Potential impacts of Project Next Generation on Hector's dolphins and other marine mammals

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Introduction

Hector's dolphin (*Cephalorhynchus hectori*) is a small dolphin species found only in the coastal waters of New Zealand. In recent decades the species has declined substantially in abundance, largely due to unsustainable bycatch in fishing gear (e.g. Baird and Bradford 2000; DOC and Mfish 2007). Hector's dolphin is listed as Endangered by the International Union for the Conservation of Nature (IUCN) and Department of Conservation (DOC), and conservation of this species is an ongoing important management goal for the New Zealand government.

Port of Otago Ltd's (POL) proposed *Project Next Generation* (PNG) aims to provide access to Port Chalmers port facilities by larger vessels (POL 2010). Central to the proposed project is the plan to deepen and widen the harbour channel to Port Chalmers through dredging. This is projected to result in the removal of up to 7.2 million m^3 of sand, silt, mud, rock and shingle from the harbour, with this material to be dumped at a location identified as 'Site A0' as well as other, existing inshore dumping sites outside the mouth of Otago Harbour (POL 2010).

The importance of conserving Hector's dolphin is recognised by government and non-government agencies and stakeholders within and outside New Zealand. The New Zealand Government's Vision statement for the management of Hector's dolphins states that "Hector's dolphins should be managed for their long-term viability and recovery throughout their natural range" (DOC and Mfish 2007). Similarly, in the DOC Marine Mammal Action Plan for 2005–2010, several key objectives for the conservation of Hector's dolphin were identified. These included the objectives to "effectively protect Hector's and Maui's dolphins from recreational and commercial fisheries-related mortality and other avoidable adverse effects of tourism and other coastal use and development" and to "facilitate the recovery of the species and ensure that the local and national population dynamics (including the genetic diversity) of the species are maintained and restored to a viable self-sustaining state within its natural range" (Suisted and Neale 2004). Due to the significance of Hector's dolphin as an endemic species, there is a need to consider the potential impacts of major coastal development (such as PNG) taking place within the species' range. This report discusses the potential impacts of the proposed dredging activities and deposition of dredge spoils, based on published scientific data as well as sightings and strandings that have not yet been published.

The impacts of dredging on marine mammal populations has been identified as a potential threat to several species, including the Indo-Pacific humpback dolphin (Baldwin *et al.* 2004) and the Irrawaddy dolphin, especially for populations already impacted by other human activities such as fisheries (Smith *et al.* 2007). The potential impacts include marine mammals being displaced from their current habitat, due to direct disturbance (e.g. noise caused by dredging, dumping and vessel traffic, explosive charges, unusual levels of turbidity) and/or indirect impacts (in particular ecological effects on dolphin prey). These direct and indirect impacts may increase fragmentation of Hector's dolphin populations and may slow the recovery of right whales and the endemic New Zealand sea lion to the Otago coastline.

Mark James' hearing evidence makes it clear that adverse ecological effects from the disposal of large volumes of dredge spoil can not be avoided. Most benthic species could not survive repeated deposition in the vicinity of the deposit sites. Recovery of some species, such as polychaete worms, could take up to a year. However, longer lived species could take several years to recover after dredging stops. James states that fish and birdlife can be impacted directly through impacts on foraging success and indirectly through effects on their food resources.

Given the difficulties of accurately predicting the environmental effects of this development, it is proposed to proceed on the basis of 'adaptive management'. As explained in the draft Environmental Monitoring Plan (EMP), adaptive management requires detailed monitoring of a wide range of species that may be affected by the development and management strategies to avoid, remedy or mitigate adverse effects.

A draft EMP has been prepared, but this is so poorly developed at this stage that it would provide insufficient guidance for scientifically robust monitoring let alone responding to adverse effects. For example, without a monitoring programme for marine mammals being included in the EMP, it will clearly not be possible to determine if PNG causes any changes in distribution, abundance or feeding success for these animals.

Several threatened species in the area may already be close to their 'tipping point' and would need to be monitored closely. A precautionary approach would be not to grant a consent for this development, unless it can be shown that the environmental effects will be minor. An adaptive management approach would already be a substantial departure from a precautionary approach. Reasonably detailed EMPs were developed for the Clifford Bay marine farm and Kaipara Harbour turbine proposal. These would be useful as examples of minimum requirements for a development of this scale. It is not clear why POL, in collaboration with its current scientific experts, has not prepared a comprehensive EMP, defining environmental trigger levels, monitoring plans and management strategies.

Hector's dolphins off Otago

Local abundance and distribution

The South Island Hector's dolphin population has recently been estimated at 7,268 individuals (Coefficient of Variation 0.16; Dawson *et al.* 2004; Slooten *et al.* 2004). It is clear that population sizes were historically much higher and the dolphins' distribution more continuous. The population has declined significantly from more than 20,000 individuals in the 1970s (e.g. Dawson 1991; DOC and Mfish 2007; Slooten and Dawson 2010). Records show that Hector's dolphin was formerly much more abundant off the Otago coastline than currently (e.g. Diver 1866).

Hector's dolphins have a fragmented distribution. For example, there are high densities along the West Coast and at Banks Peninsula (e.g. Dawson and Slooten 1988; Dawson *et al.* 2004; Slooten and Dawson 2010; Slooten *et al.* 2004), but lower densities and gaps in distribution in South Otago and the north coast of the South Island.

The southeastern South Island (here defined as the area south of Timaru to Te Waewae Bay, Southland) is an area where Hector's dolphin populations are discontinuous. Surveys carried out by Dawson *et al.* (2004) estimated a population of 310 individuals (95% Confidence Interval 201-478) from Timaru to Te Waewae Bay. Since 1970, the Hector's dolphin population in the area from Oamaru to Taieri Mouth has declined to about 20% of its original size (Slooten and Dawson 2010). Population size in statistical fishing area 24 was estimated at 215 individuals in 1970 (CV 0.49). Recent surveys in the area indicate a population of about 50 individuals.

The sightings and strandings maps in figure 1 include data from systematic surveys (e.g. Slooten and Dawson 1988; Bräger *et al.* 2002; Dawson *et al.* 2004; Turek 2011), sightings from Ministry of Fisheries observers; DOC sightings, strandings and bycatch data, *Monarch* Wildlife Cruises sightings and reports from University of Otago Portobello Marine Lab staff (Table 1, Fig. 1).

Hector's dolphins are normally found in small groups of 2-10 individuals. Larger aggregations are formed when several such groups come together and usually last from a few minutes to two hours. Hector's dolphins have been recorded within the entrance of Otago Harbour itself (*Monarch* data and observations by the authors), indicating the potential for direct impacts of the dredging work on dolphins, as well as indirect effects such as environmental effects resulting from the dumping of dredge spoil (see below).

