marine mammals will mainly focus on the three most relevant species discussed above; Hector's dolphin, New Zealand fur seal and southern right whales.

Potential interactions between marine mammals and coastal development result from an overlap between the spatial location of the development and important habitats of the species. The area in which the proposed reclamation activities will occur (Te Awaparahi Bay) has undergone previous reclamation works. As Sneddon & Barter (2009) found, its habitats were relatively uniform and predominated by soft sand-mud benthic communities and a mainly artificial intertidal zone, neither of which have any special scientific or conservation values. In addition to its modified ecosystem, the bay's close proximity to the working port and shipping channel means it is highly unlikely that Te Awaparahi Bay constitutes an important feeding or breeding habitat for any marine mammal species. However, its relative proximity to the harbour entrance and the natural curiosity of these species may result in individual animals or groups traveling past or through Te Awaparahi Bay on their way in or out of the harbour. Hector's dolphins have been regularly observed within Gollans Bay during Travis' (2008) study and between Sticking Point and Breeze Bay by captains of the Black Cat tour boats (pers. comm. R. Thomas, Black Cat captain)

The direct effects of an overlap between marine mammal species and coastal development can range from physical injuries or mortalities (*e.g.* vessel strikes or entanglements) to avoidance or even abandonment of the area by the species due to the general increase in activity (*e.g.* traffic). The issue of underwater noise effects (Question 41) is addressed by Hegley Acoustics. In this case, the construction of the proposed reclamation is not expected to result in any direct effects in terms of physical injuries, direct mortalities, significant habitat loss and/or even long-term avoidance by any of the three species. This conclusion is based on:

1. A potential increase in vessel traffic:
    - These species, in general, are very curious and either have a nearshore distribution pattern or visit bays, harbour and other nearshore habitats on a regular basis. Frequenting coastal regions, such as Lyttelton Harbour waters, means these

species are in constant contact with all sizes of commercial, recreational and eco-tourism vessels and various coastal activities.
- Hector's dolphin are attracted to boats or unusual noises, and often safely approach and/or bowride with numerous vessels.
- Fur seals often respond neutrally to boats when in the water, although may bowride occasionally.
- Low probability of any construction vessels encountering a migrating southern right whale - currently only 1-3 individual whales are sighted near Lyttelton Harbour entrance waters each year, and these sightings are restricted mainly to winter months and occasionally spring months (*e.g.* October). Southern right whales are curious, but will most likely avoid moving vessels if possible.
- Any increase in vessel traffic will be slow moving, short-term and fairly localised in nature.

2. Potential habitat loss:
    - The actual size of the proposed reclamation area (~13 hectares[1]) to be disturbed is very small to insignificant in relation to these species' overall home ranges (see question 38) and other available nearby habitats that are similar.
    - There is a lack of evidence that the proposed reclamation area serves as important, unique and/or rare habitat for any marine mammal species in terms of feeding, resting and/or breeding activities.
    - Any habitat disturbance or loss is expected to be short-term and temporary, and limited to within the reclamation area only (colonization of new and disturbed substrates by benthic and intertidal communities is predicted to begin immediately and be completely indistinguishable from the existing community within two years – Sneddon & Barter 2009).

3. Possible long-term avoidance of reclamation area:
    - Individuals of these species that regularly frequent Lyttelton Harbour have been previously exposed to similar types and levels of port construction and reclamation activity within the harbour (maintenance dredging within Lyttelton Harbour has been occurring since 1876). This previous exposure has not resulted in any known long-term avoidance behaviours as all three species continue to regularly live and/or visit the harbour.
    - If avoidance of the proposed reclamation area did occur, it is expected to be temporary and have little direct effect on the populations due to the relative short-term nature of construction process and small scale of the disturbed area.

Indirect effects may result from physical changes to the habitat itself that adversely affect the health of the local ecosystem and/or impinge on important prey resources. The proposed reclamation activities are not expected to result in any detrimental or long-term ecosystem effects on these marine mammal species. This assessment is based on:

1. Potential effects on the local ecosystem:
    - Relatively uncontaminated sediments to be dredged from the toe of the existing Te Awaparahi Bay reclamation.
    - Relatively small percent of benthic habitat loss (~0.3%) of comparatively low productivity and low biodiversity within Te Awaparahi Bay. Rapid recolonisation of the new seawall and adjacent benthic areas will allow the area to recover completely (Sneddon & Barter 2009).

[1] This includes the toe of the reclamation under the water surface *i.e.* total area covered by geotextile.

- Any increase in turbidity effects from dredging or construction activities are expected to be similar or less than those generated by on-going maintenance dredging of the nearby shipping channel (Sneddon & Barter 2009), and thus are not expected to adversely affect any nearby habitats or prey species.

2. Potential effects on prey species:
    - Only temporary and localised avoidance of the proposed reclamation area by individual fish species with no effect on species recruitment.
    - Resident fish and marine mammal species are regularly exposed to highly turbid waters within the harbour and adjacent coastal regions, and may actually take advantage of such conditions to catch prey species.

2. Fisheries and pelagic biological resources

Note: The following discussion is limited to non-avian fauna. The distribution, habits and effects of the proposal on seabirds are beyond the scope of the survey and assessment work carried out by Cawthron.

Question 38 *A detailed description of benthic ecology in the harbour has been provided. Please also provide information on marine mammals, seabirds (including shorebirds), fish and other pelagic biological resources of the harbour that may utilise the area of immediate influence of the proposed works*.

Fish and other pelagic biological resources of the harbour that may utilise the area of immediate influence of the proposed works.

