Cultural Impact Assessment

Project Next Generation

Otago Harbour

Kāi Tahu Ki Otago Ltd

May 2010

Acknowledgement

The preparation of a cultural impact assessment on the proposed capital dredging of the Otago Harbour was a complex undertaking. The assistance of the following individuals and groups is gratefully acknowledged:

- **The Manawhenua Working Group, who guided the preparation of the assessment;**
- **Dr Terry Broad, Eco-Dynamic Systems, who provided guidance on ecological issues;**
- **Dr Gail Tipa, Tipa and Associates, who peer reviewed the cultural impact assessment;**
- **Sìne Fraser, who undertook historical research into the cultural association of Kāi Tahu Whānui with the Otago Harbour;**
- **Lincoln Coe, General Manager Infrastructure, Port Otago Ltd, who provided the technical reports and information required to undertake the assessment. Further, the assistance of Port Otago Ltd generally throughout the assessment is acknowledged; and**
- **Mark James, Aquatic Environmental Sciences Ltd, who oversaw the preparation of the supplementary paper on key species of interest to Ngāi Tahu.**

Front Cover Image

Louis Le Breton, *Mouillage d'Otago (Nouvelle Zélande)*. Dessiné par L. Le Breton. Lith.é par P. Blanchard. Lith de Thierry frères Paris. Gide Editeur. Voyage au Pôle Sud et dans l'Océanie. Atlas pittoresque. pl 181 [1846] hand coloured lithograph, 181 x 310mm, Acc. No. : 91/40, Hocken Collections Uare Taoka O Hakena, University of Otago, Dunedin, N.Z.

KTKO LTD consultancy	
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Contents

1. Introduction

Kāi Tahu Whānui are tangata whenua within Otago and have a responsibility as tangata tiaki (kaitiaki) of the environment to assess how Port Otago Ltd's proposed capital dredging project, Project Next Generation, will impact upon their cultural values.

The container ships currently calling at Port Chalmers have a nominal carrying capacity of 4,100 twenty-foot equivalent units (TEU)[1] and are 285m long, 32.6m wide and have a maximum draft of 12.5 m. The next generation of container ships will potentially have a carrying capacity of up to 6,000 TEUs and may be up to 320 m long, 42 m wide and require a draft of 14.5 m.

The lower channel of the Otago Harbour, and the swinging basin and berths at Port Chalmers, will need to be widened and deepened to accommodate the next generation of container shipping. The key elements of this project include:

- **An extension of the existing maintenance dredging programme to upgrade the channel;**
- **Removal of rock at Rocky Point and Acheron Head, alteration of berths, and preliminary work on the Port Chalmers swinging basin undertaken by a barge mounted excavator;**
- **A major capital dredging contract to complete the development.**

In addition, Port Otago Ltd ('Port Otago') will extend the multi-purpose wharf at Port Chalmers and reconfigure the container terminal to improve the operational flexibility of the port.

Port Otago has approached KTKO Ltd to provide an assessment from a tangata whenua perspective of Project Next Generation. The objectives of this assessment are to:

- **Identify the effects of Project Next Generation, and the ancillary consent for the multipurpose wharf (the 'ancillary consent'), on tangata whenua cultural values, interests, and associations with the Otago Harbour.**

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[1] **A TEU, or twenty-foot equivalent unit, is a standard international measurement for containers. It is the equivalent of a container 20 feet long by 8 feet wide by 8 feet high (6.1m x 2.4m x 2.4m).**

- **Improve tangata whenua understanding of the proposal by providing comprehensive information on the nature and effects of Project Next Generation.**
- **Provide a basis for on-going consultation between Kāi Tahu ki Otago, interrelated tangata whenua groups and Port Otago during the development and implementation of Project Next Generation.**

Further, the cultural impact assessment may:

- **Identify methods to avoid, remedy or mitigate adverse effects on cultural values, interests, and associations with the Otago Harbour.**
- **Suggest appropriate conditions of consent if the applicable Consent Authority is of a mind to grant consent to the proposal.**

The boundary of this assessment is primarily that of the Otago Harbour and Te Tai O Arai Te Uru, the Otago coastline from Aramoana to Moeraki.

The participants in this project will be Kāi Tahu Whānui representatives from Te Rūnanga o Moeraki, Kāti Huirapa Rūnanga ki Puketeraki, Te Rūnanga o Ōtākou, East Otago Taiapure Management Committee, Korako Karetai Trust, and the Karaitiana, RL Karaitiana & Taituha Trust.

This report should not be seen as all the consultation required with Kāi Tahu Whānui but as a basis for ongoing consultation and discussion with Port Otago.

2. Methodology

The methodology for the assessment involved the following key stages:

Stage 1: Review of the Project Documentation[2]

The Assessment of Environmental Effects, Applications and Technical Reports provided by Port Otago were reviewed.

Stage 2: Literature Review

A literature review was undertaken that drew together the relevant resources relating to the association of Kāi Tahu Whānui with the Otago Harbour and Te Tai O Arai Te Uru. The review collected information from a variety of sources including:

[2] **The review of technical reports was on-going. Technical reports were progressively completed and made available by Port Otago Ltd throughout the assessment.**

- **Books and Publications;**
- **Cultural Evidence of Kāi Tahu Whānui;**
- **Cultural Impact Assessments prepared by KTKO Limited;**
- **Kāi Tahu ki Otago Natural Resource Management Plans;**
- **Site Visits; and**
- **Statutory Acknowledgements for Taonga Species, Taonga Fish Species and Shellfish Species, and Te Tai O Arai Te Uru (Otago Coastal Marine Area).**

Stage 3: Identification and Scoping of Issues

A consultation document was prepared that summarised the key elements of Project Next Generation. This summary was used to facilitate the identification of key issues by the Manawhenua Working Group. In addition, a technical review of the ecological research undertaken for Port Otago Ltd was commissioned from Dr Terry Broad of Eco-Dynamic Systems Ltd.

Stage 4: Port Otago Ltd – Response to Issues

The issues of concern for Manawhenua and the recommendations of the Eco-Dynamic Systems report were referred to Port Otago Ltd for comment. Port Otago Ltd duly commissioned a supplementary report that provided information on the key species of interest to Kāi Tahu (James et al, 2010).

Stage 5: Assessment of Environmental and Cultural Effects

The issues identified by the Manawhenua Working Group and Eco-Dynamic Systems Ltd, and the supplementary information provided by Port Otago Ltd, were assessed.

Stage 6: Preparation and Peer Review of the Cultural Impact Assessment

The draft cultural impact assessment was independently peer reviewed by Dr Gail Tipa. In parallel, the recommendations of the assessment were reviewed by the Manawhenua Working Group. The cultural impact assessment was revised in light of comments received.

3. Project Description - Project Next Generation

3.1 Introduction

Port Otago intends widening and deepening the lower channel of the Otago Harbour, and altering the swinging basin and berths at Port Chalmers, to

accommodate the next generation of container shipping. The key elements of the project include:

- **An extension of the existing maintenance dredging programme to upgrade the channel;**
- **Removal of rock at Rocky Point and Acheron Head, alteration of berths, and preliminary work on the Port Chalmers swinging basin undertaken by a barge mounted excavator;**
- **A major capital dredging contract to complete the development.**

3.2 Proposed Changes to the Lower Harbour Channel, Swinging Basin and Berths

The "Landfall Tower" beacon, which is located to the east of Heyward Point, marks the approach to the harbour entrance. The lower harbour channel extends 13 kilometres from the "Landfall Tower" to the vessel turning basin at Port Chalmers.

The existing channel has a minimum depth of 13 metres below chart datum[3], increasing to a minimum of 14.5 metres at the north end of the mole at Aramoana. Further, there are sections along the length of the channel that exceed that depth due to natural scouring.

The current proposal provides for the following improvements to the lower harbour channel, the swinging basin and the wharf berths:

<u>Landfall Tower to Aramoana Mole</u>

The approach channel is to be increased to a minimum declared depth[4] of 17.5 metres from the "Landfall Tower" to a point just north of the mole at Aramoana. The western edge of the channel will be widened to realign the direction of approach to the harbour entrance.

<u>Aramoana Mole to Harrington Bend</u>

The channel will be deepened to a declared depth of 16 metres below chart datum from the harbour entrance to a point two thirds of the way around Harrington Bend.

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[3] **'Chart datum' means the lowest, generally expected tide at Port Chalmers.**

[4] **The declared depth is the depth that can be relied on for the purpose of shipping movements. Some over dredging, ranging from 0.5 metres south of the mole up to 1 metre north of the mole, is required to achieve the declared depth.**

Harrington Bend to Port Chalmers Basin

The bed of the channel will gradually slope up to achieve a depth of 15 metres and continue at that depth up to and including the Port Chalmers basin. The inner edge of the bends, respectively Harrington Bend, the bend off Taylers Point, Pulling Point, and the bend opposite Deborah Bay, will be realigned.

The Swinging Basin

The width of the swinging basin is to be increased by up to 115m with a significant volume of dredging along the eastern edge. The declared depth of the basin will be increased to 15 metres.

The Port Chalmers Berths

The berths alongside the Container and Multipurpose Wharves are to be deepened to 16 metres and widened from 37 to 50 metres.

3.3 Dredging Program

The upgrade of the channel will take place in three stages, respectively:

Stage 1: Extension of Maintenance Dredging[5]

It is proposed to begin the dredging programme using the *New Era*, in conjunction with the existing maintenance dredging. The hours of operation of the plant will be extended to 24 hours a day 7 days a week.

Stage 2: Preliminary Capital Works

The preliminary capital works using a barge mounted excavator and the *New Era* will include:

- **Removal of rock in the Lower Harbour at Rocky Point and Acheron Head using explosives and an excavator;**
- **Increasing the depth and width of berth areas, and the placement of rock to support the wharf structure; and**
- **Preliminary work on the Swinging Basin and Channel. This work involves the lowering of the seabed in shallows and inter-tidal areas to allow access by a larger contract dredge.**

[5] **The use of the *New Era* will reduce the environmental effects of dredging. The limitation of the *New Era* is its capacity; each load is 600m^3 compared to 11,000m^3 for a large contract dredge.**

Stage 3: Major Capital Dredging

Major Capital Dredging using a large trailing suction dredge is proposed to complete the development. It is anticipated that capital dredging would take between 6 - 8 months to complete.

3.4 Disposal of Spoil

The volume of dredged material to be removed is approximately 7.2 million cubic metres. This includes an over dredging allowance of 0.3m over the whole dredged area. The dredge spoil will be disposed of as follows:

- **Dredging material will be deposited at the existing disposal sites off Heywards Point, Spit Beach and Shelly Beach, up to the volume permitted by the existing resource consent (450,000 cubic metres). The disposal will be managed to ensure that 90% of the material deposited over any 12 month period is sand.**
- **Rock removed from Acheron Head and Rocky Point will either be used to strengthen berth areas or deposited in the consented disposal area off Heywards Point.**
- **The balance of the 7.2 million cubic metres of material from the major capital dredging program will be deposited at a new deep water disposal site. This disposal site is located in 27 metres of water on a submarine "Peninsula Spit". This disposal site is 6.3 kilometres to the northeast of Taiaroa Head on the periphery of the northerly flowing Southland Current.**

3.5 Maintenance Dredging

Maintenance dredging is required to maintain a safe and navigable waterway in the Otago Harbour.[6] Sediment enters the shipping channel as a result of:

- **Coastal Processes;**
- **Slope erosion of the hillsides surrounding the harbour;**
- **The discharge from the Leith River, creeks and from storm water pipelines;**
- **Remobilisation of sediment from the intertidal banks.**

There are five main areas that require maintenance dredging, respectively the entrance channel; the lower harbour channel; the Port Chalmers inner basin and berths; Victoria Channel; and the Dunedin basin and berths.

[6] **Davis, 2009**

Port Otago has resource consent to discharge maintenance dredging spoil at Heywards Point, Spit Beach and at Shelly Beach (South Spit Beach). The maximum quantity of maintenance spoil discharged annually across all three sites is limited to 450,000 cubic metres.

The transport of sediment from these disposal sites has been studied by Bunting, Single and Kirk (2003). This study concludes that there is no evidence to suggest that spoil from the Heyward Point site is moving north and contributing to siltation of the Blueskin Bay Estuary, nor is spoil from all three sites directly re-entering the harbour. The study shows that spoil discharged at the Shelly Beach and Heywards Point sites is quickly transported away from these disposal areas and is dispersed over the near shore. In contrast, there is significant retention of spoil at the Aramoana site.

3.6 Extension to the Multipurpose Wharf and Fishing Jetty

The proposed extension to the multipurpose wharf is 135 metres long and varies in width from 28 metres to 37 metres. The extension will improve the operational flexibility of the port.

In addition, Port Otago will construct a fishing jetty at the end of the Boiler Point public walkway. The jetty will extend 30 metres into the coastal marine area. A security fence will separate the jetty from the working port. The jetty is a facility for the community and will not have facilities for container traffic or fishing vessels.

4. Cultural Association with the Otago Harbour

4.1 Introduction

> ***"A beautiful sheet of calm water, surrounded by an amphitheatre of wooded hills, uniformly covered by trees, which clothe them from their summits to their bases, where they hang over and are reflected in the water."*** [7]

The Otago Harbour is a drowned valley that is 22km long with an average width of 2.3km.

[7] **Dr David Monro. Description of the Otago Harbour in 1844*, in T.M. Hocken (1898) Contributions to the Early History of New Zealand (Settlement of Otago). Cited in Evison (1993), pp.203***

The upper and lower reaches of the harbour are effectively divided by peninsulas at Port Chalmers and Portobello, and by the islands, Kamau Taurua (Quarantine Island) and Rakiriri (Goat Island).[8]

The hills surrounding the harbour were covered in forest up to the 1860s.[9] These forests were full of bird life including Kakariki (orange-fronted and red-crowned parakeets), Kereru, Toutouwai (robins), Piwakawaka (fantails), Miromiro (Tomtits), Pihoihoi (Larks), Kaka, and Tui. The rapid growth of Dunedin from 1861 resulted in extensive clearance of the dense broadleaf-podocarp forest; by 1896 only scattered remnants remained.[10]

Otago Peninsula – GNS Science, Photographer: Lloyd Homer, www.gns.cri.nz

4.2 Māori Association with the Otago Harbour

Waitaha, Kāti Mamoe and Kāi Tahu made use of the Otago Harbour as a food resource (mahika kai), as a means of travel and as a realm of Papa-tū-ā-nuku to be respected.

Rangiriri (Goat Island) was the abode of Takaroa, the atua or guardian spirit of all that lives in the sea, in southern mythology. Takaroa would be acknowledged in karakia (prayer / incantation) before and after each fishing voyage. Food would not be taken on a fishing trip for fear of invoking the wrath of Tangaroa. All sea life was likened to the children of Takaroa.