Recent data from Jennifer Turek's MSc project at Otago University indicates that the Otago Hector's dolphin population comprises two subpopulations: (1) a small, local population between Oamaru and Moeraki and (2) a second, apparently separate population from Karitane to Taiaroa Head off Otago Peninsula. Further surveys and data analysis will be carried out to help determine the level of separation between these two local subpopulations. Additional scientific surveys are being carried out by University of Otago until at least December 2011, to provide a more definitive answer to this and other questions about dolphin distribution, movements and habitat use in the area. We will document the frequency with which these populations use the areas impacted by dumping activities.

Hector's dolphins display high site fidelity with average alongshore home ranges of approximately 50 km of coastline (Rayment *et al.* 2009a). Population density is high from Banks Peninsula southward, drops to medium about halfway between Timaru and Oamaru and low from Oamaru to Otago Peninsula and very low or absent south of Otago Peninsula. On the south coast there is a small population in and around Porpoise Bay (Catlins) and another, larger population in Te Waewae Bay. Any impacts on the Otago population would substantially increase fragmentation of the natural range of Hector's dolphin and would further isolate the populations on the south coast.

Habitat use

Hector's dolphins are found in relatively shallow, coastal waters and rarely seen in waters deeper than 100 metres (e.g. Slooten *et al.* 2006). No migrations have been observed, however there are seasonal changes in distribution. Hector's dolphins are strongly concentrated in shallow, nearshore waters in summer, but disperse more widely with respect to depth and distance offshore during winter (e.g. Dawson *et al.* 2004; Slooten *et al.* 2006; Rayment *et al.* 2009b). There is no evidence of different habitat use by males and females, nor of particular habitats being favoured for breeding or nursing. This is consistent with data for most other dolphin species, which also use their range for all activities including feeding, breeding, travelling, socialising and other behaviours.

Hector's dolphins frequent the Otago Harbour entrance and adjacent offshore area year-round, with sightings peaking in November and March (Fig. 2). Several resident individuals have been identified. Group sizes vary, with most ranging between 2-10 animals (Fig. 3), and groups of 20 or more reported occasionally. These values are comparable to data collected by researchers in other areas (e.g. Bräger *et al.* 2002; Dawson et al. 2004; Webster *et al.* 2009). Newborn calves have been reported between January and March; this is also consistent with reports from other areas (e.g. Dawson and Slooten 1993; Slooten 1991).

The diet of Hector's dolphin consists of a wide range of small fish species (both pelagic and benthic) as well as crustaceans, squid, and octopus (Hutchison, Lalas and Slooten in prep; Slooten and Dawson 1994). Examination of stomach contents of dolphins found stranded or caught in fishing gear along the east coast of the South Island show that the diet includes small (mostly <15 cm) benthic fish such as red cod (*Pseudophycis bachus*), ahuru (*Auchenoceros punctatus*), stargazers (*Leptoscopidae*) and Graham's gudgeon (*Grahamichthys radiata*) as well as flatfish, sprats, yellow-eyed mullet and squid (Hutchison, Lalas and Slooten in prep; Slooten and Dawson 1994). Regional differences in prey preferences in different populations are being studied, as are long-term trends in the importance of individual prey species. Hector's dolphins are often seen foraging just outside the Otago Harbour entrance, feeding in the tidal fronts caused by the intermingling of Harbour water with the open ocean.

Conservation importance of population

Small, fragmented populations such as the one off Otago are at a high risk of becoming increasingly isolated from other populations along the coast. This may seriously impact the long-term viability of such populations (e.g. inbreeding, reduced reproductive rates through lack of nearby mates and other types of Allee effects) and may lead to the disappearance of the species from large portions of its range. Based on evidence of Hector's dolphin distribution and movement patterns, recolonisation of vacated areas will take many decades if it occurs at all (Slooten 2007; Slooten and Dawson 2010).

Hector's dolphins off Otago represent the southernmost known concentration of this species along the east coast of the South Island. Therefore, the conservation of Hector's dolphins in this area is of considerable and demonstrably national significance.

Potential impacts of proposed project on Hector's dolphins

The proposed project includes dredging of the shipping channel a few kilometers beyond the Otago Harbour entrance in an area where Hector's dolphins are regularly seen (Fig. 1). For this reason, potential impacts related to both dredging and disposal are addressed in this review. There is limited information on the potential impacts of dredging and spoil disposal on marine mammals, and significant local data gaps need to be filled to allow a scientifically robust assessment of impacts.

Dredging and dumping operations have direct and indirect impacts at a range of levels of biological organisation in the marine environment, including ecological perturbations, community changes, physiological and behavioural responses by organisms, and shifts in dominant cellular or microbial processes. It is important to evaluate the magnitude and importance of dredge-related impacts at each of these levels of biological organisation, even if only generally, in the water column and on the seafloor, from the patterns of meiofaunal assemblages to noxious chemicals in the tissues of higher level predators like marine mammals and seabirds (Galloway et al. 2004) to identify ecological pathways which may be relevant to key species. General principles of managing and monitoring dredge spoil include: 1) Finding a low-energy, depositional location for dredge material disposal, 2) Effective sediment testing and characterisation programme to make sure the sediments, as modified by the dredging process, are not toxic to marine life and 3) A detailed monitoring programme (e.g. Ports of Auckland; Germano 1992) with an associated management plan to mitigate impacts if performance does not match expectations.

Prior to any new operations, it would be prudent to record and evaluate marine mammal and seabird sightings during the existing, maintenance dredging operations inside the harbour, and in the area around Otago Harbour entrance. Such observations provide a starting point for determining whether dolphins avoid the area when dredging or dumping is taking place.

Several of the documents provided by POL suggests that mobile species including marine mammals will leave impacted areas. Although marine mammals and other species may be able to move away from a disturbance, avoidance may not always be an option. This may be the case when 1) the pressure occurs in an area of high significance to the animals (e.g. high prey abundance) or where alternative habitat is not locally available; 2) when the risk of leaving an area outweighs the impact of remaining in the area (e.g. through increased risk of predation); 3) when they cannot physically detect the pressure (e.g. through temporary deafness caused by high-energy anthropogenic noise at close range); or 4) when they are incapable of avoiding the pressure (e.g. through injury; Bejder *et al.* 2009).