A wide variety of fish species have been anecdotally reported in Lyttelton Harbour, including instances as strandings in the Lyttelton Dry-dock (Table 2). Recreational fishing is known to occur in the Lyttelton outer harbour, and regions in the proximity of the upper harbour mudflats are recognised as important nursery/roosting areas for wildlife and habitats for fish species such as sole (*Peltorhamphus novaezeelandiae*), red cod (*Pseudophycis bachus*), spotted stargazer (*Genyagnus monopterygius*) and flounder (*Rhombosolea* sp.) (DOC 1990)

During summer, the port area is frequented by juvenile fish of species such as red cod, yellow eyed mullet (*Aldrichetta forsteri*), blue warehou (*Seriolella brama*), spiny dogfish (*Squalus acanthias*) and green pufferfish (*Contusus richei*). Adult fish such as red cod and quinnat salmon (*Oncorhynchus tshawytscha*) have also been caught from the wharves. No stock abundance figures were available for the harbour itself but the sheltered, relatively shallow waters of the wider Harbour area cannot be neglected as possible spawning and nursery grounds for many of these species. In a study of the reproductive biology of the pufferfish (*Contusus richei*) from Lyttelton Harbour, Habib (1979) found pufferfish start to spawn at summer time from October to March.

However, the benthic area in the vicinity of the proposed reclamation is not particularly sheltered from surge and survey data indicates that it possesses no benthic characteristics (*e.g.* benthic communities, biogenic structures) which would suggest its specific importance in regard to either feeding or spawning activity. Of the species likely to comprise the majority of the recreational fishing catch from within the Harbour (*e.g.* flatfish, red cod, and gurnard); all are believed to be fairly wide-ranging in their habits.

Table 2 Table 1 List of fish species targeted or caught incidentally by recreational fishers within Greater Lyttelton Harbour; based on historical data and reliable anecdotal evidence [Canterbury Anglers Club, Lyttelton Dry Dock, Ministry of Fisheries (Recreational Fisheries), University of Canterbury (School of Biological Sciences)]. Adapted from Bennett & Sneddon (2006).

Common name	Scientific name
Red cod	*Pseudophycis bachus*
Sand flounder	*Rhombosolea plebeia*
Sole	*Peltorhamphus novaezeelandiae*
Quinnat Salmon	*Oncorhynchus tshawytscha*
Monkfish / Stargazer	*Kathetostoma giganteum* or *Genyagnus monopterygius*
Trevalli	*Caranx georgianus*
Ling	*Genypterus blacodes*
Kahawai	*Arripis trutta*
Terakihi,	*Nemadactylus macropterus*
Blue cod	*Parapercis colias*
Butter fish	*Odax pullus*
Blue moki	*Latridopsis ciliaris*
Red gurnard	*Chelidonichthys kumu*
Garfish/ piper	*Hyporhamphus ihi*
Yelloweye mullet	*Aldrichetta forsteri*
Spotty	*Notolabrus celidotus*
Puffer fish	*Contusus richei*
Conger eel	*Conger vereauxi*
Stingray or skate	*Sasyatis brevicaudatus*
Spiny dogfish	*Squalus acanthias*
Seven gill shark	*Notorynchus cepedianus*
School shark/lemon shark	*Galeorhinus australis*
Rig	*Mustelus lenticulatus*

Question 39 *Please assess the potential effects of the proposed activities on …. fisheries resources and other pelagic biological resources in and around the harbour in terms of effects on resources in the immediate area and identify whether there is any potential for far-field effects.*

Potential effects of the proposed activities on fisheries resources and other pelagic biological resources in and around the harbour and the potential for far-field effects.

Direct physical disturbance

Based on the construction methodology outline, direct physical disturbance of benthic habitats is unlikely to extend more than a few tens of meters from the edge of the structural footprint of the reclamation. This makes the area of disturbance very small relative to the size of similar benthic habitats occurring within Lyttelton harbour.

The area of seabed to be reclaimed is already modified to some extent as follows:

- It is bounded to the north and west by the artificial structure of the existing coalyard seawall.
- It is in close proximity to periodic dredging of the harbour main channel to the south and the disposal of dredge spoil in Gollans Bay to the east.

- The substrate and bathymetry result to some degree from the use of “mud-waving” as a method of establishing the earlier reclamation of the current coalyard.

Furthermore, the survey data indicates that the seabed area which will be lost or significantly disturbed by the project contains no specialised habitats or food sources which may be limited in the wider area. On this basis, effects on fishery and other ecological resources resulting from direct disturbance to habitats are expected to be minimal.

Although the presence of the reclamation will have some effects on local tidal currents in the immediate vicinity, effects on general harbour tidal flows and circulation will be negligible. Neither will the reclamation present any barrier to fish passage into and out of the upper reaches of the harbour, either during construction or subsequent operation.

Far-field effects

As detailed in the Cawthron Report 1509 (Sneddon & Barter 2009), far-field effects will be limited to temporary turbidity plumes generated by construction activities such as dredging, spoil disposal, placement of the bunding structure and, potentially, water displaced from the reclamation paddock during infill.

With its expanses of mud-flats in the upper reaches, significant wind-fetch and wave penetration, Lyttelton Harbour is a naturally turbid environment and water column sediment concentrations can vary through quite wide ranges. Species frequenting the harbour year-round, or as part of their natural range/life cycle, will be naturally tolerant of these conditions. High-strength plumes from construction activities will be localised (typically up to about 100m) and the effect on far field turbidity (*e.g.* beyond 100 m) is unlikely to exceed that of natural variation from periodic land run-off and wave resuspension of sediments (pers. comm. G. Teear, Ocel Consultants).

3. Biosecurity

ECAN have requested further information in relation to the biosecurity risks of the proposal, as follows:

Question 42 *The pest species in Lyttelton Harbour and implications of the new habitat created by the reclamation on their distribution, especially of Undaria pinnatifida (Asian kelp), Styela clava (clubbed tunicate) and Sabella spallanzanii (Mediterranean fanworm). All three species have been declared as unwanted under New Zealand’s Biosecurity Act 1993.*

Question 43 *Implications of the proposal in terms of the further establishment, spread and impacts of the above species by associated vessel movements during reclamation and as a result of ongoing coal handling operations.*

Each of these points is addressed below.