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8 **Otago Regional Council / Dunedin City Council *(*1991: 2*)***

9 **The forested hills described by Dr Munro in 1844 still existed in 1858. John Douglas describes 'high mountains' covered from top to bottom in evergreen trees thickly placed together [John & Maggie Douglas Letters, October 1858, Otago Settlers Museum Archive, DC 2527].**

10 **Kai Tahu ki Otago Ltd *(*2006*)***

The tūpuna used numerous methods of catching fish in the harbour and the estuaries and creeks, including netting, trolling, spearing and line fishing. Barracouta, Red Cod (Moka), Patiki (Flounder), Kokiri/Puamorua (Leather Jacket), Koura (Crayfish), and Kaio were collected. In addition, middens show the evidence of the gathering of kai moana, including pipi, cockle (Tuaki), mussel, pāua, toheroa, oyster, pūpū and kina (Sea Egg).[11]

Ducks (Pateke), other birdlife including weka, and Sea Lions (the female and male sealion, Kake and Whakahao respectively), were also food sources. Whalebone was used for making weapons, tools, and ornaments.

Waka would travel from the kaik (villages) that were scattered around the harbour to various tauraka waka (canoe landing sites). Koputai (Port Chalmers) was one such landing site where hunting parties would venture into the bush clad Kapukataumahaka (the slopes of Mihiwaka / Mt Cargill) in search of woodhen (weka) a favourite food.[12]

By the 19th Century settlement was focused on the Coast from Taieri Mouth to Moeraki, around the Lower Harbour and on Muaupoko (Otago Peninsula). There were tangata whenua settlements on the Taieri Plain (including Maitapapa at Henley) and at Taieri Mouth; along the western edge of the Otago Harbour from Koputai to Te Waiparapara on the Aramoana Spit; in the northern bays and inlets, including Whareakeake (Murdering Beach) and Purakaunui; around Puketeraki / Waikouaiti (now Karitane) area; and at Moeraki.

The kaik (villages) on Muaupoko (Otago Peninsula) included Okia (Flat), Takiharuru (Pilots Beach), Little Papanui, Te Rauone (Te Rauone Beach), Te Ruatitiko (Harington Point), Tahakopa (bottom of Pipikaretu Road), Omate (in front of the marae), Waipepeka (south end of the flat in front of marae), and a settlement at Harwood. In addition, Pukekura (Taiaroa Head) was an important fortified pa. Its position had been strategically important in times of political unrest.[13]

[11] **Edward Ellison (1991)**
[12] **Edward Ellison (1991)**
[13] **Ōtākou Marae Resource, *At the Front Gate* (undated); Anderson (1998).**

Ōtākou Kaik (foreground) and ships anchored inside the Aramoana Spit, 1840. Louis Le Breton, Port Otago (Nouvelle Zélande), Dessiné par L. Le Breton. Lith. par Sabatier. Imp. par Lemercier à Paris. Gide Editeur. Voyage au Pôle Sud et dans l'Océanie. Atlas pittoresque. pl. 180 [1846] hand coloured lithograph, 277 x 421mm; on paper, Acc. No.:91/41, Hocken Collections Uare Taoka O Hakena, University of Otago, Dunedin, N.Z.

5. Kāi Tahu Whānui

This section of the assessment provides an overview of the Kāi Tahu ki Otago Papatipu Rūnanga, and interrelated tangata whenua Groups, whose interests are potentially affected by the proposed capital dredging programme within the Otago Harbour.

Kāi Tahu ki Otago/Papatipu Rūnanga

Kāi Tahu ki Otago is a term used to refer to the collective Papatipu Rūnanga of Otago. The relevant Papatipu Rūnanga for this proposal are Te Rūnanga o Moeraki, Kati Huirapa Rūnanga ki Puketeraki, and Te Rūnanga o Ōtākou. The takiwā or area of interest that the individual Papatipu Rünanga operate in exclusively is most pronounced in the coastal environment.

Te Rūnanga o Moeraki

Ki Uta Ki Tai (From the Mountains to the Sea)
Uenuku Marae, Moeraki

The takiwā of Te Rūnanga o Moeraki is based at Moeraki and extends from the Waitaki River to the Waihemo (Shag) River. The interests of Te Rūnanga o Moeraki Rūnanga are concentrated in the Moeraki Peninsula area and surrounds, including Te Rakahineatea Pā, Koekohe (Hampden Beach), and Te Kai Hinaki (the Boulders Beach) with its boulders. In addition, the interests of the Rūnanga extend both north and south of the Moeraki Peninsula, within their takiwä.

Kāti Huirapa Rūnanga ki Puketeraki

The takiwā of Kāti Huirapa Rūnanga ki Puketeraki centres on Karitane and extends from the Waihemo River (Shag River) to Purehurehu (north of Heywards Point). The strategic headlands for the Rūnanga being Matakaea (Shag Point), Huriawa, Pā Hāwea, Brinns Point, Mapoutahi and Heywards Point.

The people that lived in this area chose to do so because of the abundance of kaimoana and mahika kai[14]. Mataīnaka Lagoon (Hawkesbury Lagoon) was a major whitebait spawning area and was highly treasured for the catching of this delicacy.

[14] **Places where food and resources are either produced or obtained, respectively from the sea (kaimoana) and the land (mahika kai)**

The Waikouaiti River was an abundant source of tuna (eel), pātiki (flounder), shellfish and whitebait. Waimataitai Lagoon (Goodwood) was an important whitebait area. Okahau (Blueskin Bay) is a rich resource of shellfish, and Warrington surf beach is a place where frost fish are picked up. Many species of shellfish and fish can still be caught off the rocks at Huriawa, Puketeraki and Brinns Point.

Kāti Huirapa Rūnanga ki Puketeraki Marae

<u>Te Rūnanga o Ōtākou</u>

The Otago Harbour is an important resource to Ōtākou people that has provided a thousand years of transport for generations of Kāi Tahu tūpuna. It has also been a food basket, providing a rich source of kaimoana including the noted tuaki (cockle).

The name "Ōtākou" is derived from the name of the eastern channel which runs by the present day settlement, a name transferred to the land by the early whalers. Pukekura (Taiaroa Head) guards the entrance to the harbour, and traditionally was one of the outstanding strongholds of Kāi Tahu in the southern part of Te Waipounamu. Pukekura enjoys a commanding view of all that lies before it, exposed as it is to the four winds it is a natural home to the tōroa (Northern Royal Albatross).

Te Rūnanga o Ōtākou - Tamatea

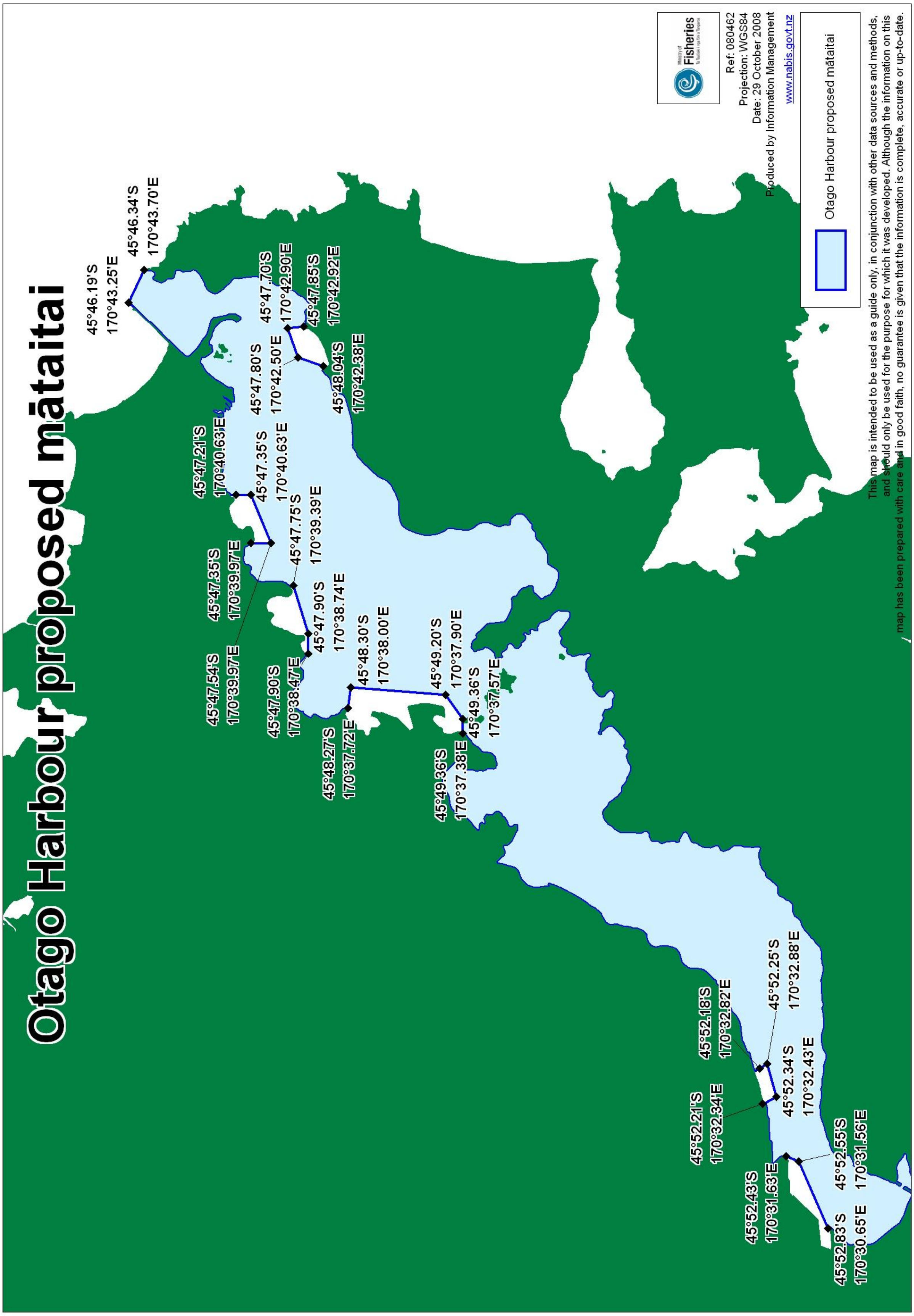
Te Rūnanga o Ōtākou has applied to the Ministry of Fisheries for a Mātaitai Reserve for the Otago Harbour.[15] The management aims of the Mātaitai are to:

- **Ensure the local community and Ngāi Tahu Whānui are able to undertake recreational activities and exercise their customary rights respectively;**
- **Ensure the protection of fisheries resources so that an abundant supply of mahinga kai is available to Ngāi Tahu Whānui and the local community; and to**
- **Prevent further degradation of the mauri and wairua of the Ōtākou fishery.**

The proposed Mātaitai Reserve would encompass all of the Otago harbour, excluding wharfs and dry-dock areas used for commercial operations.

Public submissions on the proposed Mātaitai have now closed. The application and submissions are now being considered by the Ministry of Fisheries. The decision on the proposed Mātaitai Reserve will be provided to Port Otago Ltd when it becomes available.

15 **Mātaitai reserves help recognize the customary use and management practices of Māori in the exercise of fishing rights. Commercial fishing is excluded within Mātaitai reserves, unless provided for by regulation. In contrast, commercial fishing can continue as of right within a Taiapure.**


Otago Harbour proposed mātaitai
45°46.19'S 170°43.25'E
45°46.34'S 170°43.70'E
45°47.70'S 170°42.90'E
45°47.85'S 170°42.92'E
45°47.80'S 170°42.50'E
45°48.04'S 170°42.38'E
45°47.21'S 170°40.63'E
45°47.35'S 170°40.63'E
45°47.35'S 170°39.97'E
45°47.75'S 170°39.39'E
45°47.54'S 170°39.97'E
45°47.90'S 170°38.74'E
45°47.90'S 170°38.47'E
45°48.30'S 170°38.00'E
45°48.27'S 170°37.72'E
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Ministry of Fisheries
Ref: 080462
Projection: WGS84
Date: 29 October 2008
Produced by Information Management
www.nabis.govt.nz
Otago Harbour proposed mātaitai
This map is intended to be used as a guide only, in conjunction with other data sources and methods, and should only be used for the purpose for which it was developed. Although the information on this map has been prepared with care and in good faith, no guarantee is given that the information is complete, accurate or up-to-date.

Tangata Whenua Groups

Karaitiana, RL Karaitiana & Taituha Trust

The Karaitiana, RL Karaitiana & Taituha Trust, is an Ahu Whenua Trust formed under the Te Turi Whenua Act 1993. The land administered by the trust is situated at Te Rauone, and includes 17 crib sections and one section on Te Rauone Beach. A clause in the trust order requires the protection of the ecological balance of the land and the sustainable management of kai moana resources.

Te Rauone Beach, Muaupoko (Otago Peninsula)

Korako Karetai Trust

The Korako Karetai Trust represents the descendents of Korako Karetai. Korako Karetai was the original owner of a section of the Pukekura headland through a Crown Grant Title. The trust was formed to negotiate the return of Korako Karetai land at Pukekura and to manage sustainable activities on the land, including identification and preservation of the cultural taonga of Pukekura for future generations.