An apparent lack of response by a group of animals to a stressor (sometimes identified as 'habituation' to it) may simply be the result of a subset of individuals (e.g. sensitive individuals like females with young calves, or those that are capable of expending additional energy reserves, or those without significant prior investment in travelling to the area), leaving the area when the stress begins. Subsequent observations then record only the behaviours of those animals staying behind, and also often fail to take into account that these individuals may have widely differing reasons for doing so. Without measuring actual physiological or behavioural indicators of distress, such observations run the risk of detecting 'habituation' (i.e. an attenuation of responses to a stimulus) among remaining animals when no such conclusion is actually warranted (Bejder *et al.* 2009).

Dredging impacts

Disturbance

Groups of Hector's dolphins, including calves, are observed regularly in the area around Taiaroa Head and Otago Harbour entrance by staff from *Monarch* Wildlife Cruises, and researchers (Fig. 3). The presence of a dredge operating within this area for several months may have a negative impact on these animals, as they are sensitive to disturbance by large vessels (Travis 2008). Hector's dolphins are often attracted to small boats as evidenced by the 'swim-with-a-dolphin' tourism ventures in Akaroa and elsewhere (Dawson *et al.* 2004; Travis 2008). However, they tend to avoid larger vessels, including dredges and container vessels (Travis 2008). For example, Hector's dolphins are much more common in Akaroa Harbour than Lyttelton Harbour. Increases in vessel traffic could cause Hector's dolphins to abandon the area around Otago Harbour, thereby losing access to a potentially important habitat and foraging area. It would therefore be appropriate for the Port to model the total occupancy time of the dredge in sensitive areas, and the latency period between occupations for the required amount of dredging if the work were to be carried out by the TSHD or a smaller dredge such as the *New Era*.

Acoustic impacts

Hector's dolphins, like all cetaceans, are highly sensitive to underwater sounds which play a vital role in their lives (e.g. communication, foraging, predator avoidance, etc.). The statement that marine mammals have hearing thresholds less sensitive than land mammals (point 68 in Mr Cawthorn's hearing evidence) is incorrect (e.g. see Au 1993). Anthropogenic noise introduced into the marine environment are known to impact cetaceans in a variety of ways. These include reducing the distance over which individuals can detect each other (masking), changes in behaviour, temporary hearing loss, permanent physical injury and death (Weilgart 2007). Assuming that it will be possible to ensure that no marine mammals are present near the planned blasting operations, serious injury or death are unlikely outcomes. However, close monitoring would be needed to test for disturbance caused by blasting, dredging and dumping. The exact nature of the sound produced by dredging varies considerably depending on the type of dredge used, as well as the local environment. Only limited work has been done assessing the noise output of different types of dredges. Apparently, no relevant sound recordings have been made of the existing dredge nor the planned larger dredge to be used for PNG. However, the following main conclusions can be drawn (from Thomsen *et al.* 2009):

- Dredge noise can be detectable underwater at distances of up to 6km, depending on local conditions;
- Source levels greater than 180 dB re 1 µPa at 1 m can be expected;
- Most of the sound produced by dredging will be relatively low frequency (<1 kHz);
- Noise production is likely to extend over a prolonged period of time. The actual sound level and length of time are still uncertain as POL has not yet committed to vessel(s) and time period(s).

Thomsen *et al.* (2009) concluded that most types of dredging would be considered a 'medium' impact when compared to other anthropogenic noise sources, i.e. less loud than pile driving, sonar, or seismic surveys, but considerably louder than small ships, operational offshore windfarms, and drilling for oil and gas. Small cetaceans are known to be sensitive to a wide range of sounds from 300 Hz to well above 100kHz (e.g. Dawson and Thorpe 1990; Kastelein *et al.* 2002). Whales and dolphins are capable of hearing noises likely to be produced by dredging. In addition, dredging sounds will mask the sounds produced by some marine mammal species.

Though local equipment and expertise are available, there do not appear to be any data on the current underwater soundscape in and offshore of Otago Harbour, nor any empirical information about the potential levels of underwater noise that would be generated by the proposed dredging activity (Ballagh 2009 and hearing evidence). Given the significance of underwater sound to marine mammals this is a serious and easily rectified data gap. The introduction of a high-intensity, low-frequency sound source (such as a large dredge) would likely represent a significant alteration in the local marine acoustic environment. Based on the work by Thomsen *et al.* (2009), the sound of the dredge would be detectable throughout most of Blueskin Bay as well as the entire area off Taiaroa Head where Hector's dolphins have been observed. Such widespread noise pressure over lengthy periods, audible across a significant fraction of their habitat, may have negative impacts on this population of Hector's dolphins as well as other marine mammals in the area.

In addition, the proposed rock removal at Acheron Head and Rocky Point, using explosives, are likely to cause significant disturbance to marine life in the area. Hector's dolphins could be seriously injured if they were in the vicinity of explosive charges being detonated. These small dolphins are difficult to detect, even in good weather conditions. In challenging sighting conditions (e.g. glare, rough seas, poor visibility, darkness, etc) the sighting probability can be less than 10%. Use of explosives would involve substantial risk for Hector's dolphins, New Zealand sealions and other protected species. Acoustic impacts can also affect dolphins by affecting their prey species.

Displacement of fish through habitat destruction or disturbance (mechanical or acoustic) may also result in a reduction of available prey. There is little information on the acoustic sensitivity of the fish species upon which Hector's dolphins feed. Experiments with other fish species have indicated that some (particularly herrings, but also benthic species such as Atlantic cod) are quite sensitive to low-frequency sounds, and may therefore leave the area. The potential impacts of anthropogenic noise on prey species of Hector's dolphin require further investigation. Local increases in turbidity may negatively impact distribution and/or abundance of prey species, requiring dolphins to spend more time foraging elsewhere.

Dumping impacts

Disturbance and acoustic impacts

The potential for disturbance of Hector's dolphins by ongoing dredging (described above) would be exacerbated by regular movements of the dredge through areas where Hector's dolphins are regularly encountered to reach dumping sites (Fig. 1). Vessel movements would increase ambient noise levels in the area between the harbour entrance and A0, potentially leading to displacement of Hector's dolphins from important habitat.

Habitat alteration and potential effects of dolphin prey

The deposition of approximately 7.2 million m^3 of dredge spoils at the A0 dumpsite, and potentially at the inshore dump sites, will substantially alter the habitat in these locations as explained in Dr James' evidence. While maps were provided showing the distribution of benthic habitats for the outer Harbour, no detailed information about habitats has been provided for the large area that would be affected by dumping at the A0 site. Likewise, no detailed information is available for areas surrounding A0 that would be affected by increased sedimentation as a result of the dumping activity - e.g. Fig. 28 in the AEE (POL 2010) and more detailed sediment plume maps in section 11 of Bell et al. (2009). Without such maps, it is very difficult to determine what effects the disposal of this material will have on local marine habitats and therefore on fish populations and their predators (including marine mammals and seabirds). Further information has been gathered at A0 but the report about this research has not been made available at the hearing. For example, it is still not clear how close the nearest bryozoan beds are (e.g. to the east of A0).