New habitat and pest species

The new seawall of the reclamation will essentially be of the same material type (rip rap style quarried boulder rock) and length (~800 m) as the present wall. Depths in front of the seawall will be around 9 m or less. Hence, the extent of artificial habitat will not change appreciably from the present situation; the key difference is that bare surfaces will be available for colonisation by potential pest species.

Baseline ecological surveys were conducted in the Lyttelton Port area in 2002 and again in 2004 for MAF Biosecurity New Zealand (MAF BNZ). The 2004 survey recorded 269 species or higher taxa, of which 23 species were reported as non-indigenous, 55 cryptogenic (those whose geographic origins are uncertain) and 40 indeterminata (taxa for which there is insufficient information for identification to species level). Of the three species noted of concern by ECAN, it is mainly Sabella that is of interest, as is made evident in the discussion on each species below:

1. Undaria: this kelp is of little interest in the context of the reclamation. It is well established in natural and artificial habitats throughout Lyttelton Harbour, in Akaroa Harbour, northern Banks Peninsula, and in fact in most ports and harbours throughout New Zealand (Forrest *et al*. 2000). Undaria was first recorded in Lyttelton Harbour in 1991; however, no significant ecological impacts were documented in a three year Cawthron study (Forrest & Taylor 2002). Undaria will undoubtedly establish on the new rip rap, as it is adept at colonising this type of substratum. However, it is already present on the existing rip rap, and along the adjacent natural habitats to the east.

2. Styela: This tunicate (sea squirt) was first reported from Lyttelton Harbour in samples from the 2004 baseline survey, with a targeted delimitation survey in 2006 revealing a low density population that is widespread through the port environs and Magazine Bay marina (Gust *et al*. 2008). Subsequently, we have observed low densities of Styela in adjacent natural habitats (B. Forrest, pers. obs., November 2009). Styela is also well-established in Tutukaka marina, Waitemata Harbour and Otago Harbour. A comprehensive consideration of management options by Gust *et al*. (2008) led to the decision by MAF BNZ not to undertake any targeted management of this species in Lyttelton Harbour. Furthermore, the delimitation survey of Gust *et al*. (2008) did not find Styela on rip-rap breakwater walls. For such reasons, and because Styela is now spreading uncontrolled throughout New Zealand with vessel traffic and other vectors, we do not consider the new habitat created by the reclamation to be of any specific concern from a biosecurity perspective.

3. Sabella: The fanworm Sabella was recently detected in Lyttelton Harbour during routine marine pest surveillance funded by MAF BNZ. A subsequent delimitation survey undertaken by Cawthron revealed a low density population within the inner port (Conwell & Piola 2008). MAF BNZ has since implemented a management programme for this species, which involves diver searches and removal of Sabella from the port environs, in the hope that the population will be reduced beneath the threshold for reproduction. Funding for the continued management of this species is presently being decided by Cabinet. Under the assumption that management continues, this species is clearly of interest in terms of the reclamation. However, we have been informed by MAF BNZ that Sabella is not known to colonise rip-rap habitats and does not occur in such habitats in Lyttelton (Dr Peter Stratford, MAF BNZ, pers. comm. April 2009). In this respect, the creation of bare rip-rap substratum is not of significant concern in relation to the spread of Sabella.

Pest spread as a result of vessel movements

Construction of the reclamation and the subsequent operation of the expanded coal handling facility have the potential to alter patterns of vessel movement. Since there will be no new wharf facility associated with the reclamation, coal vessels will berth at the existing Cashin Quay wharf with an increased frequency consistent with the subsequently greater export tonnage of coal.. However, from an ongoing operational perspective, we do not attach any significance to changes in merchant vessel activities that might result from the proposal.

There are in excess of 2000 merchant vessels movements to New Zealand each year (Campbell 2004; Dodgshun *et al*. 2007). In addition, approximately 25% of the vessel traffic to New Zealand consists of vessels such as yachts, fishing vessels and barges, which all have their own characteristics and idiosyncrasies that contribute in different ways to biosecurity risk. A myriad of factors (*e.g.* altered patterns of trade) routinely arise that alter the biosecurity risk profile to New Zealand posed by merchant vessels (Taylor *et al*. 1999).

In this broader context, changes resulting from the proposal are of little consequence. We also note that merchant vessels as a whole tend to be well-maintained and antifouled (Coutts & Taylor 2004), and are subject to an Import Health Standard that requires them to exchange their ballast water en route to New Zealand. Ballast water exchange at sea is recognised as the only practical way of reducing the spread of marine pests via ballast water discharge, although it is acknowledged that this is not completely effective.

Of more significance than merchant vessels would be the use of barges or other marine structures during the reclamation construction. Barges, marine structures and slow moving vessels (*e.g.* tugs that tow barges) can become heavily fouled (*e.g.* Coutts 2002; Coutts & Forrest 2007; Hopkins & Forrest 2009). Moreover, the slow speed at which such structures/vessels travel (cruising speed of 5 - 10 knots) is generally considered to favour the survival of their associated fouling assemblages (Davidson *et al*. 2006; Coutts *et al*. 2010). Hence, factors of potential concern in relation to the reclamation would be:

- The use of such structures/vessels from source regions outside Lyttelton Harbour, in particular from overseas source regions known to harbour marine pest species. We note that MAFBNZ is working towards developing stringent pre-border vessel hull fouling requirements to reduce biosecurity risks from these structure/vessel types when they visit New Zealand waters.

- The potential that such structures/vessels could be infected by Sabella and Styela (to a lesser extent) while associated with the reclamation works, and further spread these pests when moving to New Zealand locations outside the region.