Pilot Beach, Pukekura

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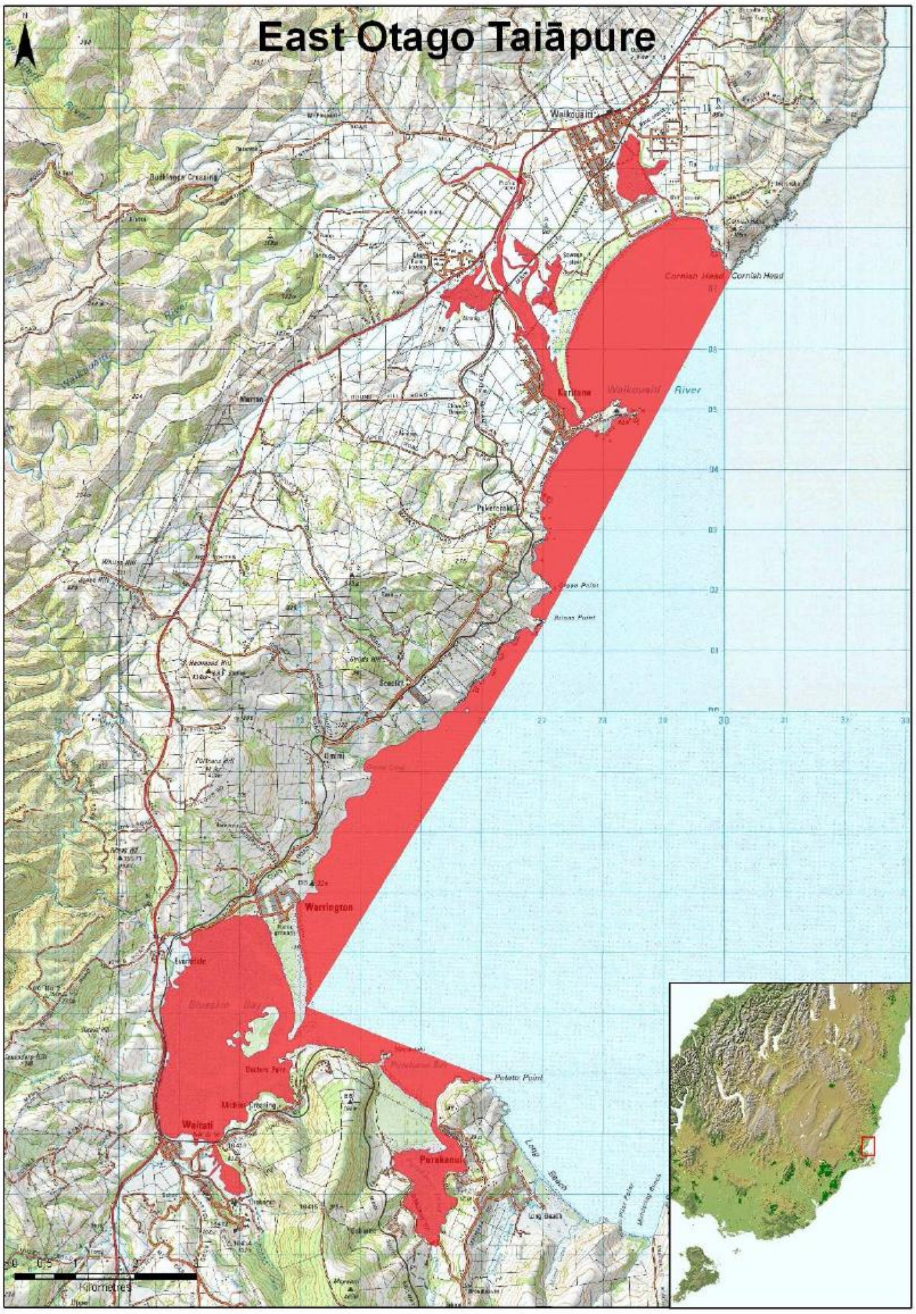
East Otago Taiāpure Management Committee

Taiāpure are local fisheries and customary fishing management areas established under the Fisheries Act 1996. Taiāpure are established where the area is of special significance to iwi or hapu as a food source, or for spiritual or cultural reasons.

The East Otago Taiāpure was gazetted in July 1999. The vision for the Taiāpure is to provide for a sustainable, healthy, abundant and accessible fishery that provides for the community's customary, recreational and commercial needs.

The Taiāpure encompasses all marine and estuarine waters enclosed by a line commencing at Cornish Head, proceeding along a straight line to Brinns Point, then along a straight line in a south-westerly direction to a point on Warrington Spit, then following a straight line in an easterly direction to Potato Point and finally proceeding generally west and north along the mean high water mark to the point of commencement.[16]

[16] **Fisheries (East Otago Taiäpure) Order 1999**



The entire fishery within the Taiāpure remains an important source of kaimoana for Kāi Tahu Whānui. Data from the excavation of midden deposits shows a traditional reliance on manga (barracouta) and hoka (red cod), with Hokarari (ling) and hāpuku (groper) being next in importance followed by a range of species including wrasse, rāwaru (blue cod) and moki.[17] A wide variety of shellfish were collected from sandy and rocky shorelines as well as from the estuary. These included pipi, tuakai (cockles), pāua, cats eye, mussel and oyster.

[17] **East Otago Taiāpure Management Plan, January 2008.**

The rocky shoreline of the Huriawa peninsula, together with the two long sandy beaches lying to the north and south provided plentiful kaimoana, including sole and pātiki (flounder).

Kaimoana Resources of Karitāne / Puketeraki	
Ika	**Kai Mātaitai**
Maka (barracouta)	**Pipi**
Hāpuku (groper)	**Pāua**
Hoka (red cod)	**Kina**
Hokarari (ling)	**Kōura (crayfish)**
Rāwaru (blue cod)	**Kutai (green mussel)**
Pātiki (flatfish)	**Tuaki (cockles)**
Pawhaiwhakarua (wrasse)	**Tuatua**
Pau (Wrasse)	**Tio (oysters)**
Tuna (eels)	
Moki	
Inaka (whitebait)	
Kanakana	
Marine Mammals	**Seaweed**
Kekeno (NZ fur seal)	**Karengo (sea lettuce)**
Source: East Otago Taiāpure Management Plan, 2008	

6. Statutory Framework

6.1 Ngāi Tahu Claims Settlement Act 1998

The Ngāi Tahu Claims Settlement Act included as cultural redress a number of mechanisms to recognise and give practical effect to Ngāi Tahu mana over taonga resources and areas of land. These include Statutory Acknowledgements, Topuni, Nohoanga and place name changes.

The aim of statutory acknowledgments is to improve the effectiveness of Ngāi Tahu participation under the Resource Management Act in decisions affecting taonga species, customary fish species, and acknowledged areas. The statutory acknowledgements for Taonga Species, Taonga Fish Species and Shellfish Species, and Te Tai O Arai Te Uru (Otago Coastal Marine Area), are set out in Appendix 3.

6.2 Kāi Tahu ki Otago Natural Resource Management Plans

6.2.1 Introduction

The Kāi Tahu ki Otago Natural Resource Management Plans 1995 and 2005 are the principal resource management planning documents for Kāi Tahu ki Otago. The kaupapa of the plans is 'Ki Uta ki Tai' (Mountains to the Sea), which reflects the holistic Kāi Tahu ki Otago philosophy of resource management.

The Natural Resource Management Plans express Kāi Tahu ki Otago values, knowledge and perspectives on natural resource and environmental management issues. The plans are an expression of kaitiakitanga. While the plans are first and foremost planning documents to assist Kāi Tahu ki Otago in carrying out their kaitiaki roles and responsibilities, they are also intended to assist others in understanding tangata whenua values and policy.

The 2005 plan (the Natural Resource Management Plan) is divided into catchments, with specific provisions for the whole Otago area and each catchment. The current proposal is located within the Otago Harbour Catchment.

The 2005 Natural Resource Management Plan contains objectives and policies for the coastal environment, taku tai moana me wai Māori[18], mahika kai (kai moana) & biodiversity, and cultural landscapes that are relevant to the current proposal by Port Otago.

6.2.2 Otago Region: Coastal Envrionment: Taku Tai Moana Me Wai Māori

OBJECTIVES [5.8.3]		ASSESSMENT
General	The spiritual and cultural significance of taku tai moana me te wai māori is recognised in all management of the coastal environment.	The purpose of preparing this cultural impact assessment is to ensure that the spiritual and cultural significance of the Otago Harbour and Te Tai o Arai Te Uru is recognised and provided for in the management of capital dredging.

[18] Taku tai moana me te wai māori – Foreshore, seabed and all water.

OBJECTIVES [5.8.3]		ASSESSMENT
General *continued*	**Te Tai o Arai Te Uru is healthy and supports Kāi Tahu ki Otago customs.**	**Monitoring before, during and after completion of capital dredging is recommended to ensure that the Otago Harbour and Te Tai o Arai Te Uru are healthy and will continue to support Kāi Tahu ki Otago customs.**

6.2.3 Otago Region: Coastal Environment: Mahika Kai (Kai Moana) & Biodiversity

OBJECTIVES [5.8.11]		ASSESSMENT
General	**Te Tai o Arai Te Uru supports the full range of healthy ecosystems and species.**	**Monitoring of the effects of dredging on key species and ecosystems of importance to Kāi Tahu, including tuaki, flat fish, seagrass and kelp, is a recommendation of this assessment.**
	There is an abundance of healthy kai moana.	**Major beds of shellfish that are important to Kāi Tahu will either endure or will re-establish after completion of capital dredging.** **Fish are mobile and well able to take flight from the noise, disturbance, and high suspended sediment levels caused by dredging and by disposal events.**

POLICIES [5.8.12]		ASSESSMENT
General	**To require that dredging and reclamation works avoid physical damage to kai moana sites, habitat and the integrity of the seabed.**	**No reclamation is proposed as part of Project Next Generation.**

POLICIES [5.8.12]		ASSESSMENT
General (***continued***)	**To require that dredging and reclamation works avoid physical damage to kai moana sites, habitat and the integrity of the seabed.**	**The alignment of the deepened channel is mostly within the existing channel alignment. The channel will be widened on the inside of Harington Bend adjacent to the Aramoana sandflats and on the eastern side of the Port Chalmers swinging basin.** **An 8,000m^2 inter-tidal area on the eastern edge of the Port Chalmers swinging basin will be removed. The affected intertidal area is approximately 0.15% of the total intertidal area in the Lower Harbour.**

6.2.4 Otago Region: Coastal Environment: Cultural Landscapes

POLICIES [5.8.16]		ASSESSMENT
General	**To require the protection of fragile sand dunes and sand flat ecosystems through:** • **Monitoring erosion rates and any flooding that occurs;** • **Monitoring and controlling the effects of harbour dredging and reclamation; and** • **Monitoring and ensuring the sustainable use of sand.**	**The Hydrodynamic Modelling (NIWA-Bell) and Physical Coastal Environment & Assessment (Single) concludes that the deepening of the channel will not accelerate coastal erosion or deposition.** **Monitoring of beach and near shore profiles at Shelly Beach, Aramoana, Pilots Beach, Te Rauone Beach, and Omate Beach before, during and after completion of the capital dredging project is recommended.**

6.2.5 Otago Harbour Catchment: Wai Māori and Wai Tai

POLICIES [8.2.3]		ASSESSMENT
Monitoring and Research	To encourage research and monitoring into sediment deposition at Blueskin Bay and Pūrākaunui.	A separate stream of work is underway on the ecological effects of deposition and sediment transportation from the existing maintenance dredging disposal sites. Previous work by Bunting, Single and Kirk (2003) concludes that spoil from the Heyward Point disposal site is not moving into the Blueskin Bay Estuary. The hydrodynamic modelling predicts that sediment from the off-shore capital dredging disposal site would not be transported into Blueskin Bay.
	To promote research and monitoring of ship movements and impacts from wash within the Harbour.	Pullar and Single (2009) have assessed the effects of ship movements and the impact of vessel waves. The cumulative effect of a deeper channel will be to reduce vessel wake for all vessel transits, as compared with the existing channel.
Dredging	To encourage the dumping of all dredging material beyond the continental shelf.	The dumping of dredging material beyond the continental shelf is not economically viable.[19] There are no unique or special ecological communities at the selected off-shore disposal site. Further, the site is away from scallop and bryozoan beds and from fishing areas.

[19] Lincoln Coe (General Manager Infrastructure, Port Otago Ltd), Personal Communication

POLICIES [8.2.3]		ASSESSMENT
Dredging	Dredging activity should not impact on tuaki and other marine life.	Deposition of sediment within the Lower Harbour will be less than 0.3 mm per day or 24 mm over the whole dredging programme. This level of sedimentation is below the critical levels that have a significant impact on cockles (20-30 mm in an event). Research undertaken for Port Otago Ltd concludes that capital dredging will not adversely impact on key species and ecosystems of importance to Kāi Tahu, including tuaki, flat fish, seagrass and kelp

6.3 Conclusion on the Statutory Framework

Kāi Tahu Whānui have a cultural, spiritual, historic, and traditional relationship with the Otago Harbour and Te Tai O Arai Te Uru (the Otago Coastal Marine Area). Therefore, particular sensitivity to cultural values is required during the proposed capital dredging project.

The Kāi Tahu ki Otago Natural Resource Management Plans express Kāi Tahu Whānui values, knowledge and perspectives on natural resource and environmental management issues. Specifically, the environmental effects of capital dredging on the integrity of the seabed and coast, and on key species and ecosystems, concern Manawhenua.

Research undertaken for Port Otago Ltd concludes that capital dredging will not adversely impact on key species and ecosystems of importance to Kāi Tahu Whānui, including tuaki, flat fish, seagrass and kelp. Nor will the project adversely affect the integrity of the seabed or the physical coastal environment.

Overall, Project Next Generation is consistent with the objectives and policies of the Kāi Tahu ki Otago Natural Resource Management Plans. However, an independent audit of the hydrodynamic modelling, and monitoring of the environmental effects of dredging, is recommended.

7. Assessment of Environmental and Cultural Effects

7.1 Introduction

The following methodology was adopted to identify the issues of concern for Kāi Tahu ki Otago and the tangata whenua Groups:

a. A consultation document was prepared that summarised the key elements of Project Next Generation. This summary was used to facilitate the identification of key issues by the Manawhenua Working Group.

b. A peer review of the ecological research undertaken for Port Otago Ltd was commissioned from Dr Terry Broad of Eco-Dynamic Systems Ltd (Refer to Appendix 4).

c. The potential issues identified by the Working Group and Eco-Dynamic Systems Ltd were referred to Port Otago Ltd for comment. Port Otago Ltd provided supplementary information on these issues.

d. The issues identified by the Manawhenua Working Group and Eco-Dynamic Systems Ltd, and the supplementary information provided by Port Otago Ltd, were then assessed (refer to the following section).

7.2 Assessment of Environmental and Cultural Effects

An assessment framework was developed that reflects the environmental philosophy and cultural values of Kāi Tahu ki Otago.[20] The framework was structured around Port Otago's technical work[21]; the potential effects identified by the Manawhenua Working Group and Eco-Dynamic Systems Ltd; and two interrelated cultural dimensions respectively Mauri and Mana.

[20] The Mauri Model developed by Dr Kepa Morgan, Associate Dean (Māori), Faculty of Engineering, The University of Auckland, provided a starting point for the development of the assessment framework. The Mauri Model or Mauriometer converts environmental impacts into quantitative performance measures.

[21] The technical reports prepared for Port Otago Ltd address the Hydrodynamic Environment, Physical Coastal Environment, Sedimentation, and Ecology. A further category, Social Environment, was added to capture issues identified through the Manawhenua Working Group interviews.