It is clear from the information provided in the AEE (POL 2010) that site A0 is a 'dispersive' site, rather than a 'containment' site. Relatively coarse material (e.g. sand) would be expected to be contained at site A0, or at least to move relatively short distances over relatively long time periods. However, fine material (e.g. silt, mud) would be expected to disperse fairly quickly and over a relatively large area.

In addition to physical modification of the habitat, there is a possibility of increasing the spread of invasive species. Some 16 non-indigenous species have been found in Otago Harbour surveys by NIWA. Paavo (2007) found that dredging with the currently used dredge New Era transported a sand community (single hopper load of 700 m^3), intact, from one location to another in the coastal zone and that the transplanted community survived for between 42 and 109 days.

It is clear that dumping dredge spoils can affect community structure. Relevant local information includes research by Paavo (2007), which showed a significant decrease in pinwheel shells (*Zethalia zelandica)* in one of the current dredge disposal sites at Aramoana. Paavo (2007) found 10-240 *Zethalia zelandica* per m^2 inside dumpgrounds as opposed to 20-1150 individuals per m^2 outside (matching depths and exposure) resulting in a significant biomass difference (42 grams of wet weight per m^2 as opposed to 219 grams) of a species known to be fed upon by paddle crabs (*Ovalipes catharus).* This is likely to have implications for local fish and seabird communities. Some of these species feed on crabs or directly on the pinwheel snails, including red gurnard *(Chelidonichthys kumu)*, sole *(Peltorhampus spp.)*, flounder *(Rhombosolea spp.)*, ling *(Genypterus blacodes)*, skate *(Dipturus innominatus)*, southern pigfish *(Congiopodus leucopaecilus)* and shags. Several (at least 11) of these species are also locally important to commercial fishermen. Some of these fish species are, in turn, eaten by Hector's dolphins and other marine mammals and seabirds.

It is not clear from the materials provided by Port Otago Ltd what small-scale habitat structure exists within the A0 site, which might be negatively impacted by the dumping of dredge material. Nor is there information about how the influx of sediment with a different size composition might negatively affect the surrounding habitat in terms of their ability to sustain fish species that form the main food source for Hector's dolphin. It is not known how important the area affected by dumping at and around A0 is for the foraging of Hector's dolphins, relative to the surrounding areas. No systematic marine mammal surveys of A0 and the surrounding area have been undertaken. This is a concern, given the importance of benthic fish species in the diet of Hector's dolphin. Comprehensive research data are needed to determine the current occurrence and habitat use by Hector's dolphins and other marine mammal and seabird species, including the dumping sites and adjacent areas. This information is necessary to determine the ability of the area to sustain fish species that form the main food source for Hector's dolphin.

As indicated in Figure 8 of James' hearing evidence, fish and birds will be affected in three different ways: 1. Impaired feeding, 2. Loss of food and 3. Bioaccumulation of toxins from the dredge spoil. This information does not appear to have been carried through into Cawthorn's evidence.

Resuspension of deposited sediments

The dumping of the proposed volumes of sediments will cause a separation of sediments by grain size, with the largest (gravels and sands) remaining close to the original dump site, but smaller particles (i.e. silt) being transported over many kilometres. There are several ways in which this process could have negative impacts on Hector's dolphin. Increasing levels of silt and particulate organic matter in the water column could negatively affect the foraging efficiency of dolphins through displacement of prey species to clearer waters. This is a particular problem with fish, whose gill rakers may become clogged with silt, causing these species to leave the area as a result. It is unlikely that reduced visibility as a result of increased silt levels will significantly impede the navigation of Hector's dolphins. However they may avoid areas of extremely high silt concentrations.

Resuspended sediment may be transported by currents for many kilometres, thereby significantly increasing the ecological footprint of the proposed dredge spoil disposal. There is also no mention of how dumping is planned to occur within the 2 km diameter designation site. Given a presumed northward drift of fine sediments we assume that dumping would take place in the southern portion of the grounds, but would one site be targeted or many? From first principles we would expected different benthic ecological responses to these two different practices. The long-term effects of deposition of large volumes of fine sediments on the marine habitats and associated ecology of shallow waters north of Otago Harbour have not been quantified in the material provided by Port Otago. Therefore, there is no assurance that the habitats currently used by Hector's dolphin would remain unaffected by increased sedimentation as a result of dredge spoil disposal. This is particularly relevant as it appears that a considerable amount of dredge spoil may be deposited at existing dumping grounds in the vicinity of the Mole and Heyward Point, as well as A0.

Sediments in the Blueskin Bay area are finer and contain a greater amount of organic material (Paavo 2007) than those near A0 or the continental shelf in general. Jonker (2003) modelled sediment disturbance frequency in Blueskin Bay and found that seabed sediments are disturbed between 70 and 20 days per year at depths near 20 m. This relatively high disturbance frequency is similar to that found at corresponding areas off Aramoana Beach, despite coarser sediments, due to the more energetic wave environment (Paavo et al. in press). While Bell et al. (2009) have modelled the northward drift of material (which has been subsequently peer-reviewed and approved) there has been no empirical test of the model nor an analysis of model performance in other, similar, situations elsewhere.

Contaminants

Contaminants are one of the conservation threats to Hector's dolphin included in the Threat Management Plan for the species (DOC and Mfish 2007). The information provided on contaminant loads of the material to be dredged from Otago Harbour was not sufficiently detailed to allow a science-based assessment of the likely impact on Hector's dolphins or other marine mammals. However, studies done off Hong Kong highlight the risk to fisheries and resident dolphins when contaminated spoils are deposited in fish and dolphin habitat (Clarke et al. 2000; Hung 2004).

Dredge spoils frequently contain a wide range of toxic chemicals, received through historic and/or current (legal, illegal and/or accidental) discharges from ships, from other on-site sources and as input from further upstream. Tests were undertaken of sediment core samples at five sites along the Otago Harbour channel for pollutants. These included heavy metals

(As, Cd, Cr, Cu, Ni, Pb, Zn), hydrocarbons (incl. PAHs, PCBs and petroleum hydrocarbons), cyanide and nitrogen. Results from these tests indicated that none of these particular contaminants occurred at levels exceeding the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Hill Labs analysis, in Greene 2008). However it would be premature to conclude on this basis that the dredge spoils do not pose a pollution hazard.