In the event that structures/vessels to be used in construction are sourced from outside New Zealand, the above possibilities could be adequately mitigated by a requirement (*e.g.* consent condition) for the applicant to develop a biosecurity risk assessment and management plan (BMPRA). Such a plan could identify risks from structure/vessel activities, and associated management strategies to minimise risk and would contribute towards the border clearance requirements of MAFBNZ. A recent example was a BMPRA developed for a drilling rig operating in waters under the jurisdiction of Marlborough District Council (Forrest & Hopkins 2009).

4. Stormwater

Question 55 Potential effects to the marine environment from dust suppressants applied to the coal stockpiles.

Many of the marketed formulations for dust suppressants are proprietary, and general claims as to their "non-toxic" nature are not easily verifiable. However, historically used petroleum- coal- and pitch-based products have increasingly been replaced by less environmentally harmful products based on emulsions of organic polymer resins, lignosulphonates or anionic surfactants.

In a broad review of organic chemicals of emerging environmental concern, Arhens (2008) noted that insufficient information was available to assess the potential ecological impacts of dust suppressing agents. However, the agents most likely to be used for the suppression of dust at the LPC coal stockpile are identified as being based on the following chemicals:

- Polyvinyl acetate (PVA) emulsions
- Anionic polyacrylamide (PAM)
- Lignosulphonates
- Natural (non-synthetic) gums

Polyvinyl acetate (PVA)
Polyvinyl acetate is a synthetic polymer and a member of the vinyl ester family. It has been widely used as the basis of many adhesives since the 1940's; and vinyl acetate emulsions are also heavily used in paints, textile sizing and nonwoven binders. Setting occurs with the removal of water due to evaporation or absorption into a substrate. The polymer cross-linking which occurs as the emulsion dries results in a water and UV-resistant film which will not easily breakdown or leach into run-off water.

The cured film is essentially non-toxic and has been used as a protective coating for cheese to render it safe from humidity and fungi. Its relative insolubility means that PVA will not contribute to dissolved contaminants in coal stockpile runoff. While it is possible that a component of the film would be incorporated into the stormwater particulate load once the crust is mechanically disturbed, it is likely that most of this would be removed with coagulation/flocculation in the lamella treatment plant.

Polytetra-fluoroethylene (PTFE)
It is understood that one of Dupont's dust suppressant formulations marketed specifically for such applications (Dusgone^{TM} 6006) contains 2% to 20% (by total weight) of 0.05 to 0.5 μm polytetra-fluoroethylene (PTFE) resin particles as a dispersion in the synthetic polymer resin emulsion (Dupont Product Information). PTFE (teflon^{TM}) is inert and highly stable below 350°C hence does not represent a toxicity risk. Potential environmental effects associated with the very fine nature of these particulates are unknown but would only be of concern if significant quantities were released to harbour waters. Since they would be incorporated into the polymer matrix of the cured resin film, they are very unlikely to be an environmental risk, and in any case would mostly be mixed into the coal pile itself or removed in stormwater treatment.

Polyacrylamide (PAM)
Anionic polyacrylamide (PAM) is a large (12-15 mg/mol) water-soluble (non-cross-linked) anionic molecule. PAM has been marketed since the mid-nineties as a soil conditioner to reduce irrigation-induced erosion and enhance infiltration. It is also a component of commercially available flocculants used in water treatment. About 800,000 ha of US irrigated land use PAM for erosion and/or infiltration management (Sojka *et al.* 2007). Its use on farm land and construction sites for

erosion control is favoured in order to protect the water quality of nearby rivers and streams (Nwankwo 2001).

For the most part, polyacrylamide is resistant to microbial attack, and its degradation is mainly through physical breakdown. Polyacrylamide has been shown to be non-toxic to humans, animals, fish, and plants and it has a wide variety of high-human contact applications from children's toys to sub-dermal use in aesthetic surgery. The only concern has been the toxicity of its residual monomer (acrylamide) which is carcinogenic and neurotoxic (Arhens 2008). While traces of unreacted acrylamide monomer can be present in polymerised acrylamide, this is claimed to be generally less than 0.05% in commercial products. The residual monomer is bio-degradable and does not accumulate in soils (Seybold 1994).

PAM is widely used in potable water treatment. Trivalent metal salts like ferric chloride and aluminium chloride are bridged by the long polymer chains of polyacrylamide. This results in significant enhancement of the flocculation rate and allows water treatment plants to greatly improve the removal of total organic content (TOC) from raw water.

Being water soluble, PAM used as a dust suppressant would be present in coal stockpile storm runoff, but its strong surface-attractive properties would mean it was generally associated, through adsorption, with suspended particulates, aiding the flocculation processes in the treatment plant. The very little PAM that might pass through the lamella plant would be dispersed and harmlessly degrade in receiving waters.

Lignosulphonates:
Lignosulphonates contain primarily wood resin and, as they are typically industrial waste products, their exact composition can be variable. They tend to biodegrade very slowly and may have low to moderate toxicity in freshwater ecosystems [LC50 = >100 mg/L (96-hour rainbow trout bioassay) Kimberly-Clark MSDS 2007]. Due to a high biochemical oxygen demand (BOD ~ 100,500 ppm), mass spills of lignosulphonates will de-oxygenate water where the dispersion/dilution characteristics of a water body are limited. In general, they are not regarded as particularly harmful in most receiving environments.

Natural (non-synthetic) gum
Natural organic gums contain no synthetic polymers. Non-toxic plant derived gums include many which are used in the food industry as additives. These are usually poly-saccharide-based and are inherently biodegradable. Polysaccharide gums can exhibit a range of chemical properties including variable solubility in water. Resinous gums are likely to be more persistent in the environment but most are relatively insoluble and unlikely to result in toxic effects. Any dust suppressants of low solubility are likely to be effectively removed in flocculation/coagulation treatments.