MAURI	
Key Principles • **Whakawhanaungatanga** [22] • **Rangatiratanga** [23] • **Kaitiakitanga (Stewardship / Guardianship)** • **Ki Uta Ki Tai (Mountains to the Sea)**	**Key Indicators** • **Land, water, air quality or quantity** • **Gain / loss of taonga koiora / taonga tuku iho (valued flora and fauna both native and introduced)** • **Maintenance / denigration of natural processes**

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MANA	
Key Principles • **Manaakitanga** • **Whānau Ora (family health & wellbeing)**[24]	**Key Indicators** • **Gain / loss of cultural relevance or value** • **Enhancement / limitation of customary gathering** • **Enhancement / limitation of cultural practices** • **Public health, safety, common good** • **Gain / loss of recreational value** • **Enhancement / limitation of recreational value** • **Gain / loss of economic value**

[22] **Whanaungatanga denotes the fact that in the traditional Māori thinking relationships are everything – between people, between people and the physical world, and between people and the atua (spiritual entities) [*Ngati Hokopu v Whakatane DC, C168/02*]**

[23] **The right of Māori to possess and control that which is theirs in accordance with their customs and having regard to their own cultural preferences [*Land Air Water Association v Waikato Regional Council* A110/01, Paragraph 391]**

[24] **The references to whānau ora in this report <u>are not</u> references to the Central Government programme of the same name.**

7.2.1 Hydrodynamic Environment

Factor	Potential Effects	Cultural Effects: Mauri	Cultural Effects: Mana
Hydrodynamic Environment			
Tidal Currents and Range (Harbour)	**Changes to the height and flows of tides.**	• **Changes to the habitat parameters of key species.** • **Potential effects on the viability of species of cultural importance within the harbour.**	• **Limitations on the customary and recreational gathering of kaimoana and flat fish within the harbour.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on public safety.** • **Potential effects on whānau ora**
Tidal Currents and Range (Harbour)	**Changes to tidal velocities resulting in the accretion of the inter-tidal sandbanks making navigation within the harbour at low tide increasingly difficult.**	• **Hydrographic changes within the lower harbour outside the channel.**	• **Limitations on customary and recreational fishing.** • **Limitations on cultural practices including manaakitanga.** • **Loss of recreational value.** • **Potential effects on whānau ora.**

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Hydrodynamic Environment			
Tidal Currents and Range (Harbour)	**Changes to tidal velocities resulting in increased erosion within the lower harbour.**	• **Potential for increased erosion of beach deposits and dunes from the lower harbour beaches, including Te Rauone Beach (the northern end of Te Rauone Beach is eroding, resulting in a loss of access from the Te Rauone Reserve to the Beach and threatening coastal properties).**	• **Potential for the erosion of historical material and koiwi (human skeletal remains) from the lower harbour beaches.** • **Limitations on the customary and recreational use of the lower harbour beaches by whānau.** • **Potential effects on whānau ora.**
Tidal Currents and Range (Harbour)	**Scouring of the inter-tidal tuaki (cockle[25]) banks from changing tidal velocities.**	• **Loss of tuakai habitat.** • **Potential changes to the habitat parameters of tuaki affecting the viability of the species in the lower harbour.**	• **Limitations on the customary and recreational gathering of tuaki within the harbour.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**

[25] **Cockles / New Zealand Littleneck Clams (Austrovenus Stutchburyi)**

Discussion [26]

The deepening of the channel will lead to a small increase in the tidal range within the Harbour. A 16mm increase in the total height of the tide is predicted, which is a difference of 8mm at low and high tides respectively. The existing tidal range is approximately 2.0m (spring tide) so the predicted change is less than 1%.

Overall a reduction in tidal currents of 0.1m/s is predicted. Though there will be some localised increases in average peak current of around 0.02 to 0.05m/s at Harrington Bend (off the Ōtākou groyne - #10 beacon). The change in tidal currents is 6%, which would not result in significant changes to the transport of sediment within the harbour. The Hydrodynamic Modelling (NIWA-Bell) and Physical Coastal Environment & Assessment (Single) concludes that there will not be substantive effects in relation to accelerating coastal erosion or deposition.

Recommendations

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
General	1	Commission an independent audit of the Lower Harbour hydrodynamic modelling.
Tidal Range and Tidal Currents	2	Monitor changes to the tidal range and to tidal currents within the Lower Harbour during and after completion of the capital dredging project.

[26] Port Otago Ltd

7.2.2 Physical Coastal Environment

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Physical Coastal Environment			
Otago Harbour	**Potential for dredging to collapse the inter-tidal tuaki (cockle) banks.**	• **Loss of tuakai habitat.**	• **Limitations on the customary and recreational gathering of tuaki within the harbour.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**
Otago Peninsula	**Wave effects of 6,000 TEU container ships on the lower harbour beaches.**	• **Potential changes to beach profiles and the benthic environment in the lower harbour.** • **Effects of a increase in wave energy on the lower harbour beaches.**[27]	• **Potential for the erosion of historical material and koiwi (human skeletal remains) from the lower harbour beaches.** • **Increased risk to public safety from vessel waves.** • **Limitations on the customary and recreational use of the lower harbour beaches by whānau.** • **Potential effects on whānau ora.**

[27] Vessel wave effects are of short duration. The scale of effects is dependent on the speed, size and displacement of the vessel, channel size and water depth (bathymetry), the height of the tide, and the prevailing winds (Pullar and Single, 2009).

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Physical Coastal Environment			
Otago Peninsula	Wave effects of 6,000 TEU container ships on Te Rauone Beach.	• Potential changes to the profile and the benthic environment of Te Rauone Beach. • Effects of a increase in wave energy on Te Rauone Beach.	• Potential for the erosion of historical material and koiwi (human skeletal remains) from Te Rauone Beach. • Increased risk to public safety from vessel waves.[28] • Limitations on the customary and recreational use of Te Rauone Beach by whānau. • Potential effects on whānau ora.
Otago Peninsula	Potential for an increase in vessel waves if a change in ship speed is required to navigate the Harrington Bend.	• Potential changes to beach profiles and the benthic environment from Harington Point to Ōtakou. • Effects of a increase in wave energy.	• Potential for the erosion of historical material and koiwi (human skeletal remains). • Increased risk to public safety from vessel waves. • Limitations on the customary and recreational and use of Te Rauone Beach, Wellers Rock, and Omate Beach. • Potential effects on whānau ora.

[28] Vessel waves currently cross Te Rauone Beach and road when there is a high tide and a westerly.

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Physical Coastal Environment			
Careys Bay	Tugs manoeuvring ships within the swinging basin create turbulence for smaller boats at Careys Bay. Will that turbulence increase if the tugs are manoeuvring larger container ships?	• Short term increase in wave energy during manoeuvring of container ships within the swinging basin.	• Short term effects on the recreational use of Careys Bay by whānau.

Discussion [29]

The alignment of the deepened channel is mostly within the existing channel alignment. The only significant widening of the channel will occur on the inside of Harington Bend adjacent to the Aramoana sandflats and on the eastern side of the Port Chalmers swinging basin. The stability and slope of the existing channel banks were carefully assessed during the channel design process, with the final batter or bank profile matching the existing slopes. These existing and designed slopes vary from 1 in 3 at Port Chalmers to 1 in 7 and 1 in 8 around Harington Bend. A historical assessment of slope stability (1950 to present) was also undertaken to confirm long term slope stability. The dredged volume of $7.2Mm^3$ includes the removal of all the material required to construct these stable batter slopes.
The only intertidal area affected will be the eastern edge of the Port Chalmers swinging basin, an area of approximately $8{,}000m^2$ between 0.0m and 0.3m above chart datum.

[29] Port Otago

The Lower Harbour intertidal areas between 0.0m and 1.0m above chart datum total approximately 6,000,000m^2. Therefore, the affected intertidal area at Port Chalmers is approximately 0.15% of the total intertidal area in the Lower Harbour.

There will be no change in vessel speed. The vessel speeds that are required for the existing 4100 vessels will also be required to safely navigate larger vessels in the deeper harbour channel. There is potential for a 10-15% increase in individual wake height for a 6000 vessel transit as compared with the existing 4100 TEU vessels, which is within the natural variability of the existing wave environment. Further, as 6000 TEU vessels are capable of carrying more cargo there would be a reduced number of vessel transits (and wake). The cumulative effect of a deeper channel will be to reduce vessel wake for all vessel transits, as compared with the existing channel. Pullar and Single (2009) recommend management measures to increase the awareness of the community, including users of the harbour, of the effects of vessel traffic.

In relation to Te Rauone beach, the existing erosion and natural and artificial influences are documented in the technical reports, respectively Channel Design (Port Otago), Vessel Effects (Pullar and Single) and Physical Coastal Environment & Assessment (Single). Port Otago Ltd is working with a Coast Care Committee and residents to address community concerns relating to recent changes in the profile of Te Rauone Beach. Possible options for restoring Te Rauone Beach include the construction of a retention structure, for example a breakwater, and sand nourishment. The Te Rauone beach restoration project is being advanced separately from Project Next Generation.

The vessel and tug speeds when the larger vessels are slowing to approach Port Chalmers will be similar to the existing speeds. Therefore it is unlikely there will be an increase in turbulence and effects in Carey's Bay above what occurs at present with the existing vessels. Communication with all harbour users in relation to vessel effects and safety when vessels are manoeuvring at Port Chalmers is discussed in the Vessel Effects report. Many of the recommendations of the Vessel Effects report should be advanced independently of larger vessels using the Port.

Recommendations

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
Beach and Near Shore Profiles	**1**	**Monitor beach and near shore profiles at Shelly Beach, Aramoana Flats, Pilots Beach, Te Rauone Beach, and Omate Beach before, during and after completion of the capital dredging project.**
Public Safety	**2**	**Install signs on beaches and boat ramps to advise the public of the risks associated with passing vessels.**
	3	**Advise Kāti Huirapa Rūnanga ki Puketeraki and Te Rūnanga o Ōtākou of scheduled vessel arrivals.**

7.2.3 Sedimentation

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Sedimentation			
Capital Dredging	**Suspended sediment settling over the tuaki (cockle) beds. Is tuaki (cockle) habitat able to recover from the effects of dredging?**	• **Loss of tuakai habitat.** • **Changes to the habitat parameters of tuaki affecting the viability of the species in the lower harbour.**	• **Restrictions on the customary and recreational gathering of tuaki by whānau.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Sedimentation			
Capital Dredging	**Suspended sediment settling over the Te Rauone tuaki (cockle) beds. The Te Rauone tuaki (cockle) beds are located between the inter-tidal area and the edge of the channel.**	• **Loss of tuakai habitat.** • **Potential changes to the habitat parameters of tuaki. Are tuaki (cockles) able to migrate through any additional sediment layer?** • **Potential effects on the viability of tuaki at Te Rauone Beach.**	• **Restrictions on the customary and recreational gathering of tuaki at Te Rauone Beach by whānau.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**
Capital Dredging	**Suspended sediment settling over the Aramoana Salt Marsh Flats.**	• **Changes to the habitat parameters of key species.** • **Potential effects on the viability of species of cultural importance on the Aramoana Salt Marsh Flats.**	• **Limitations on the customary and recreational gathering of kaimoana and flat fish on the Aramoana Salt Marsh Flats.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Sedimentation			
Maintenance Dredging	**Effects of an increase in maintenance dredging on habitat and reef systems from Warrington to Kakanui.**	• **Potential effects on the Blueskin Bay estuary and North Coast ecosystems if Port Otago fully exercises its current maintenance dredging consent. The consent authorises the deposition of 450,000 cubic metres of spoil off Heywards Point, Shelly Beach and the Aramoana Spit.**	• **Limitations on the customary and recreational gathering of kaimoana and flat fish.** • **Limitations on customary and recreational fishing.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**
Maintenance Dredging	**Transportation of rock, silt and clay from the Heywards Point disposal site into the Blueskin Bay estuary and along the North Coast.**	• **Potential effects on the Blueskin Bay estuary and North Coast ecosystems.**	• **Limitations on the customary and recreational gathering of kaimoana and flat fish.** • **Limitations on customary and recreational fishing.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Sedimentation			
Maintenance Dredging	**Effects of a build up of fine sands on habitat and reef systems within the Blueskin Bay estuary and along the North Coast.**	• **Changes to the habitat parameters of key species.** • **Potential effects on the viability of species of cultural importance within the Blueskin Bay estuary and along the North Coast.**	• **Limitations on the customary and recreational gathering of kaimoana and flat fish.** • **Limitations on customary and recreational fishing.** • **Limitations on cultural practices including manaakitanga.** • **Economic impact on whānau engaged in commercial fishing.** • **Potential effects on whānau ora.**
Disposal of Spoil (Site AO)	**Changes to the benthic ecology and biota at the disposal site from the deposition of dredge material.**	• **Smothering of benthic ecology and biota at the disposal site.**	• **Localised impact on customary and recreational fishing within the immediate vicinity of the disposal site.**

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Sedimentation			
Disposal of Spoil (Site AO)	Effects of decaying organic matter (shellfish) dredged from the harbour on the water column.	• Ecological opportunities offered by the temporary increase in nutrients at the disposal site. • Potential for the short term enhancement of the fishery in the immediate vicinity of the disposal site.	• Enhancement of recreational fishing in the immediate vicinity of the disposal site. • Short term enhancement of recreational value.
Disposal of Spoil (Site AO)	Potential for sediment to be carried by the currents into the Blueskin Bay estuary and along the North Coast from Warrington to the Moeraki Peninsula.	• Effects on habitat and reef systems if sediment dispersal differs from that modelled. • Potential effects on the viability of species of cultural importance within the Blueskin Bay estuary and along the North Coast.	• Limitations on the customary and recreational gathering of kaimoana and flat fish. • Limitations on customary and recreational fishing. • Limitations on cultural practices including manaakitanga. • Economic impact on whānau engaged in commercial fishing. • Potential effects on whānau ora.

Factor	Potential Effects	Cultural Effects: Mauri	Cultural Effects: Mana
Sedimentation			
Disposal of Spoil (Site AO)	**Potential for contaminated spoil from the swinging basin and channel to be carried by the currents into the Blueskin Bay estuary and along the North Coast.**	• **Potential effects on key species of cultural value from contaminated spoil.**	• **Limitations on the customary and recreational gathering of kaimoana and flat fish.** • **Limitations on customary and recreational fishing.** • **Limitations on cultural practices including manaakitanga.** • **Economic impact on whānau engaged in commercial fishing.** • **Potential effects on whānau ora.**
Disposal of Spoil (Site AO)	**Effects on deep water species if dredge spoil ends up in canyon ecosystems.**	• **Potential effects on key species of cultural value.**	• **Limitations on customary and recreational fishing.** • **Limitations on cultural practices including manaakitanga.** • **Economic impact on whānau engaged in commercial fishing.** • **Potential effects on whānau ora.**

Discussion [30]

Introduction

Suspended sediment and sedimentation are the most obvious adverse effect of dredging. Comprehensive sediment modelling predicts that suspended sediment concentrations are likely to be well within the normal background range, except for areas adjacent to dredging and disposal sites. These sediment levels have been shown to have little effect on fish eggs, larvae or adults. In the immediate area of the dredging and disposal sites suspended sediment is predicted to be relatively high but short term in duration.

Effects on Tuaki (Cockles), Pipi and Tuatua

The key conclusions contained within the Supplementary Report[31] in relation to Shellfish are as follows.