Additional sampling was carried out, in response to concerns from submitters. From a science perspective the sampling still raises some concerns. The limited number of surface sediment tests has not detected any unexpectedly high levels of contaminants. However, the amount of variability within the testing (higher unexplained Cu in one place, moderate As in another, etc.) demonstrates that the dredge claims have not yet been characterised. For claims near the port, the intensity of the sampling should reflect the amount of sediment to be moved. In other words, where more material is to be removed more intensive sampling should occur. Sub-surface samples should also be tested, as these will be exposed during dredging in addition to the weathered surface sediments that have been sampled so far. In order to represent spoil - which is modified by the dredging process - testing from the hopper would be appropriate and could be coupled with empirical testing of dumping a small amount of material at A0 to measure actual sediment transport.

Because Hector's dolphins are relatively long-lived and among the top predators in the local ecosystem, contaminants will tend to build up in their tissues through consuming polluted prey (bioaccumulation). Many contaminants are lipophilic and end up being stored in blubber tissue. These become reactivated when blubber reserves are being depleted (e.g. during winter, when food is scarce, when dealing with infection, or during lactation). The effects of contaminants on small cetaceans include a wide range of health impacts including reduced immunoresponse, cancer, and reduction in reproductive output (e.g. Ross *et al.* 2007). Fat soluble toxins increase with age in males. Females 'offload' some of their contaminant burden to nursing calves through milk which can lead to reduced survival of a female's first few calves. Because Hector's dolphins tend to have small home ranges (unlike other dolphin species such as dusky dolphins), they are likely to be chronically exposed to any contaminants present. Additional effects of pollutants on other components of the local ecosystem (e.g. prey species of Hector's dolphin) may affect the condition of the dolphin indirectly. At a minimum, additional research is required into the distribution and concentrations of contaminants within the channel sediments, as well as an assessment of current contaminant loads within a wide range of biota in the local ecosystem, including Hector's dolphin. Mr Cawthorn's evidence suggests that spoil dumping may increase prey availability for Hector's dolphin. However, if dolphins were to spend time feeding in this disturbed habitat they would be exposed to much higher loading of toxins than indicated by the assumptions regarding background dilution of toxins.

The analysis provided by Greene (2008) does not consider levels of organic matter and phosphates that may be present, and mobilised through dredging and dumping sediments. If high levels of these substances are present in the resuspended sediments, they may have a negative impact on local marine ecosystems through eutrophication, encouraging plankton blooms and associated hypoxia under particularly serious conditions. Finally, no information has been provided about the potential synergistic effects of contaminants on biota, even when each individual contaminant is present at relatively low concentrations.

Haux and Forlin (1988) describe a method for studying the effects of contaminants on fish which is now widely considered relevant to most perturbations. Tens of thousands of human-made chemicals can be found and reliably quantified in the marine environment. A practical way to study the effects of mixtures of contaminants is to examine microbial activity, small animal bioassays, or top-predator contaminant tissue loading (such as bird or mammal). A biomarker approach allows an objective identification of chemical hazards directly relevant to the ecosystem under study without resorting to an expensive 'shotgun' approach to chemical testing which does not necessarily incorporate bioavailability.

There is domestic precedent for accepted chemical monitoring best practice. The Auckland Regional Water Board recommended three levels of assessment of the spoil dredge disposal operations in the Hauraki Gulf. They used a decision-tree assessment approach to contamination testing while limiting the number and type of tests to those which are most important in the local system. Ports of Auckland sampled and analysed four samples from each dredging area (each approximately 400 x 400 m and defined by geographic or hydrologic features) to obtain an indication of contamination and variability. Sediments are analysed for the following contaminants of concern which are commonly monitored in the ports of developed nations: Total volatile solids, chemical oxygen demand, available sulfide, total organic carbon, iron, total Kjeldahl nitrogen, total phosphorus, available phosphorus, arsenic, cadmium, chromium, copper, lead, nickel, mercury, zinc, tributytin tin, total hydrocarbons, alkane hydrocarbons, polyaromatic hydrocarbons, polychlorinated biphenyls, chlorophenols, DDT, chlordane, heptachlor, heptachlor epoxide, dieldrin, endrin, lindane, organophosphate insecticides.

The Ports of Auckland followed the Apparent Effect Threshold approach discussed by Chapman et al. (1987), Chapman (1989), and Long and Morgan (1990) and were also informed by the Screening Level Approach used in Canada (Persaud *et al.* 1993; Jones *et al.* 1997). Ports of Auckland followed international precedent (e.g. Commonwealth 2002) and also conducted acute toxicity bioassays of three species (Kennedy 1990, 1991): the polychaete worm *Neanthes sp.* (larval sensitivity), oyster *(Crassostrea gigas)*, and the amphipod *(Rhepoxinius abronius)*. Ports of Auckland also evaluated the contaminants found with the potential for bioaccumulation within the receiving enviroment (e.g. KMA 1991).

It is important to note that the potential (sublethal) effects of contaminants on Hector's dolphins may take many years to manifest themselves as a decline in abundance, due to the comparatively long lifespan of these animals. For this reason, our ability to detect a long-term health risk to the local population of Hector's dolphins is presently limited; however, failure to detect such an effect does not imply that the effects themselves are absent. That is why the precautionary approach must be taken with initial detection of noxious chemicals in spoil as modified by dredging and dumping activities.

Monitoring and adaptive approaches are problematic for marine mammals

To put it simply, proceeding with Project Next Generation in the hope that monitoring will detect any unsustainable impacts on marine mammals (and other long-lived, slow reproducing animals) is not a realistic option. Biologically important trends in population size, vital parameters like survival and reproductive rates or contaminant levels, take on the order of one or two decades to detect. For example, a population decrease of 5% per year would take on the order of 10 years to detect. Of course, during this time the population would have declined to 50% of its original size. This means that, for long-lived organisms, by the time an effect can be detected it may well be too late to reverse the trend. Therefore a precautionary approach based on sound ecological principles in advance of any operations is the most appropriate option.

Other species

Several other species of marine mammals and seabirds use the area likely to be affected by the proposed dredging and dredge spoil disposal (Figs 4,5). This includes baleen whales (e.g. southern right whale, humpback whale) and pinnipeds (New Zealand fur seal and the New Zealand sea lion which is now listed by DOC as Nationally Critical), as well as at least two species of penguin and numerous other seabirds. For example, recent research has tracked a female sea lion within the proposed dump site A0 (Augé 2010). The local area is used by many species of seabirds, most of which are threatened (hearing evidence by Derek Onley).