Potential release of dust suppressants to Lyttelton Harbour
Except where dust suppressant components are water-soluble, much of the material applied to the coal stockpiles will be incorporated into the bulk coal. The soluble or partially soluble components considered above do not represent an environmental risk at the concentrations which would be expected in storm runoff from the coal stockyard. Moreover, stormwater collected and processed through the proposed lamella plant would undergo significant removal of any dust suppressant particulate matter and, in some cases, dissolved species. The small amounts of highly diluted suppressant which may be released to the Harbour would undergo substantial dilution and dispersion in the tidally flushed waters of Te Awaparahi Bay. Significant accumulation of such chemicals in benthic sediments would not be expected to occur.

Question 67 *The TSS and NTU relationship provided yields a negative TSS for NTU values below 8.2. Explanation of the applicability of this relationship, and the validity of using it to assess the effects of the stormwater discharge. Assessment also of the sensitivity of the assessment of effects to changes in the TSS:NTU relationship.*

Turbidity is a measure of the optical properties of a fluid, whereas total suspended solids defines a physical property. There is no exact intrinsic relationship between the two. It is noted in chapter 11 of the New Zealand municipal wastewater monitoring guidelines (Barter & Forest 2002) that:

> *"Although nephelometry is a widely used measure of clarity, the readings themselves are not directly comparable with other clarity measures such as transmissivity. That is, NTU's cannot be converted to percent transmittance, suspended solids concentrations, secchi depth or black disk distance without deriving the relationship on the given receiving water or effluent through the collection of site specific measurements (Davies-Colley & Smith 2001). Another pitfall to these turbidity measurements is that different instruments from various manufacturers may yield different readings."*

However, within suitably bounded ranges of a number of variables (including particle size and nature), a simple relationship may be determined empirically for the interval of interest. The footnote to the plot in Figure 15 in Cawthron Report 1509 states that:

> *"Two values with very high TSS and NTU were removed from the dataset. These values adversely affected the linearity of the data and were discarded as outliers for the range in question."*

In the case of coal particulates in stormwater, the assumption of linearity was made for the purposes of simplicity and it is not to be inferred that the relationship is inherently linear. The range of experimental data was for TSS of 8-142 mg/L and turbidity of 8-265 NTU. Zero forcing of the trend line was not used since very low or high values do not add to the best fit of the relationship over the range of interest (although, in this case, zero forcing would not have affected the correlation significantly).

For the limited experimental data, the best fit trend line passing through zero would have been given by an exponential curve:

$$Turbidity = 435\left(1 - e^{-0.0065 \times TSS}\right) \qquad (R^2 = 0.880)$$

However, the use of this more complex relationship would overstate the degree of confidence in this calibration and is subject to the same concerns regarding its extrapolation outside the range of experimental data. The difference in fit to the data was also minor (for the linear fit, $R^2 = 0.857$).

Cawthron report 1509 identifies two principal effects from coal fines in the discharge:

1. reduction in visual clarity and/or changes in colour; *i.e.* degradation of the optical qualities of the receiving water.
2. deposition of suspended material on the seabed (which can cause smothering of benthic epibiota and/or infauna); *i.e.* resulting in a physical stressor to benthic communities.

The validity of using the linear relationship is not to assess the effects of the stormwater discharge, but rather to show that, for the purposes of monitoring over a range of coal particulate loadings, the physical stressor (TSS) can be approximated from a measurement of turbidity.

The limitations of turbidity as a proxy for other parameters are well known. The New Zealand municipal wastewater monitoring guidelines state that:

> *"Even with these problems … , turbidity is still widely used for both discharge and receiving environment monitoring programmes because of a number of factors including ease of use, small sample sizes, and very low cost."*

Given the specific nature of the source of particulates in the coalyard stormwater (*i.e.* coal fines) and the controlled nature of the bench-top calibration of the two parameters, it is considered that the linear relationship may be used with a reasonable degree of confidence over the range plotted. The exact nature of the relationship and its predictions will change slightly depending on the trend line chosen for the data and other factors such as coal source and grain size distribution and the relative predominance of non-coal particulate material; however, the assessment of receiving environment effects is not considered particularly sensitive to such changes.

The emphasis on aesthetic effects from the discharge was based on the assessment that the plume would be visibly unacceptable at TSS levels well below those which would result in benthic smothering or toxicity impacts. Since turbidity is an optical effect, it is an appropriate basis for a criterion guarding against aesthetic impacts. In this regard, a TSS limit may be seen as a proxy for the optical impacts defined more appropriately by turbidity (NTU), rather than the other way around. Hence the sensitivity of the relationship between TSS and NTU was not considered critical to the assessment of effects in the CMA.

Question 68 Short and long-term stability of poly-aluminium chloride coagulant (PAC) in the stormwater plume and assessment of potential effects in a marine receiving environment

Coagulants such as poly-aluminium chloride (PAC) act by neutralizing the surface charge of particles, reducing the electrostatic repulsion between them to promote their aggregation. By contrast, flocculents (*e.g.* long chain organic polymers with reactive ends) function as interparticle bridges, linking particles together which would normally repel one another.

There is little documented evidence of typical concentrations of residual poly-aluminium chloride remaining in treated stormwater. However, the proposed treatment process is designed to dose coagulant at the optimum concentration to avoid over-dosing of the chemical. The performance of the clarification process ensures that the colloidal suspension reacts with the coagulant and forms a floc that settles out in the clarifier [pers. com. Charles Mellish; MWH (NZ)]

There is also very little available in the literature concerning the effect of residual water-treatment coagulants in the marine environment. Most toxicological and bioassay studies have focused on freshwater species or non-marine species of alga and bacteria and tend to indicate a low level of biological risk in aquatic receiving environments. PAC is itself widely used in drinking water treatment.

Addition of the aluminium coagulant to water results in dissolved aluminium ions being incorporated into aluminium hydroxide and aluminium phosphate precipitates. These precipitates combine with phosphorus, suspended solids, metals and other dissolved and suspended matter. The insoluble precipitates are stable and, as particle size increases, so does density and the aggregates sink (ARC 2003). A small amount of the aluminium added may stay with the finished water or effluent in either colloidal particulate ($Al(OH)_3$) or soluble form (*e.g.*, $AlOH^{2+}$, $Al(OH)_2^+$, $Al(OH)_3$, $Al(OH)_4^-$), dictated by the conditions of the treatment process and in particular, the pH.