Cockles have a preference for sediments with less than 10% mud/silt content but can tolerate up to 85% mud. Therefore, cockles are unlikely to be excluded from intertidal areas as a result of the dredging operation. Sediment deposition in intertidal areas that have been identified as important for the gathering of cockles, including the Aramoana Sand Flats, Pulling and Tayler Points and Harwood, is unlikely to have a significant impact as:

- **Deposition will be less than 0.3 mm per day or 24 mm over the whole dredging programme. These depositions are below the critical levels that have a significant impact on cockles (20-30 mm in an event).**
- **Cockles are mobile and can burrow through the small layers of fine sediment that would deposit in intertidal areas during dredging.**
- **Deposited sediment will be resuspended and mobilised by tidal movement and wave activity. Much of the sediment will eventually be flushed out of the harbour.**
- **Large intertidal areas with substantial cockle beds will receive negligible deposition of sediment.**

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30 **Eco-Dynamic Systems Ltd (2009); Port Otago Ltd, 2010.**
31 **James, Boyd and Probert (2010). *Information on Key Species of Interest to Ngāi Tahu – Supplementary Paper for Next Generation Project***

- **Recruitment would occur in the short to medium-term if unexpected losses were to occur in some regions.**

Further, the major cockle beds would be largely unaffected by increases in suspended sediments (SS) because:

- **Cockles can tolerate high levels of SS. The condition of cockles only decreases at sediment levels above 300-400 milligrams per litre (mg/l).**
- **These concentrations of sediment would only be experienced by the major cockle beds for short periods, for example opposite Acheron Point for 5-7% of the time during dredging in the Cross Channel and Tayler Bend sections.**
- **Most areas where large cockle beds occur would be largely unaffected and would experience concentrations under 100 mg/l (Harwood, Te Rauone, Aramoana).**
- **Cockles are expected to survive several days at high concentrations. Sediment concentrations would return to lower levels when the dredge moves on to other areas.**

Pipi are less tolerant of fine sediments and tend to be excluded if mud content is over 67%, preferring sediments with less than 5% mud. However, populations of pipi tend to be found in the sub tidal channels and marginal areas where there is significant water movement. In these areas fine sediments are unlikely to settle for long and will be re-suspended and dispersed. Pipi are unlikely to be impacted by the predicted deposition of sediment because of their ability to burrow through several centimetres of fine sediment. The major pipi beds identified to date are in the Aramoana area where suspended sediment concentrations are predicted to be under the 75 mg/l threshold at which pipi are likely to be impacted. Only parts of the main channel and marginal and intertidal areas between the Port, Quarantine Island and Latham Bay would experience concentrations over 100 mg/l and mostly when dredging occurs close to the Port.

Tuatua are generally considered a surf species and only small populations have been recorded in the harbour with more significant populations towards the entrance. There is no information on the sediment tolerances of tuatua.

However, tuatua tend to be a sub tidal species and again significant water movement will ensure that effects on these populations, if they were to occur, would be short-term. If some of the beds in areas around Aramoana were affected then recruitment would occur from other populations nearby and along the open beaches.

In conclusion, major beds of shellfish important to Ngai Tahu are expected to persist and if there were unexpected losses then they would recover in the short- to medium-term through recruitment and recolonisation from within the Lower Harbour.

Maintenance Dredging

The effects of maintenance dredging are documented within the Assessment of Environmental Effects and in the technical reports including the Hydrodynamic Modelling Report (NIWA-Bell) and Physical Coastal Environment & Assessment Report (Single).

The demand for maintenance dredging within the harbour will not change as tidal inflow and outflow are almost unchanged. Further, a demand for increased maintenance dredging is unlikely, as the final deepened channel will have slopes that match the existing channel slopes to minimise the risk of slumping. Ongoing maintenance dredging volumes are expected to be similar to what exists at present. The only increase in maintenance dredging may occur at the entrance to the Lower Harbour, where the increased depth of the channel may intercept some of the natural movement of sediment across the channel.

Port Otago Ltd is not seeking a renewal of the existing maintenance disposal consent as part of the current application. A separate stream of work on maintenance dredging is currently underway. The application for the renewal of the maintenance dredging disposal consent will use knowledge gained from Project Next Generation but will also specifically look at the ecological effects of deposition and sediment transportation from the existing maintenance dredging disposal sites. The upstream or downstream effects of disposal at these existing sites will be addressed in detail when an application is lodged for the renewal of the maintenance dredging consent in 2011. However, previous work by Bunting, Single and Kirk (2003) concludes that spoil from the Heyward Point disposal site is not moving into the Blueskin Bay Estuary.

Disposal of Spoil from Capital Dredging (Site AO)

The off-shore disposal site is 6.3 kilometres to the northeast of Taiaroa Head in approximately 27 metres of water. The disposal site is approximately 2km in diameter and is located on a submarine "Peninsula Spit". This disposal site is on the periphery of the northerly flowing Southland Current.

There will be a substantial loss of the existing benthic communities within the disposal site due to smothering, with smothering reducing as distance increases from the site. However, there are no unique or special communities at the site. Further, the site is away from scallop and bryozoan beds and from fishing areas. The ecology of the disposal site and immediate area may remain in an opportunistic stage for some time, but is expected to have recovered within 1-5 years after disposal ceases. In contrast, lower intensity disposal of spoil by the New Era would have less effect and most biota should persist.

The dredged material will predominately be sand (62%) with the remainder being silts (33%) and clays (4%). The small proportion of rock (1%) will not be disposed off-shore. The dredged material was tested for contamination and is within the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (the ANZECC guidelines).

Sandy material disposed of at the off-shore site will become part of the natural seabed and existing sand transportation regime. This sandy material would be indistinguishable from the natural sediment that is moving North Northeast along the submerged 'Peninsula Spit'. It is very unlikely that sand-sized material, other than isolated grains, deposited at the off-shore site would move westwards to reach the near shore zone (depths less than 15m).

Silty material will disperse widely to the North Northeast during disposal. There is potential for the dilute edge of the sediment plume to reach the coast at low concentrations along the Otago Heads and north of Cornish Head (Waikouaiti Bay). The estimated concentrations near the coast are predicted to be within the normal range of turbidity[32] experienced in coastal areas.

[32] **Turbidity is a measure of the relative clarity of water.**

Further, the hydrodynamic modelling predicts that no sediment deposition would occur within Blueskin Bay or around Karitane Point within 48 hours following disposal. Finally, it is noted that finer material will not settle in open coastal areas as it is quickly remobilised by waves and currents.

Some silt material from disposal will end up in the off-shore canyons. However, the canyons receive significant quantities of fine silt material that is discharged to the open coast from rivers to the south of Otago Peninsula. The estimated volume of silt material from the capital dredging is insignificant in comparison to that deposited by natural processes.

Recommendations

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
General	1	Commission an independent audit of the Lower Harbour and Off-Shore hydrodynamic modelling.
Turbidity and Sedimentation[33]	2	Monitor the sediment plume from the dredging operation and from the off-shore disposal of dredged material.
	3	Monitor turbidity and sedimentation at Acheron, Pulling and Tayler Points, Aramoana, off the Otago Peninsula from Harwood to Te Rauone Bay, and along the North Coast from Blueskin Bay to the Moeraki Peninsula, before, during and after completion of capital dredging.
Contamination	4	Undertake ongoing testing of the material dredged from the Swinging Basin for contamination.

[33] The Dredging Environmental Management Plan (Port Otago) should direct changes to the dredge routine where turbidity and sedimentation exceed the environmental limits for key species of importance to Kāi Tahu, including tuaki (cockles) and pipi.

7.2.4 Ecology

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Ecology			
Key Species: Macrocystis Pyrifera (Bladder or Giant Kelp), Durvillaea (Bull kelp or Rimurapa), and Porphyra Coleana (High Golden Karengo / Karengo or Parengo)	Regional or local depletion.	• Potential effects on the viability of key species of cultural value. Note(s): 1. Bladder and Bull kelp are a nursery plants. 2. Bull kelp / Rimurapa is a taonga species that is used to make pōhā (kelp bags that are used to preserve food). 3. Karengo or Parengo is an edible kelp. • Potential effects on the physical coastal environment including erosion and reduced beach building.[34]	• Limitations on the customary and recreational gathering of kaimoana and flat fish. • Limitations on customary and recreational fishing. • Limitations on cultural practices. • Economic impact on whānau engaged in commercial fishing. • Potential effects on whānau ora. • Potential for the erosion of historical material and koiwi (human skeletal remains).

[34] Attached kelp 'forests' or 'stands' are a structural component in inshore and coastal areas that modify wave flows and energy (Ministry of Fisheries, 2009)

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Ecology			
Key Species: Seagrass	Regional or local depletion of sea grass meadows within the Otago Harbour and coastal estuaries as far north as the Moeraki Peninsula.	• Changes to the habitat parameters of key species. Note(s): Seagrass meadows play a number of important ecological roles in estuarine and shallow-water coastal ecosystems, they enhance nutrient cycling, stabilise sediments, elevate biodiversity, and provide nursery and feeding grounds for a range of invertebrates and fish.[35] • Potential effects on the viability of species of cultural importance within the harbour and along the north coast.	• Limitations on the customary and recreational gathering of kaimoana and flat fish within the harbour and along the North Coast. • Limitations on customary and recreational fishing. • Limitations on cultural practices including manaakitanga. • Potential effects on whānau ora.

[35] Niwa (2007).

Factor	Potential Effects	Cultural Effects	
		Mauri	Mana
Ecology			
Key Species: Tuaki (Cockles)	Regional or local depletion of tuaki populations.	• Loss of tuakai habitat. • Changes to the habitat parameters of tuaki affecting the viability of the species in the lower harbour and along the North Coast. Note(s): i. Further information is required on the quantity of tuaki being displaced, the cumulative effects of that displacement, and on the mitigation measures proposed to address the displacement of cockle habitat. ii. Is there a relationship between cockle populations in the Harbour and on the North Coast? Are the populations at Blueskin Bay and Waikouaiti being reseeded from the Otago Harbour? iii. Is there potential to remove tuaki prior to dredging for use as seed stock? iv. Was dredging responsible for the depletion of cockle beds within the Lyttelton Harbour?	• Limitations on the customary and recreational gathering of tuaki within the harbour and along the North Coast. • Limitations on cultural practices including manaakitanga. • Potential effects on whānau ora.

Factor	Potential Effects	Cultural Effects: Mauri	Cultural Effects: Mana
Ecology			
Molluscs and Crustaceans	**Regional or local depletion.**	• **Changes to the habitat parameters of molluscs and crustaceans affecting the viability of species in the lower harbour and along the North Coast.** • **Note(s) Species of importance include: Tuatua; Pipi; Pāua; Kina; Kōura (crayfish); Kōura Papatea (rock lobster); Kutai (green mussel); Cook's Turban; Cat's Eye; and Tio (oysters).**	• **Limitations on the customary and recreational gathering of molluscs and crustaceans within the harbour and along the North Coast.** • **Limitations on cultural practices including manaakitanga.** • **Economic impact on whānau engaged in commercial fishing.** • **Potential effects on whānau ora.**
Key Species: Flatfish/Flounder	**Regional or local depletion of flatfish / flounder populations.**	• **Loss of flatfish habitat.** • **Changes to the habitat parameters of flatfish affecting the viability of species in the lower harbour and along the North Coast. Note(s): Pātikitotara (yellow-belly flounder), pātiki (sand flounder, greenback flounder, NZ sole), pātikimohoao (black flounder), kutuhori, pātiki rore, pakeke (NZ sole).**	• **Limitations on the customary and recreational gathering of flatfish within the harbour and along the North Coast.** • **Limitations on cultural practices including manaakitanga.** • **Potential effects on whānau ora.**

		Cultural Effects	
Factor	**Potential Effects**	**Mauri**	**Mana**
Ecology			
Key Species: Fish	**Regional or local depletion of fish populations.** **Regional or local enhancement of specific fish populations, eg Blue Cod (Rāwaru).**	• **Changes to habitat parameters affecting the viability of species in the lower harbour and along the North Coast.** • **Potential enhancement of habitat for specific species, eg Blue Cod (Rāwaru).** • **Potential effects of dredging and the disposal of spoil on fishing sites at Rocky Point, Drivers Rock, Taiaroa Head and McGregors off Heyward Point.** • **Notes: i. Species commercially harvested by Ngāi Tahu Seafood include: Barracouta (Maka); Bluenose; Blue Cod (Rāwaru); Dory; Eels (Tuna); Groper (Hāpuku); Hake, Hoki, Ling (Hokarari); Monkfish, Orange Roughy, Sea Perch, Shark, Skate, Snapper, Sole, Spiny Dog, Squid, Tarakihi, Red Cod (Hoka); Warehou. ii. Other species of importance include Pawhaiwhakarua or Pau (wrasse); Blue and Red Moki; Inaka (whitebait); Kanakana; Kohikohi (Trumpeter); Mararī (Butterfish / Greenbone); and Gurnard.**	• **Potential changes in the customary take and cultural practices.** • **Potential for a change in the fish species targeted by recreational fishers (It is noted that the construction of a new fishing jetty will enhance recreational opportunities at Port Chalmers).** • **Economic impact on whānau engaged in commercial fishing.** • **Potential for reduced social or financial dividends from Te Rūnanga o Ngāi Tahu if species commercially harvested by Ngāi Tahu Seafood are adversely affected.** • **Potential effects both positive and negative on whānau ora.**

Factor	Potential Effects	Cultural Effects: Mauri	Cultural Effects: Mana
Ecology			
Invasive Species	**Potential for the introduction of invasive species that are not currently found in the Otago Harbour and along the North Coast**	• **Displacement of native kelp species by invasive species including Undaria.** • **Changes to the habitat parameters of key species of cultural value within the lower harbour and along the North Coast.**	• **Limitations on customary and recreational gathering within the Otago Harbour and along the North Coast.** • **Limitations on cultural practices including manaakitanga.** • **Economic impact on whānau engaged in commercial fishing.** • **Potential effects on whānau ora.**

Discussion [36]

Introduction

The ecological effects of Project Next Generation are documented in the Assessment of Environmental Effects and the technical reports, including *Ecological Environment and Assessment* (NIWA-James), *Off-Shore Ecology* (NIWA-Willis), *Harbour Ecology* (Benthic Science Ltd / Otago University), *Harbour Rocky Shores (*Benthic Science Ltd – Paavo), Te Rauone Latham Bay Ecology (Benthic Science Ltd – Paavo), *Bird Foraging* (NIWA-Sagar), and *Fisheries* (Boyd).