Many of the potential impacts of the proposed activities on Hector's dolphin are likely to apply to other marine mammal (and some seabird) species using the area as well. For example, baleen whales are known to be strongly dependent on low-frequency sound for communication (Southall *et al.* 2007), and many seal species are also known to be sensitive to low-frequency sounds (Terhune and Turnbull 1995; Kastak and Schusterman 1998). The impact of a persistent increase in noise over a wide area may therefore be significant not just for Hector's dolphin, but for other marine mammal species, including some that are rare or endangered. Activity that may impact species such as the New Zealand sea lion or yellow-eyed penguin should be carefully considered, given the great significance of Otago populations for the survival of these species.

Mr Cawthorn's evidence includes some surprising statements, which are not supported by scientific evidence. For example, the statement "Fur Seals will be unaffected by dredging" is difficult to support. It is seldom in the nature of science to provide such categorical statements, and to do so without compelling evidence is extraordinary. Mr Cawthorn provides a rather selective summary of research carried out by others. Some of the literature he quotes has been superceded by more recent research. For example, his reference to Street (1964) is superceded by more recent and more local information published by Fea et al. (1999). He is incorrect in stating that the nearest sealions are hauled out at Aramoana. In fact there are resident sea lions based in the harbour itself. They are regularly seen in the area of the proposed blasting. One of them regularly hauls out on Black Jacks Point, South of the Ravensbourne fertiliser works. Bottlenose dolphins enter the harbour from time to time, and have been seen to travel right up to the limit of the upper harbour (Fig. 4). Right whales have been seen in the proposed blasting area.

Hector's dolphins, right whales and seals are tolerant of vessel movements to an extent. However, each of these species is most abundant in areas where human disturbance is low. For example, Hector's dolphin is much more common in Akaroa Harbour than Lyttelton Harbour, and avoid large vessels including dredges (Travis 2008). The broadband sound pressure levels in the table on page 18 of Cawthorn's evidence are incorrect. For example, bottlenose dolphins make sounds of up to 230 dB. It is not clear where the information in this table came from. Sound levels causing temporary or permanent threshold shifts depend on the frequency of the sound. It is not meaningful to say that 180 dB sound could cause temporary hearing impairment (Cawthorn's point 70), without specifying the frequency of the sound. His statement 71 appears to be one of personal opinion. No evidence is provided to support the statement that sounds would not be detected past the harbour entrance in either Cawthorn's or Ballagh's evidence. Mr Cawthorn's statement 72 implies that pressure waves reaching Aramoana would not do physical harm to sea lions. However, there is no reason to believe that sea lions would not detect these pressure waves. i.e. There is no evidence to suggest there would be an absence of behavioural reaction.

Public sightings of right whales reported to DOC show that this species is present in the Otago area year-round, with peak sightings numbers in June-October. Since 2003, there have been 86 right whale sightings between Oamaru and Nugget Point. Fifteen of these sightings were in the Otago Harbour - Taiaroa Heads area, with at least two sightings well inside the harbour between Wellers Rock and Careys Bay. Historically, right whales were very commonly seen within Otago Harbour and whaling took place inside the harbour. Right whales are slowly recovering to areas around the New Zealand mainland. Human activities with the potential to disturb right whales or their habitat may act to slow this recovery. Additional research is needed to determine habitat use of marine mammal species using the Otago Harbour area.

Conclusions

The Otago coastline is an important area for marine mammals and seabirds, including local populations of Hector's dolphins and New Zealand sealions. Both of these species are endemic and threatened with nationally declining populations. The local Hector's dolphin population has declined over the last 30-40 years to less than a quarter of its original population size (Slooten and Dawson 2010). Protection measures implemented in 2008 may lead to a slow recovery at *status quo* stress levels. Any additional environmental impacts in the area are likely to reduce the effectiveness of these protection measures. The Hector's dolphin population in the Otago Harbour - Taiaroa Head - Blueskin Bay - Karitane area represents the southernmost concentration of Hector's dolphins along the east coast of the South Island. Any impacts on this population would substantially increase fragmentation of the natural range of this species. For this reason, conservation of small relict populations such as the one in the Otago Harbour - Karitane area is of wider significance for the nationwide conservation of this species. In particular, this population may be the only source of individuals that might recolonise parts of the Otago coastline further south.

New Zealand sealions were once found all around New Zealand. Currently, the only substantial breeding colonies are in the subantarctic islands. A small number of pups born each year on Otago Peninsula represent the first indication of sealion recovery to the mainland. Sealions are frequently seen well inside Otago Harbour. Other marine mammals regularly seen off the Otago coast include right whales, humpback whales, common dolphins, dusky dolphins and bottlenose dolphins. Right whales, bottlenose dolphins and dusky dolphins are seen from time to time inside Otago Harbour. Right whales and humpback whales are at a fraction of their original population sizes and very slowly recovering in New Zealand waters. In addition, many species of seabirds are found in the area of which most are threatened.

Potential threats to Hector's dolphins (as well as other marine mammals and seabirds), from the proposed dredging and dumping of dredge spoils, include:

- increased levels of disturbance through vessel movements
- increased noise for lengthy periods
- destruction of seafloor habitat caused by dredging the harbour channel, incuding an area outside the harbour entrance
- damage to seafloor habitat caused by dumping dredge spoil at the A0 site and increased dumping volumes at other sites closer to shore
- alteration of habitats at and around dumping sites through transport of fine-grained sediments, affecting benthic organisms and potentially affecting biomass and

distribution of fish and other organisms that are predators of benthic organisms and prey for seabirds and marine mammals

- population reduction and/or redistribution of prey species away from dredged areas and dumping sites, due to increased levels of noise, suspended silt, etc.
- remobilisation of contaminants (e.g. from the existing port area to a much wider marine area), with potential health effects for marine mammals, seabirds and their prey

The applicant has failed to provide quantitative estimates of the likely impact of the dredging activity on marine mammals, seabirds and their prey. A precautionary approach on the basis of current information would involve either no dredging or disposal of dredge spoils on land. We understand that land disposal has been considered uneconomical. If the dredge spoil is to be dumped at sea, it is preferable that one or more dump sites be identified which are truly depositional for the spoil dumped there – i.e. where the dumped material can be expected to remain rather than dispersing into the surrounding environment. If for whatever reason containment is not possible, then quantitative mammal impact models should be constructed based on proven dispersal pathways.