Aluminium is among the least mobile of the major elements in the geological sedimentary cycle. It is one of the most abundant elements in soil and sediment although concentrations vary widely. Environmental exposure is not simply a question of release and toxic concentrations, but also of bioavailability and the factors which determine its speciation. Under acidic conditions and, to a lesser extent, under alkaline conditions, solubility is increased. The trivalent ion is the dominant species below pH 5 and a hydroxyl anion predominating above pH 6.2, the minimum solubility point. Aluminium remains relatively insoluble in the neutral pH range (6.0-8.0). While it is true that solubility of aluminium increases above neutral pH, the increase is not as steep as with decreasing pH and solubility remains generally low at pH 8.3, the highest pH typically expected in Lyttelton Harbour waters.

Moreover, the higher ionic strength and relative magnitude of individual ion concentrations in saline waters compared with freshwaters lead to differences in coagulation reactions with aluminium salts. Aluminium is highly reactive in seawater and will be rapidly scavenged by particulate matter when released into this medium (CEPA 2008). Aluminium toxicity is also significantly attenuated in the presence of particulate and dissolved organic matter including humic substances, as well as by pH in the super-neutral range. These are all significant features of estuarine waters and it is therefore likely that any residual coagulant would be rapidly inactivated.

In reference to more sensitive freshwater receiving environments, ARC (2003) reported that, even at doses in excess of requirements, the dissolved aluminium is reduced in the receiving environment very rapidly to very low concentrations with no serious toxicity implications. Since the alkalinity of receiving waters has an important bearing on aluminium toxicity potential, seawater would be expected to be among the least sensitive of receiving waters to toxic effects.

Even in the event of low pH discharges from the coalyard stormwater treatment system, which could contain relatively high concentrations of potentially toxic dissolved aluminium, are likely to be rapidly rendered non-toxic on entering any marine environment given the highly buffered nature of seawater and since available initial dilution will be significant.

Question 69 *Please clarify whether dispersion modelling was carried out as part of the assessment of the potential dilution of the discharge in the coastal marine area. If so, please provide details of the model used and assumptions.*

No dispersion modelling was carried out for the stormwater outfall. Although Te Awaparahi Bay has been identified as an eddy in the tidal flow, it is subject to surge penetration from the harbour entrance. Hence dispersion processes are significant. As mentioned in our Report supporting the AEE (Appendix 14, page 47) the new reclamation shoreline would increase exposure to tidal flows which would, in turn, increase dilution/dispersion processes and this would serve to offset the increased stormwater discharge volume. Given the proposed level of treatment, recent and historical monitoring data indicating no discernible effects on benthic or intertidal communities from the current outfall and the scientific literature supporting generally low toxicity from coal particulates, it is considered unlikely that the reclamation outfall will result in any adverse effects on benthic ecology beyond the 100 m mixing zone.

A bench-top dilution series using coalyard stormwater effluent was carried out (section 5.3.2, p43-44 of our report 1509; Appendix 14 of the AEE) from which it was established that a dilution ratio of 10:1 would be required for a 50% change in clarity from an 80 NTU effluent. In addressing pH effects (p45), it was assessed from previous empirical work with acidic coal run-off (pH 4.5) that an allowable pH change of less than 0.2 units would be met also with a dilution of 10:1. This level of dilution is very low and it would be expected that this would be met very close to the outfall, if not within the "boil" itself. It was not believed that dispersion modelling was necessary to support this assessment.

Question 70 *Please provide an assessment of the dilution achieved at the location of the sensitive species referred to in the application.*

The dilution series was carried out to determine the upper limit of effluent turbidity (NTU) which would serve to meet the colour and visual clarity standards in the Regional Coastal Environment Plan (Rule 7.1 (b)). Dispersion modelling was not required to conclude that a 10:1 dilution would be met within meters of the outfall and is therefore a very conservative figure, especially since a 100 m nominal mixing zone is allowed for in the Rule.

All references to sensitivity of organisms and communities are context-specific. The sentences in question were in reference to sensitivity to drying out/desiccation between tides and the reference was made only in this context (also in section 3.6.2, paragraph 3). It served only to explain one aspect of differences between the armor rock-wall communities and those of the natural rock shelf at Battery Point, the latter supporting pools of standing water between tides. The meaning of the descriptor was not recognized as being ambiguous at the time of writing or in peer review.

The benthic ecological survey of Te Awaparahi Bay covered by our report (Appendix 14) did not identify any species in the area particularly sensitive to stressors associated with the stormwater outfall. The 10:1 dilution, which would meet the standards in the Regional Coastal Environment Plan on colour and visual clarity (p44), also matched that considered necessary to meet guidelines for changes in the pH of receiving waters (p45).

With regard to benthic ecological effects, historical benthic monitoring records associated with the current stormwater outfall were provided and interpreted in some detail in our report [Appendix 14 of the AEE; coal particulates – section 4.2; sediment contaminants – section 4.3 and 5.2.2 (p40); benthic communities – sections 4.4 and 5.3.2 (p47)]. An assessment of the intertidal communities close to the outfall was also provided, together with the finding that these are “typical of rocky shorelines of the Lyttelton Harbour area”.

Section 3.3 of our report shows the results of infauna community analysis for inshore stations at varying distances from the present stormwater outfall. Not only were communities at the inshore stations shown to be particularly diverse, they showed no gradient effect which could be attributed to the proximity of the outfall, despite such a gradient being apparent in the coal particulate content of sediments. This is consistent with scientific literature suggesting the relatively non-toxic nature of coal particulates (pages 30-33).