36 **Eco-Dynamic Systems Ltd (2009), Port Otago (2010)**

KTKO Ltd commissioned a review of the ecological research from Dr Terry Broad (Eco-Dynamic Systems Ltd)[37]. This review concluded that further information was required on the physical parameters of key species of importance to Kāi Tahu. Port Otago duly commissioned a supplementary paper to collate information covering the habitats, tolerances and potential effects and losses of populations of shellfish and fish.[38] Species of particular interest to Kāi Tahu include cockles (tuaki), pipi, tuatua, flatfish species, blue cod, various coastal fishes, rock lobster (crayfish) and paua.

Kelp Communities

Kelp communities exist in the harbour and offshore in rocky reef areas. Within the Lower Harbour rocky habitat at Kamau Taurua (Quarantine Island) and Rakiriri (Goat Island), the artificial groynes, and at the mole, will be subject to higher concentrations of silty water. In contrast, the hydrodynamic modelling concludes that the concentrations of fine silts dispersing to the North of the off-shore disposal site will be at very low concentrations, and within the levels experienced under natural conditions.

Seagrass Communities

The effects on seagrass are detailed within the *Ecological Environment and Assessment* (NIWA-James) report.

The Harbour is naturally turbid at times and communities are adapted to periods of high suspended sediment concentrations and low water clarity. The modelling indicates that sedimentation levels could reach over 1000 mg/l but only for short periods in the immediate vicinity of the main channel. The highest levels of sedimentation and turbidity predicted could have a moderate effect on seagrasses but this would be for less than 5% of the time and would be localised in extent. The communities would recover when dredging ceases.

[37] ***Project Next Generation Otago Harbour: A Review of Ecological Reports and Identification of Issues*, Eco-Dynamic Systems Ltd (2009). Refer to Appendix 4**
[38] **James, Boyd and Probert (2010). *Information on Key Species of Interest to Ngāi Tahu – Supplementary Paper for Next Generation Project***

Tuaki (Cockles)

The effects of Project Next Generation on Tuaki are discussed above at pages 43 – 44. In answer to the specific questions regarding cockles:

- **The inter-tidal habitat removed at Port Chalmers is 8,000m^2 in area, which is less than 0.15% of the lower harbour inter-tidal area between 0.0m and 1.0m above chart datum.**
- **Cockles in the directly affected area at Port Chalmers could be taken for recreational, cultural or scientific purposes before dredging commenced. However, while the directly affected cockles could be used as seed stock there is only a small quantity in this area.**
- **Port Otago is not aware of any direct relationship between the Otago Harbour cockles and cockle populations in Blueskin Bay or Waikouaiti.**
- **Port Otago are not aware that dredging was responsible for the depletion of the cockles in Lyttleton Harbour. However, it is understood that the re-seeding exercise in Lyttleton Harbour with Otago cockles has been quite successful.**

Fish

The Supplementary Report prepared for Kāi Tahu provides detailed background information on fish types, diet and habitats and on local populations. This report also discusses the tolerances of key species to dredged sediments.

Exposure of fishes to dredging and disposal will occur in pulses over the duration of the dredging programme. Fish are mobile and well able to take flight from the noise, disturbance, and high suspended sediment levels caused by dredging and by disposal events. Fishes can be expected to return to dredged areas as soon as the dredge ceases, to forage for benthic organisms exposed during dredging. When suspended sediment levels drop to levels they can tolerate fishes will also be attracted to the disposal site to forage for biota exposed in the dredged material.

Suspended sediment levels along the rocky shorelines of the open coast are expected to be very low at less than 3 milligrams per litre (mg/l). Similarly, the deposition of sediment is expected to be less than 0.5mm. These levels of sedimentation are much lower than occur during typical episodic storm events. Overall, the exposure of fishes to suspended sediments during the dredging and disposal programme will be short term compared to the longevity of the fish species of the area. Typical life spans of fishes, rock lobster and paua are from several years to decades.

Most fishes have egg and larval phases that last for up to several weeks. These larval stages, along with permanent zooplankton are generally adapted to episodic high levels of suspended sediments that occur in estuaries and harbours such as Otago Harbour. Experiments over two weeks with different zooplankton have shown that mortality is high at levels over 10,000 mg/l. In comparison, studies have not generally shown any significant impact at the levels of suspended sediment experienced from dredging and disposal (Clarke & Wilbur 2000). Egg distributions of Otago fish species (Robertson 1980) summarised in the supplementary paper shows that eggs of most species, including the main flatfish species, are widely distributed along the coast. The proposed dredging and disposal activity would affect a very small area of the overall egg distributions of these species.

Birds

Birds are well acclimatised to ship movements. Critical periods for birds include the main breeding season and the period prior to the migration of the Godwits in the Aramoana area during February / March.

Marine Mammals

Marine mammals are highly mobile and are likely to be unaffected. However, there should be further consideration of the critically endangered Hectors Dolphin. Dredging should occur during winter when Hectors Dolphins feed further offshore and away from the disposal area.

Exotic / Invasive Species

A number of exotic species occur in the harbour. It is unlikely that they will establish at the disposal site because of the lack of hard substrates, depth and exposure. Further, an international dredging vessel would be subject to strict scrutiny by Maritime New Zealand and MAF Biosecurity New Zealand.

Pre-dredge inspections are recommended before rock is removed, with appropriate management steps required if an exotic / invasive species is present.

Recommendations [39]

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
Ecology	1	Include cultural health indicators for key species of importance to Kāi Tahu in the monitoring programme.
	2	Monitor the effects on key indicator species within the Lower Harbour and the Blueskin Bay Estuary, including seagrass, tuaki and flat fish, before, during and after completion of capital dredging.
	3	Monitor the effects on key indicator species of importance to Kāi Tahu from Blueskin Bay to the Moeraki Peninsula, including the kelp beds between Warrington and Matanaka,

[39] Eco-Dynamic Systems Ltd (2009)

Issue(s)	No.	Recommendation
Ecology (*continued*)	**4**	**Provide Manawhenua with monitoring reports during and after completion of capital works.**
	5	**Develop environmental report cards for the Otago Harbour, Blueskin Bay Estuary, and the Otago Coast**
	6	**Consult Manawhenua to minimise the impact of dredging on the cultural gathering of kai moana.**
	7	**Proactively manage the risk posed by exotic / invasive species.**

7.2.5 Social Environment

Factor	Potential Effects	Cultural Effects: Mauri	Cultural Effects: Mana
Social Environment			
Otago Peninsula	Social effects of economic growth on the Otago Peninsula communities.	• Pressure on village communities and the Otago Peninsula landscape from economic growth.	• Limitations on the ability of Kāi Tāhu whānau to return to the Otago Peninsula communities. • Separation of Kāi Tahu whānau from Papatipu Rūnanga. • Adverse effects on whanaungatanga.[40] • Loss of cultural values • Potential effects on whānau ora.

Discussion[41]

The project and the economic role that Port Otago plays must be assessed in the wider context of the Otago region. Although there would be direct regional benefits from the project, the influence of the project itself can not isolated from general growth. The pressures on the Otago Peninsula communities from general economic growth are managed and dealt with by the Dunedin City Council and the Otago Regional Council.

Recommendation (s)

No further action is recommended.

[40] Whakawhanaungatanga in its broadest context may be defined as the interrelationship of Māori with their ancestors, their whanau, hapu and iwi.
[41] Port Otago Ltd (2010)

8. Conclusion

Ahakoa kia pā te upoko o Te moana-Tāpokopoko-a-Tāwhaki ki ngā takutai o Te Waka-o-Aoraki, Engari, i tākekea te kupenga a Tahu kia oioi i roto i te nekeneke o te tai

Although the shores of Te Waipounamu may be buffeted by the turbulent currents of the great waves of the southern oceans, the fishing net of Tahu has been made flexible so as to move at one with the tide. (*Source Maaire Goddall)*

Kāi Tahu Whānui are tangata whenua within Otago and have a responsibility as tangata tiaki (kaitiaki) of the environment to assess how Project Next Generation will impact upon their cultural values.

The Otago Harbour and Te Tai O Arai Te Uru (the Otago Coast) has a cultural and spiritual meaning for tangata whenua signified through layers of tradition, association and use, and reinforced by place names.

The coastal waters and processes were integral to the way of life that our tūpuna (ancestors) enjoyed, and are as important today for Waitaha, Kati Māmoe and Kāi Tahu.[42] The whole of the coastal area offered a bounty of Mahika Kāi, including a range of kaimoana (sea food), and marine and freshwater fish.

The centrality of Takaroa[43] in our cultural beliefs also influences the way we relate to and manage our marine resources. The marine environment is a moving force, a reminder of the power of Takaroa.

This cultural impact assessment ensures that the spiritual and cultural significance of the Otago Harbour and Te Tai o Arai Te Uru is recognised and provided for in the management of Project Next Generation. The outcomes of this assessment reflect an open and collaborative engagement between Manawhenua[44] and Port Otago Ltd over the effects of capital dredging.

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42 **Collectively referred to in this assessment as 'Kāi Tahu Whānui'**

43 **The atua or guardian spirit of all that lives in the sea**

44 **The Manawhenua Working Group included representatives from Te Rūnanga o Moeraki, Kāti Huirapa Rūnanga ki Puketeraki, Te Rūnanga o Ōtākou, East Otago Taiapure Management Committee, Korako Karetai Trust, and the Karaitiana, RL Karaitiana & Taituha Trust (Refer to Appendix 2).**

The assessment benefited from the ecological review undertaken by Eco-Dynamic Systems Ltd, the technical advice provided by Port Otago's consultants, and from the peer review of the final report by Dr Gail Tipa.

The assessment concludes that monitoring and a flexible dredging programme is required to ensure that the Otago Harbour and Te Tai o Arai Te Uru is healthy and will continue to support Kāi Tahu ki Otago customs. Specifically, monitoring of the effects of dredging on key species and ecosystems of importance to Kāi Tahu, including tuaki, flat fish, seagrass and kelp, is a recommendation of this assessment.

The recommendations of this assessment are set out in full in Section 9.

Finally, it is noted that Project Next Generation offers an opportunity for Manawhenua to work in partnership with Port Otago Ltd in managing the effects of port activities, and of maintenance and capital dredging, on the cultural and spiritual values of the Otago Harbour and Te Tai O Arai Te Uru (the Otago Coast).

Spit Beach and Heyward Point

9. Recommendations

9.1 General

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
General	**1**	**Commission an independent audit of the Lower Harbour and Off-Shore hydrodynamic modelling.**
Manawhenua Consultation Group	**2**	**Establish a Manawhenua Consultation Group.** **Notes (s): The role of the Manawhenua Consultation Group, subject to negotiation with Port Otago Ltd, may include:** **a. Facilitating consultation between Manawhenua and Port Otago Ltd during the Capital Dredging Project.** **b. Providing Manawhenua input into the design of the monitoring programme, including the development of cultural health indicators for key species of importance to Kāi Tahu.** **c. Reviewing monitoring reports during and after completion of the capital monitoring programme. Technical expertise should be made available to interpret the monitoring data.** **d. Identifying methods to avoid, remedy or mitigate the adverse effects of Project Next Generation on the cultural values, interests, and associations of Manawhenua with the Otago Harbour and Te Tai o Arai Te Uru (Otago Coastal Marine Area).**

Issue(s)	No.	Recommendation
Communication	3	Develop environmental report cards for the Otago Harbour, Blueskin Bay Estuary, and the Otago Coast.

9.2 Hydrodynamic

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
Tidal Range and Tidal Currents	4	Monitor changes to the tidal range and to tidal currents within the Lower Harbour during and after completion of the capital dredging project.

9.3 Physical Coastal Environment

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
Beach and Near Shore Profiles	5	Monitor beach and near shore profiles at Shelly Beach, Aramoana, Pilots Beach, Te Rauone Beach, and Omate Beach before, during and after completion of the capital dredging project.
Public Safety	6	Install signs on beaches and boat ramps to advise the public of the risks associated with passing vessels.

Issue(s)	No.	Recommendation
Public Safety (*continued*)	**7**	**Advise Kāti Huirapa Rūnanga ki Puketeraki and Te Rūnanga o Ōtākou of scheduled vessel arrivals.**

9.4 Sedimentation

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
Turbidity and Sedimentation[45]	**8**	**Monitor the sediment plume from the dredging operation and from the off-shore disposal of dredged material.**
	9	**Monitor turbidity and sedimentation at Acheron, Pulling and Tayler Points, Aramoana, off the Otago Peninsula from Harwood to Te Rauone Bay, and along the North Coast from Blueskin Bay to the Moeraki Peninsula, before, during and after completion of capital dredging.**
Contamination	**10**	**Undertake ongoing testing of the material dredged from the Swinging Basin for contamination.**

[45] **The Dredging Environmental Management Plan (Port Otago) should direct changes to the dredge routine where turbidity and sedimentation exceed the environmental limits for key species of importance to Kāi Tahu, including tuaki (cockles) and pipi.**

9.5 Ecology

It is recommended that Port Otago Ltd:

Issue(s)	No.	Recommendation
Ecology	**11**	**Monitor the effects of dredging on key indicator species within the Lower Harbour and the Blueskin Bay Estuary, including seagrass, tuaki and flat fish, before, during and after completion of capital dredging.**
	12	**Monitor the effects of dredging and off-shore deposition on key indicator species of importance to Kāi Tahu from Blueskin Bay to the Moeraki Peninsula, including the kelp beds between Warrington and Matanaka, before, during and after completion of capital dredging.**
	13	**Provide Manawhenua with monitoring reports during and after completion of capital works.**
	14	**Consult Manawhenua to minimise the impact of dredging on the cultural gathering of kai moana.**
	15	**Proactively manage the risk posed by exotic / invasive species.**

Appendix 1 References

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Appendix 2: Manawhenua Working Group

Manawhenua Working Group

<u>Manawhenua Representatives</u>

Te Rūnanga o Moeraki	**Dr Gail Tipa**
Kāti Huirapa Rūnanga ki Puketeraki	**Dr Terry Broad, Joy Smith, Phyllis Smith**
Te Rūnanga o Ōtākou	**Edward Ellison, Hoani Langsbury**
East Otago Taiapure Management Committee	**Brendan Flack**
Karaitiana, RL Karaitiana & Taituha Trust	**Natalie and Paul Karaitiana, Gail Thompson**
Korako Karetai Trust	**Robert Coote**

<u>KTKO Consultancy Ltd</u>

Tim Vial	**Resource Management Planner**

Appendix 3: Statutory Acknowledgements

Ngāi Tahu Claims Settlement Act - Schedule 97

Statutory Acknowledgement for Taonga Species

The Crown acknowledges the cultural, spiritual, historic, and traditional association of Ngāi Tahu with the taonga species