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Table 1. Summary of data sources used to assess distribution of Hector's dolphins in the Otago Harbour area. Note that many of these sightings were made opportunistically, by tourism operators, observers on fishing vessels etc. rather than the result of random or systematic surveys of the area.

Dataset	**Area**	**Period**	**Availability**
Department of Conservation – strandings/bycatch	Otago	1970 - present	NABIS
Ministry of Fisheries – observer sightings	Oamaru – Otago Peninsula	Until March 9, 2009	Mfish data
Monarch Wildlife Cruises - sightings	Vicinity of Taiaroa Head	1994 - present	Not publicly available
Portobello Marine Lab (PML) staff - sightings	Otago Harbour, Blueskin Bay	Approx. 1980-present (non-systematic)	Not publicly available
Otago University Marine Mammal Research Group survey data	Otago	1984 - present	Dawson and Slooten 1988; Bräger *et al.* 2002; Dawson *et al.* 2004; Turek 2011

Figure 1. Sightings, strandings and bycatch of Hector's dolphin along the Otago coast from north of Oamaru to Otago Peninsula.

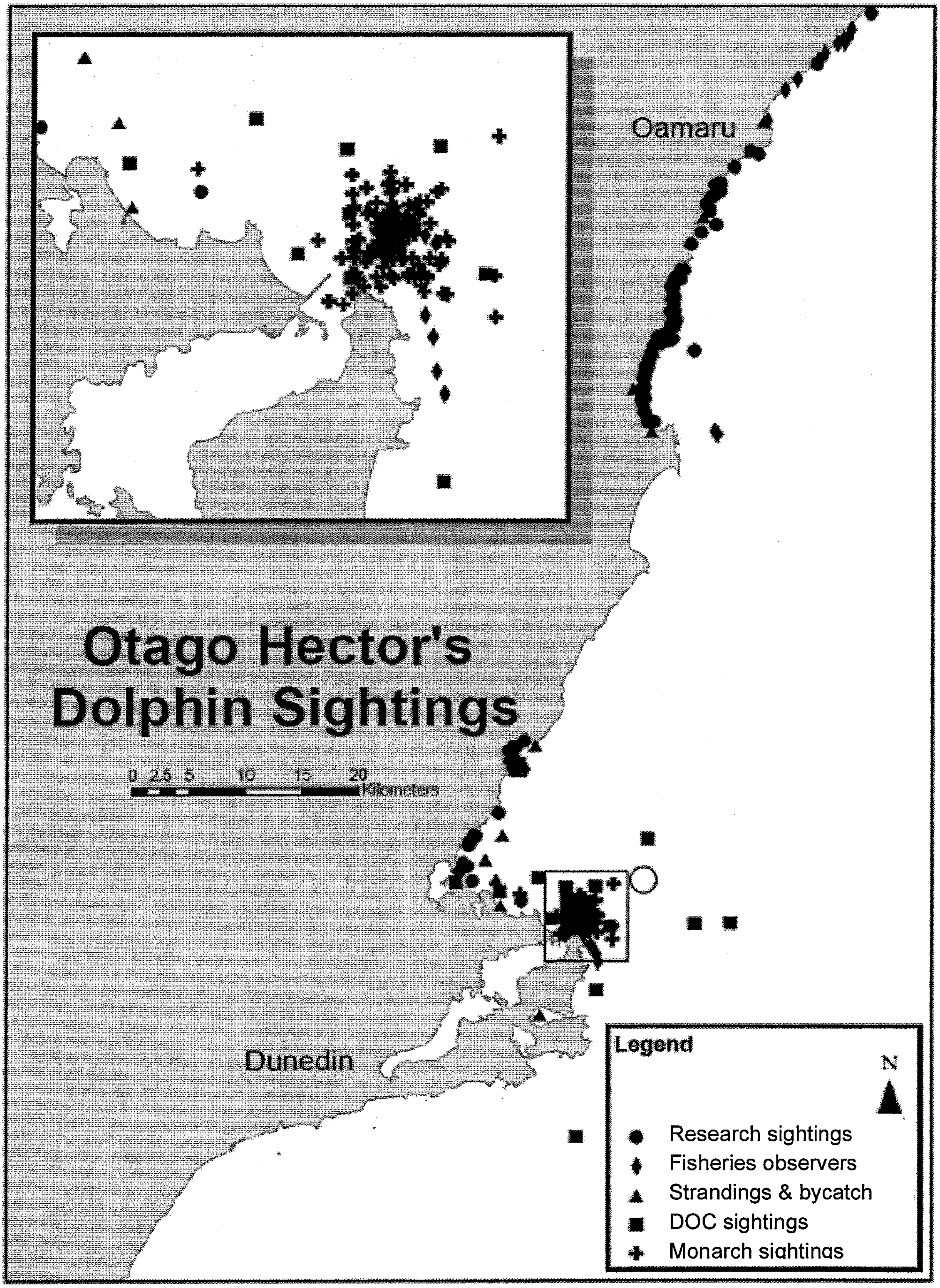

Figure 2. Hector's dolphin sightings per month, in the Taiaroa Head area from 1994-2010, based on *Monarch* wildlife cruises data.