5. Sediment contaminants

Question 71 *Significant levels of mercury (and, to a lesser extent, lead) were identified from a single inshore sediment sample. Why was this potential area of contaminated sediments described as small? What is the likely cause of this contamination and how should it be managed?*

Mercury was measured at above analytical detection limits in six of the seven sediment samples collected from Te Awaparahi Bay during the 2009 survey. Historical monitoring records from the general vicinity also suggest the presence of mercury at low levels. Hence, the available data suggest that there is a low level of mercury contamination in surface sediments within Te Awaparahi Bay; but generally below that which national environmental guidelines indicate would have a possible ecological effect. The low ecological significance suggested by these levels is consistent with the documented health (high diversity, high abundance) of the sediment-dwelling fauna in these same samples, including that of the station which returned a mercury level

(3 mg/kg) above what are believed to be ecologically significant levels [ANZECC (2000) ISQG-High for mercury = 1 mg/kg].

Hence, there was good reason to believe that the elevated level of mercury measured in the single composite sediment sample collected from Station 1 (Sneddon & Barter 2009) was the result of the chance inclusion, in the small volume of sediments analysed, of contaminated large particulate matter. Supporting factors included:

- The absence of discernible effects in sediment communities.
- The coarse nature of the sediments collected at Station 1 (adsorbed contaminant load, which is likely to be both more evenly distributed and more bioavailable, is generally associated with finer sediments).
- The patchy spatial nature of elevated levels of mercury recorded historically.

An area of Te Awaparahi Bay seabed where bulk sediment mercury levels are elevated above ISQG-High is considered unlikely in this case, but as a worst case, such an area is likely to be small due to the absence of a detectable effect on benthic communities and the proximity to other sample stations recording only very low mercury concentrations.

In terms of the *likely* source of this contamination, information in the available literature is not consistent with high mercury associated with coal fines in stormwater run-off. Mercury contamination of sediments adjacent to the dry-dock in Lyttelton Port is well documented (URS 2002, Sneddon 2010). The operation of port facilities in Lyttelton Harbour has a long history and there is anecdotal information on a number of potential contaminant sources including:

- Operation of an incinerator near Battery Point
- Discharges from vessels
- Deposition of spoil from dredging in the inner harbour with possible historical sources:
    - Dry-dock discharges from vessel hull maintenance (Sneddon 2010)
    - Laboratory discharges (Stevens & Forrest 1996)
    - Run-off associated with industrial sources

To better verify the contaminant status of benthic sediments near Battery Point, re-sampling of sediments in the vicinity of Station 1 was carried out on 12 May 2010. Three samples were collected by Van veen grab within 50 m of Station 1 (Figure 1) and analysed for mercury, chromium, copper, lead and zinc.

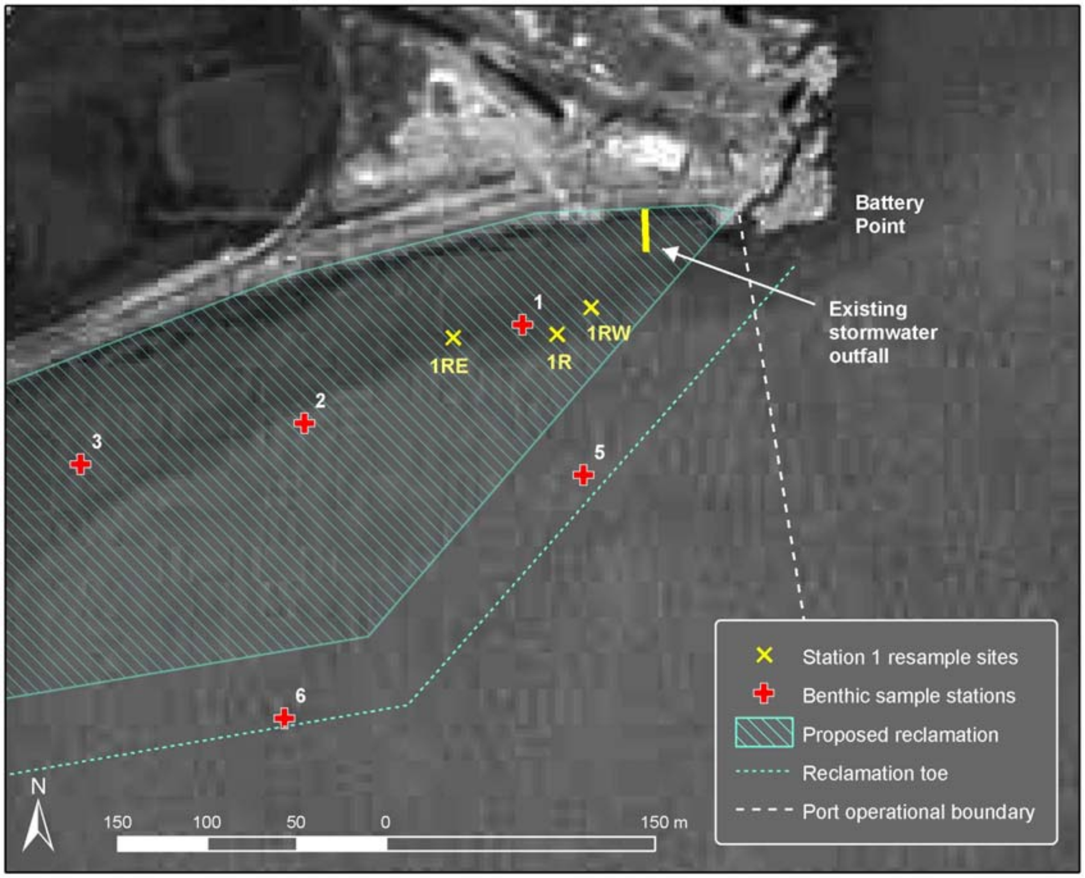

Figure 1 Eastern end of Te Awaparahi Bay showing sample stations from the August 2008 benthic survey and the May 2010 Station 1 re-sample sites.