Birds

Name in Māori	Name in English	Scientific Name
Hoiho	**Yellow-eyed penguin**	***Megadyptes antipodes***
Kāhu	**Australasian harrier**	***Circus approximans***
Kākā	**South Island kākā**	***Nestor meridionalis meridionalis***
Kākāpō	**Kākāpō**	***Strigops habroptilus***
Kākāriki	**New Zealand parakeet**	***Cyanoramphus spp.***
Kakaruai	**South Island robin**	***Petroica australis australis***
Kaki	**Black stilt**	***Himantopus novaezelandiae***
Kāmana	**Crested grebe**	***Podiceps cristatus***
Kārearea	**New Zealand falcon**	***Falco novaeseelandiae***
Karoro	**Black backed gull**	***Larus dominicanus***
Kea	**Kea**	***Nestor notabilis***
Kōau	**Black shag**	***Phalacrocorax carbo***
	Pied shag	***Phalacrocorax varius varius***
	Little shag	***Phalacrocorax melanoleucos brevirostris***
Koekoeā	**Long-tailed cuckoo**	***Eudynamys taitensis***
Kōparapara or Korimako	**Bellbird**	***Anthornis melanura melanura***
Kororā	**Blue penguin**	***Eudyptula minor***
Kōtare	**Kingfisher**	***Halcyon sancta***
Kōtuku	**White heron**	***Egretta alba***
Kōwhiowhio	**Blue duck**	***Hymenolaimus malacorhynchos***
Kūaka	**Bar-tailed godwit**	***Limosa lapponica***
Kūkupa/Kererū	**New Zealand wood pigeon**	***Hemiphaga novaeseelandiae***

Name in Māori	Name in English	Scientific Name
Kuruwhengu/Kuruwhengi	New Zealand shoveller	*Anas rhynchotis*
Mātā	Fernbird	*Bowdleria punctata punctata and Bowdleria punctata stewartiana and Bowdleria punctata wilsoni and Bowdleria punctata candata*
Matuku moana	Reef heron	*Egretta sacra*
Miromiro	South Island tomtit	*Petroica macrocephala macrocephala*
Miromiro	Snares Island tomtit	*Petroica macrocephala dannefaerdi*
Mohua	Yellowhead	*Mohoua ochrocephala*
Pākura/Pūkeko	Swamp hen/Pūkeko	*Porphyrio porphyrio*
Pārera	Grey duck	*Anas superciliosa*
Pateke	Brown teal	*Anas aucklandica*
Pīhoihoi	New Zealand pipit	*Anthus novaeseelandiae*
Pīpīwharauroa	Shining cuckoo	*Chrysococcyx lucidus*
Pīwakawaka	South Island fantail	*Rhipidura fuliginosa fuliginosa*
Poaka	Pied stilt	*Himantopus himantopus*
Pokotiwha	Snares crested penguin	*Eudyptes robustus*
Pūtakitaki	Paradise shelduck	*Tadorna variegata*
Riroriro	Grey warbler	*Gerygone igata*
Roroa	Great spotted kiwi	*Apteryx haastii*
Rowi	Ōkārito brown kiwi	*Apteryx mantelli*
Ruru koukou	Morepork	*Ninox novaeseelandiae*
Tākāhe	Tākāhe	*Porphyrio mantelli*
Tara	Terns	*Sterna spp.*
Tawaki	Fiordland crested penguin	*Eudyptes pachyrhynchus*
Tete	Grey teal	*Anas gracilis*
Tieke	South Island saddleback	*Philesturnus carunculatus carunculatus*

Name in Māori	Name in English	Scientific Name
Titi	**Sooty shearwater/ Muttonbird/Hutton's shearwater**	***Puffinus griseus and Puffinus huttoni and***
	Common diving petrel	***Pelecanoides urinatrix and***
	South Georgian diving petrel	***Pelecanoides georgicus and***
	Westland petrel	***Procellaria westlandica and***
	Fairy prion	***Pachyptila turtur and***
	Broad billed prion	***Pachyptila vittata and***
	White-faced storm petrel	***Pelagodroma marina and***
	Cook's petrel	***Pterodroma cookii and***
	Mottled petrel	***Pterodroma inexpectata***
Tititipounamu	**South Island rifleman**	***Acanthisitta chloris chloris***
Tokoeka	**South Island brown kiwi**	***Apteriyx australis***
Toroa	**Albatrosses and Mollymawks**	***Diomedea spp.***
Toutouwai	**Stewart Island robin**	***Petroica australis rakiura***
Tūī	**Tūī**	***Prosthemadera novaeseelandiae***
Tutukiwi	**Snares Island snipe**	***Coenocorypha aucklandica huegeli***
Weka	**Western weka**	***Gallirallus australis australis***
Weka	**Stewart Island weka**	***Gallirallus australis scotti***
Weka	**Buff weka**	***Gallirallus australis hectori***

Plants

Name in Māori	Name in English	Scientific Name
Akatorotoro	White Rata	*Metrosideros perforata*
Aruhe	Fernroot (bracken)	*Pteridium aquilinum var. esculentum*
Harakeke	Flax	*Phormium tenax*
Horoeka	Lancewood	*Pseudopanax crassifolius*
Houhi	Mountain ribbonwood	*Hoheria lyalli and H glabata*
Kahikatea	Kahikatea / White pine	*Dacrycarpus dacrydioides*
Kāmahi	Kāmahi	*Weinmannia racemosa*
Kānuka	Kānuka	*Kunzia ericoides*
Kāpuka	Broadleaf	*Griselinia littoralis*
Karaeopirita	Supplejack	*Ripogonum scandens*
Karaka	New Zealand laurel/Karaka	*Corynocarpus laevigata*
Karamū	Coprosma	*Coprosma robusta, Coprosma lucida, Coprosma foetidissima*
Kātote	Tree fern	*Cyathea smithii*
Kiekie	Kiekie	*Freycinetia baueriana subsp.banksii*
Kōhia	NZ Passionfruit	*Passiflora tetranda*
Korokio	Korokio Wirenetting bush	*Corokia cotoneaster*
Koromiko/Kōkōmuka	Koromiko	*Hebe salicfolia*
Kōtukutuku	Tree fuchsia	*Fuchsia excorticata*
Kōwahi Kōhai	Kōwahi	*Kowhai Sophora microphylla*
Mamaku	Tree fern	*Cyathea medullaris*
Mānia	Sedge	*Carex flagellifera*
Mānuka Kahikātoa	Tea-tree	*Leptospermum scoparium*
Māpou	Red Matipo	*Myrsine australis*
Mataī	Mataī / Black Pine	*Prumnopitys taxifolia*
Miro	Miro/Brown pine	*Podocarpus ferrugineus*
Ngaio	Ngaio	*Myoporum laetum*
Nīkau	New Zealand palm	*Rhopalostylis sapida*
Pānako	(Species of fern)	*Asplenium obtusatum*

Name in Māori	Name in English	Scientific Name
Pānako	**(Species of fern)**	***Botrychium australe and B. biforme***
Pātōtara	**Dwarf mingimingi**	***Leucopogon fraseri***
Pīngao	**Pīngao**	***Desmoschoenus spiralis***
Pōkākā	**Pōkākā**	***Elaeocarpus hookerianus***
Ponga/Poka	**Tree fern**	***Cyathea dealbata***
Rātā	**Southern rātā**	***Metrosideros umbellata***
Raupō	**Bulrush**	***Typha angustifolia***
Rautāwhiri/Kōhūhū	**Black matipo/Māpou**	***Pittosporum tenuifolium***
Rimu	**Rimu/Red pine**	***Dacrydiumcypressinum***
Rimurapa	**Bull kelp**	***Durvillaea antarctica***
Taramea	**Speargrass, spaniard**	***Aciphylla spp.***
Tarata	**Lemonwood**	***Pittosporum eugenioides***
Tawai	**Beech**	***Nothofagus spp.***
Tētēaweka	**Muttonbird scrub**	***Olearia angustifolia***
Ti rākau/Ti Kōuka	**Cabbage tree**	***Cordyline australis***
Tikumu	**Mountain daisy**	***Celmisia spectabilis and C semicordata***
Titoki	**New Zealand ash**	***Alectryon excelsus***
Toatoa	**Mountain Toatoa, Celery pine**	***Phyllocladus alpinus***
Toetoe	**Toetoe**	***Cortaderia richardii***
Tōtara	**Tōtara**	***Podocarpus totara***
Tutu	**Tutu**	***Coriaria spp.***
Wharariki	**Mountain flax**	***Phormium cookianum***
Whīnau	**Hīnau**	***Elaeocarpus dentatus***
Wī	**Silver tussock**	***Poa cita***
Wīwī	**Rushes**	***Juncus all indigenous Juncus spp. and J. maritimus***

Marine Mammals

Name in Māori	Name in English	Scientific Name
Ihupuku	**Southern elephant seal**	**Mirounga leonina**
Kekeno	**New Zealand fur seals**	**Arctocephalus forsteri**
Paikea	**Humpback whales**	**Megaptera novaeangliae**
Parāoa	**Sperm whale**	**Physeter macrocephalus**
Rāpoka / Whakahao	**New Zealand sea lion / Hooker's sea lion**	**Phocarctos hookeri**
Tohorā	**Southern right whale**	**Balaene australis**

Ngāi Tahu Claims Settlement Act - Schedule 98

Statutory Acknowledgement for Taonga Fish Species

The Crown acknowledges the cultural, spiritual, historic, and traditional association of Ngāi Tahu with the taonga fish species listed in Part A below.

Part A
Taonga Fish Species

Name in Māori	Name in English	Scientific Name
Kāeo	Sea tulip	*Pyura pachydermatum*
Koeke	Common shrimp	*Palaemon affinis*
Kōkopu/Hawai	Giant bully	*Gobiomorphus gobioides*
Kōwaro	Canterbury mudfish	*Neochanna burrowsius*
Paraki/Ngaiore	Common smelt	*Retropinna retropinna*
Piripiripōhatu	Torrentfish	*Cheimarrichthys fosteri*
Taiwharu	Giant kōkopu	*Galaxias argenteus*

Part B
Shellfish Species

Name in Māori	Name in English	Scientific Name
Pipi/Kākahi	Pipi	*Paphies australe*
Tuaki	Cockle	*Austrovenus stutchburgi*
Tuaki / Hākiari / Kuhakuha Pūrimu	Surfclam	*Dosinia anus, Paphies donacina, Mactra discor, Mactra murchsoni, Spisula aequilateralis, Basina yatei,* or *Dosinia subrosa*
Tuatua	Tuatua	Paphies subtriangulata, Paphies donacina
Waikaka / Pupu	Mudsnail	Amphibola crenata, Turbo smaragdus, Zedilom spp

Ngāi Tahu Claims Settlement Act Schedule 103

Statutory Acknowledgement for Te Tai O Arai Te Uru (Otago Coastal Marine Area)

Specific Area

The statutory area to which this statutory acknowledgement applies is Te Tai o Arai Te Uru (the Otago Coastal Marine Area), the Coastal Marine Area of the Moeraki, Dunedin Coastal and Molyneaux constituencies of the Otago region, as shown on SO Plans 24250, 24249, and 24252, Otago Land District and as shown on Allocation Plan NT 505 (SO 19901).

Under section 313, the Crown acknowledges Te Rünanga o Ngāi Tahu's statement of Ngāi Tahu's cultural, spiritual, historic, and traditional association to Te Tai o Arai Te Uru as set out below.

Ngāi Tahu Association with Te Tai o Arai Te Uru

The formation of the coastline of Te Wai Pounamu relates to the tradition of Te Waka o Aoraki, which foundered on a submerged reef, leaving its occupants, Aoraki and his brothers, to turn to stone. They are manifested now in the highest peaks in the Ka Tiritiri o Te Moana (the Southern Alps). The bays, inlets, estuaries and fiords which stud the coast are all the creations of Tu Te Rakiwhanoa, who took on the job of making the island suitable for human habitation.

The naming of various features along the coastline reflects the succession of explorers and iwi (tribes) who travelled around the coastline at various times. The first of these was Maui, who fished up the North Island, and is said to have circumnavigated Te Wai Pounamu. In some accounts the island is called Te Waka a Maui in recognition of his discovery of the new lands, with Rakiura (Stewart Island) being Te Puka a Maui (Maui's anchor stone). A number of coastal place names are attributed to Maui, particularly on the southern coast.

The great explorer Rakaihautu travelled overland along the coast, identifying the key places and resources. He also left many place names on prominent coastal features. Another explorer, Tamatea, sailed along the Otago coast in the waka Täkitimu. After the waka eventually broke its back off the coast of Murihiku, Tamatea and the survivors made their way overland back to the North Island, arriving at the coast by the place Tamatea named O-amaru (Öamaru).

Place names along the coast record Ngāi Tahu history and point to the landscape features which were significant to people for a range of reasons. For example, some of the most significant rivers which enter the coastal waters of Otago include: Waitaki, Kakaunui, Waihemo (Shag), Waikouaiti, Kaikarae (Kaikorai), Tokomairiro, Mata-au (Clutha), Pounawea (Catlins). Estuaries include: Waitete (Waitati), Ōtākou (Otago), Makahoe (Papanui Inlet), Murikauhaka (Mate-au and Koau estuaries), Tahaukupu (Tahakopa estuary), Waipātiki (Wapati Estuary). Islands in the coastal area include Okaihe (St Michaels Island), Moturata (Taieri Island), Paparoa, Matoketoke, Hakinikini, and Aonui (Cooks Head).

Particular stretches of the coastline also have their own traditions. The tradition of the waka (canoe) Arai Te Uru and its sinking at the mouth of the Waihemo (Shag River) has led to the coastal area of Otago being known as Te Tai o Araiteuru (the coast of Arai Te Uru). Accounts of the foundering, the wreckage, and the survivors of this waka are marked by numerous landmarks almost for the length of the Otago coast. The boulders on Moeraki coast (Kai Hinaki) and the Moeraki pebbles are all associated with the cargo of gourds, kumara and taro seed which were spilled when the Arai Te Uru foundered.

For Ngāi Tahu, traditions such as these represent the links between the cosmological world of the gods and present generations. These histories reinforce tribal identity and solidarity, and continuity between generations, and document the events which shaped the environment of Te Wai Pounamu and Ngāi Tahu as an iwi.

Because of its attractiveness as a place to establish permanent settlements, including pā (fortified settlements), the coastal area was visited and occupied by Waitaha, Ngati Mämoe and Ngāi Tahu in succession, who, through conflict and alliance, have merged in the whakapapa (genealogy) of Ngāi Tahu whänui. Battle sites, urupā and landscape features bearing the names of tüpuna (ancestors) record this history. Prominent headlands, in particular, were favoured for their defensive qualities and became the headquarters for a succession of rangatira and their followers. Notable pā on the Otago coast include: Makotukutuku (Öamaru), Te Raka-a-hineatea (Moeraki), Te Pā Katata, Pā a Te Wera, (Huriawa Peninsula), Mapoutahi (Purakaunui), Pukekura (Taiaroa Head), Moturata (Taieri Island). The estuaries from the Waitaki River to the Chaslands also supported various hapu.