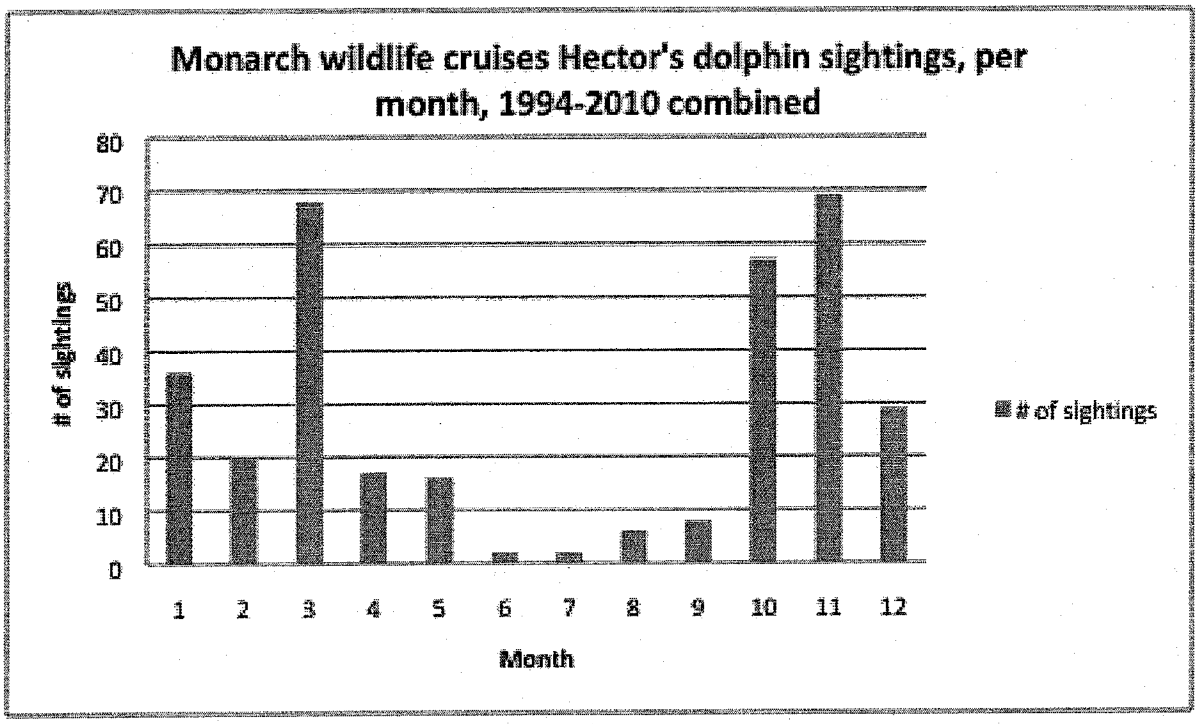

Figure 3. Number of Hector's dolphins per sighted group in the Taiaroa Head area from 1994-2010, based on *Monarch* wildlife cruises data.

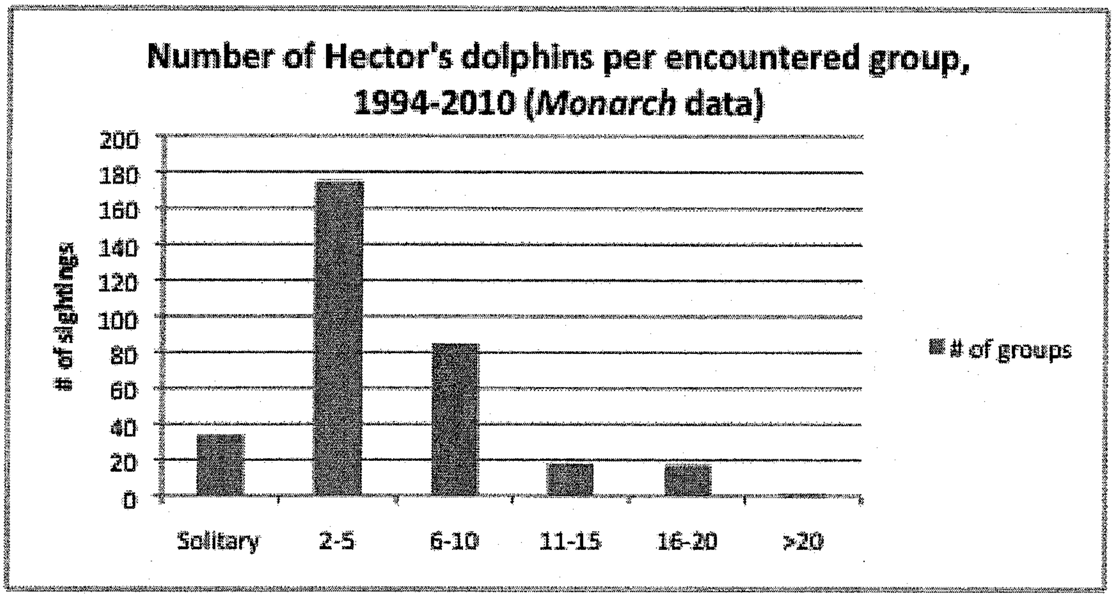

Figure 4. Bottlenose dolphins in Otago Harbour. Photograph taken by Stephen Jaquiery from the Otago Daily Times.

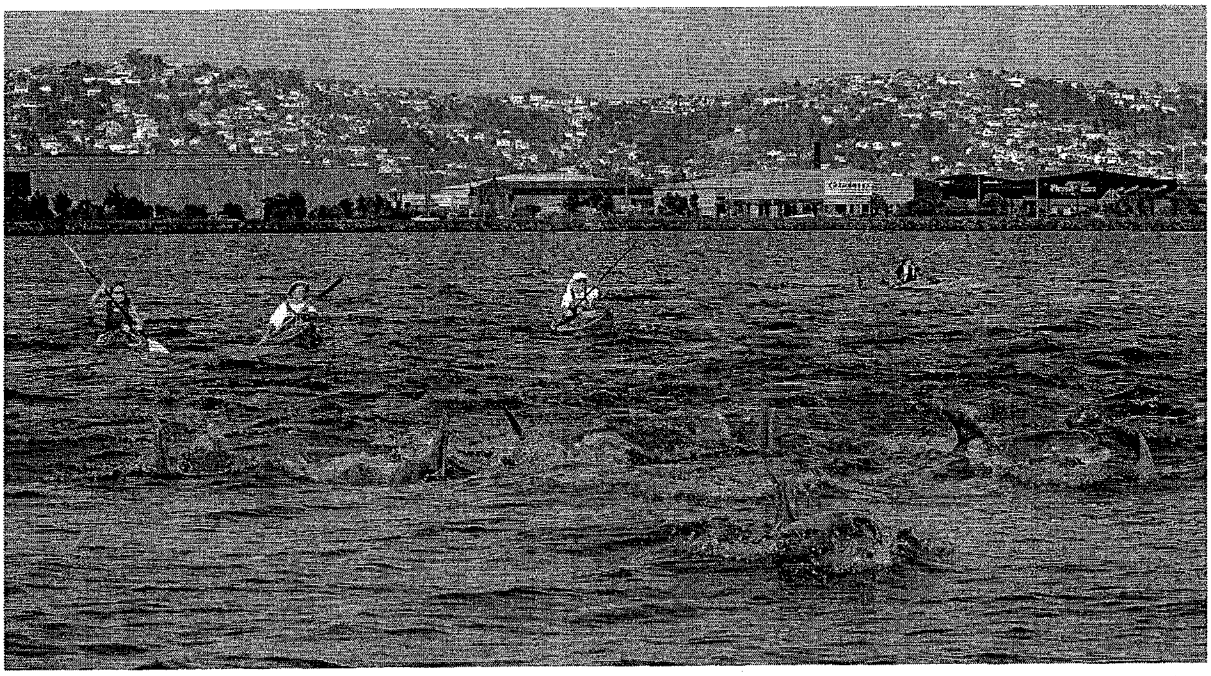

Figure 5. Right whale in Otago Harbour. Photograph taken by Dr Steve Dawson from Otago University.