The results of these sediment analyses, along with the earlier survey data from Sneddon & Barter (2009), are presented in Figure 2 below. As with the earlier data, results for mercury and lead stand out as being higher near Station 1 than at other stations in Te Awaparahi Bay. Copper and zinc appear also to be marginally higher in station 1 sediments.

The laboratory reported difficulty in duplicating the mercury results for these three samples, indicating a lack of homogeneity consistent with the influence of discrete particulates containing elevated mercury. An observation was also made by the laboratory, of the occurrence in the sample of visible particulate material of the nature of paint flakes.

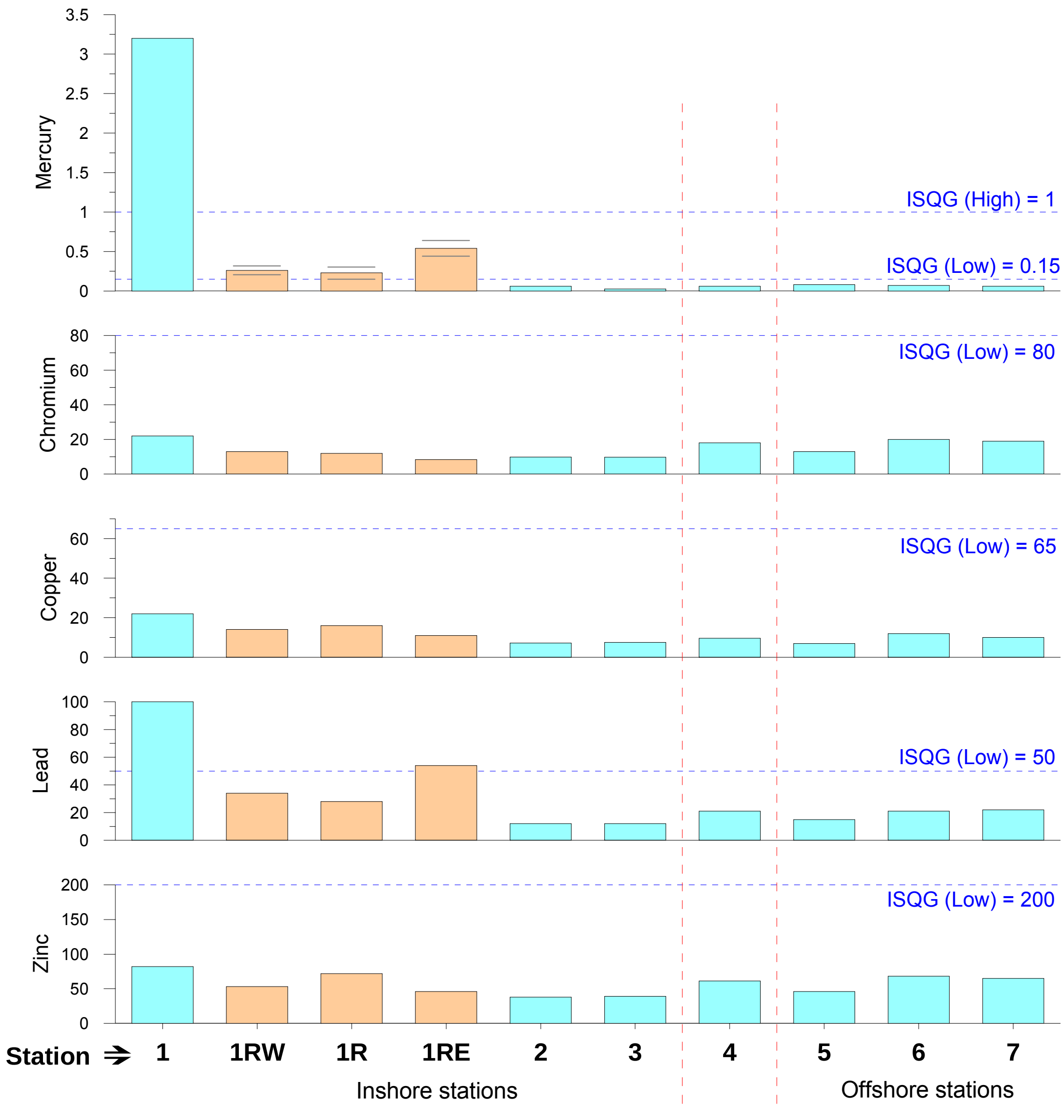

Figure 2 Contaminant levels in benthic sediments within Te Awaparahi Bay showing results from re-sampling in the vicinity of Station 1 (1RW, 1R, 1RE). Duplicate variability in re-sampled sediments is indicated for mercury. Updated from Cawthron Report 1509 (Sneddon & Barter 2009).

These results indicate that, while elevated levels of mercury and lead appear to be a feature of sediments in the localised area inshore near Battery Point, the concentrations do not exceed the ISQG-High criteria for these contaminants. This finding is in contrast to the 2008 mercury and lead results for sediments at Station 1 (Figure 2), but is consistent with their being no discernible effects on benthic communities.

The dredging of these sediments at the same time as cleaner sediments from elsewhere in Te Awaparahi Bay is likely to result in bulk spoil concentrations of metal contaminants well below ISQG-Low criteria. Additional dispersion when deposited in the consented maintenance dredge spoil grounds will further reduce these concentrations.

With regards to the Station 1 chemical analysis results from the August 2008 survey, the updated results and observations support the following conclusions:

- Although mercury and lead levels are somewhat elevated in the vicinity of Station 1 relative to offshore sediments, the earlier composite sample result was not representative of true bulk sediment levels.
- The source of the contamination appears to be from discrete particulate sources which are likely to be less bioavailable than sediment adsorbed load.

In the context of the absence of detectable effects to benthic communities in Te Awaparahi Bay, it is concluded that the disturbance and dispersion of these sediments will not result in significant adverse effects to the wider harbour area.

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