Tüpuna such as Waitai, Tukiauau, Whaka-taka-newha, Rakiiamoa, Tarewai, Maru, Te Aparangi, Taoka, Moki II, Kapo, Te Wera, Tu Wiri Roa, Taikawa, Te Hautapanuiotu among the many illustrious ancestors of Ngati Mämoe and Ngāi Tahu lineage whose

feats and memories are enshrined in the landscape, bays, tides and whakapapa of Otago.

The results of the struggles, alliances and marriages arising out of these migrations were the eventual emergence of a stable, organised and united series of hapu located at permanent or semi-permanent settlements along the coast, with an intricate network of mahika kai (food gathering) rights and networks that relied to a large extent on coastal resources. Chiefs such as Korako (several), Tahatu, Honekai, Ihutakuru, Karetai, Taiaroa, Potiki, Tuhawaiki, and Pokene being some among a number who had their own villages and fishing grounds. Otago Peninsula (Muaupoko) had many kaunga nohoanga with a multitude of hapu occupying them. At one time up to 12 kainga existed in the lower Otago harbour, some larger and more important than others.

The whole of the coastal area offered a bounty of mahika Käi, including a range of kaimoana (sea food); sea fishing; eeling and harvest of other freshwater fish in lagoons and rivers; marine mammals providing whale meat and seal pups; waterfowl, sea bird egg gathering and forest birds; and a variety of plant resources including harakeke (flax), fern and ti root. In many areas the reliance on these resources increased after the land sales of the 1840s and 1850s, and the associated loss of access to much traditional land-based mahika kai.

Many reefs along the coast are known by name and are customary fishing grounds, many sand banks, channels, currents and depths are also known for their kaimoana. One example is Poatiri (Mt Charles — Cape Saunders) the name of which refers to a fish hook. Poatiri juts out into the Pacific, close to the continental shelf, and is a very rich fishing ground. Another example is Blueskin Bay which was once a kohanga (breeding ground) for the right whale, although it is well over 150 years since it has seen this activity.

Other resources were also important in the coastal area. Paru (black mud used for dying) was obtained from some areas. Some of the permanent coastal settlements, such as those at the mouth of the Mata-au (Clutha River), and at Ōtākou and Purakaunui, were important pounamu manufacturing sites. Trading between these villages to the south and north via sea routes was an important part of the economy.

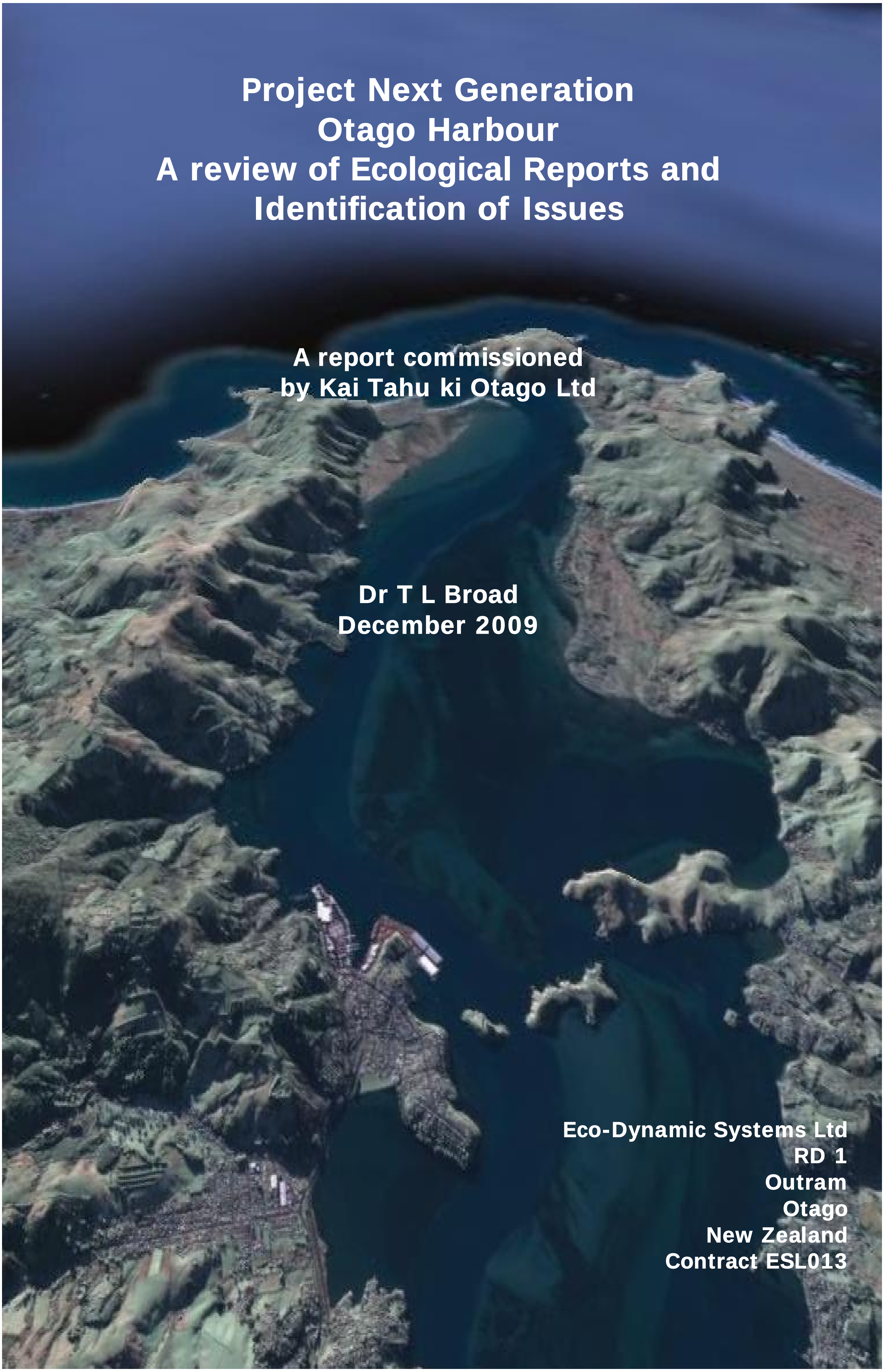
The Otago coast was also a major highway and trade route, particularly in areas where travel by land was difficult. Pounamu and titi were traded north with kumara, taro, waka, stone resources and carvings coming south. Travel by sea between settlements and hapu was common, with a variety of different forms of waka, including the southern waka hunua (double-hulled canoe) and, post-contact, whale

boats plying the waters continuously. Hence tauranga waka (landing places) occur up and down the coast in their hundreds and wherever a tauranga waka is located there is also likely to be a nohoanga (settlement), fishing ground, kaimoana resource, rimurapa (bull kelp — used to make the poha, in which titi were and still are preserved) with the sea trail linked to a land trail or mahika kai resource. The tüpuna had a huge knowledge of the coastal environment and weather patterns, passed from generation to generation. This knowledge continues to be held by whänau and hapu and is regarded as a taonga. The traditional mobile lifestyle of the people led to their dependence on the resources of the coast.

Numerous urupā are being exposed or eroded at various times along much of coast. Water burial sites on the coast, known as waiwhakaheketupapaku, are also spiritually important and linked with important sites on the land. Places where kaitangata (the eating of those defeated in battle) occurred are also wähi tapu. Urupā are the resting places of Ngāi Tahu tüpuna and, as such, are the focus for whänau traditions. These are places holding the memories, traditions, victories and defeats of Ngāi Tahu tüpuna, and are frequently protected in secret locations.

The mauri of the coastal area represents the essence that binds the physical and spiritual elements of all things together, generating and upholding all life. All elements of the natural environment possess a life force, and all forms of life are related. Mauri is a critical element of the spiritual relationship of Ngāi Tahu whänui with the coastal area.

Appendix 4: Eco-Dynamic Systems Ltd: Project Next Generation – Otago Harbour: A Review of Ecological Reports and Identification of Issues



Project Next Generation
Otago Harbour
A review of Ecological Reports and Identification of Issues

A report commissioned by Kai Tahu ki Otago Ltd

Dr T L Broad
December 2009

Eco-Dynamic Systems Ltd
RD 1
Outram
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Contract ESL013

Limitation of Liability

This report has been prepared for the sole benefit of Kai Tahu Ki Otago Ltd. in relation to this specific commission. Eco-Dynamic Systems Ltd accepts no liability with respect to its use by any other party or for any other purpose.

The interpretation and professional advice presented herein is based on the factual information available at the time of compilation. In the event of further information becoming available, the interpretation and professional advice must be subject to review.

Executive Summary

In response to the ever increasing size of shipping arriving at Port Chalmers, Port Otago intend to deepen and widen the main channel and enlarge the turning basin at Port Chalmers. Port Otago have named the programme 'Project Next Generation'. This will require a substantial dredging programme of capital works. To ascertain the effects that such an operation may have on the adjacent environment, Port Otago have completed a comprehensive research programme including macro benthos, fish, bird, mammal, and geophysical investigations.

The aim of this work was to review the ecological reports commissioned by Port Otago for Project Next Generation and to scope the issues for Manawhenua.

Primary adverse effects of dredging and dredge waste dumping are of a physical nature and can include complete loss of habitat and change to others. Although of a physical nature, these effects have the potential to influence and change the biota, which are supported by the physical environment. These are secondary effects associated with dredging through action of the primary effects outlined above.

7.1 million cubic metres of material will be dredged from the channel during a period of 4 to 6 months in total (about 120 days). Channel depth will be increased from about 13 metres below chart datum to16 metres in the swinging basin at Port Chalmers, and to 17.5 metres at the channel entrance. On average the base of the channel will be widened by 22.4 metres. Generally, readjustment of the batter slopes will be within the existing slope alignment and will not change sub tidal grades that are less than 5 metres below chart datum. In two locations, along the Aramoana side of Harrington Bend, and from opposite Deborah Bay to the swinging basin, realignment of the batters will impinge into shallower waters and the intertidal zone.

The ecological studies endeavoured to address all issues and potential effects of the dredging programme. In part they did this well but the harbour ecological studies did not address all the issues and potential effects of dredging. What is required to assess the impacts of dredging is a well defined set of physical features that define different broad habitat types that support different assemblages of flora and fauna. This is important because without good quantitative data it is very difficult to assess potential changes that may result from the dredging activity.

The Offshore macro benthos study was structured well. Sediment characteristics of grade and organic content were examined in detail. Current velocity was also measured and modelled and depth recorded at 96 randomly located sampling sites. More than 15,000 individual

animals in 120 taxa were recovered from grab samples. Depth and type of sediment appeared to be the main determinant of faunal groupings. Overall, the density of benthic invertebrates was lowest in the centre of Blueskin Bay where the silt content of the sediment was higher than elsewhere. Density and diversity of benthic invertebrates were highest just north of the Otago Harbour entrance. The fauna was typical of near shore sand zones with no rare or unique species were observed.

In contrast the harbour study was not designed well. Physical parameters were not quantitatively measured but were categorised (visually) into 11 habitat types. Unfortunately these categories were a confused mix of physical and biological characteristics. Also macro biota, especially shellfish, was poorly surveyed. 665 benthic photographs, 127 benthic grab samples and 25 core samples (from Aramoana) were collected. Over 33,000 animals were identified from 190 invertebrate taxa. The soft sediment community was dominated by amphipods and molluscs. A small patch of horse mussels were found near Wellers Rock. Oysters were discarded from grab samples believing that they were somehow accidentally caught, not realising that although common on rocks, oyster beds are also present in the harbour. The 125 mm diameter corer used on the Aramoana sand flats failed to locate the 10 to 15 tonnes of tuaki and small beds of tuatua and pipi that are reputed to be located in that area. Considering the the inherent limitations of the habitat categories, it was not surprising that the analysis did not find any association between any species and habitat category. Fortunately, the sediment samples were retained and so further work will resolve the problem.

There are relatively few rocky shores in the harbour. Surveys were carried out at Quarantine Island, Rocky Point, Acheron Point, and Pulling Point. Typical intertidal and subtidal zonation patterns were evident at all sites and no particularly rare or unusual species or communities were identified. Hard rock surfaces adjacent to Acheron and Pulling Points will have to be excavated. If the rock proves to hard for a backhoe excavator, some blasting may have to be completed. Port Otago Ltd. has previous experience with this method which includes keeping a good lookout for marine mammals and not blasting if any risk is present.

Populations of key fish and shellfish species including their habitats and diets were not identified and the information was not associated with the macro benthic data. The selection of key species should include species indicative of different habitat types, both specialists and generalists; species important to customary, recreational, and commercial fishers; and species that are specifically important to Ngai Tahu Whanau. By establishing potential effects on a small but comprehensive list of species, the study may be considered as indicative of potential effects on most, but not all, fish species. The fish study was a desk top procedure that focussed on catch return data but did not attempt to determine the impact that dredging may have on any species. Further work will be required to resolve this issue.

Although brief, the bird study appeared to be adequate. Birds were well acclimatised to ship movements. Except for roosting islands adjacent to the swinging basin which maybe at risk, as long as the dredging programme occurs during the winter, bird populations are unlikely to be effected.

Marine mammals are highly mobile and are likely to be unaffected. However, further consideration of Hectors Dolphin which is critically endangered should be considered. Dredging should occur during winter when this animal feeds further offshore and away from the disposal area.

Suspended sediments and sedimentation are the most obvious adverse effect of dredging. Comprehensive sediment modelling analysis was completed and predicted that except for areas adjacent to the dredging and disposal sites, suspended sediment concentrations are likely to be well within the normal background range. These levels have been shown to have little effect on fish eggs, larvae or adults. In the immediate area at the dredging and disposal sites, suspended sediment concentrations are predicted to be relatively high but short term in duration and below levels that would effect fish.

Sedimentation modelling predicted that for most areas in the harbour, daily sedimentation rates would be less than 0.1 mm and many areas would experience no sedimentation. Only in some locations immediately adjacent to the channel were higher levels predicted. However, these were still generally below 1.7 mm. There is potential that in some small and discrete areas with environmental variables outside those used in the model, sedimentation could be higher. At the disposal site, sediments will smother the benthos. However, no unique or special communities exist at the site and the area will be recolonised from outside the area.

A number of exotic species occur in the harbour. It is unlikely that they will establish at the disposal site because of the lack of hard substrates, depth and exposure.

Core samples from 43 locations within the existing channel were collected and analysed for contaminants. Testing showed the materials to be dredged were not contaminated.

A comprehensive monitoring programme should be developed to measure the actual effects of the dredging programme and compare these with the estimated effects. Also, this programme should be able to identify impacts that are beyond those predicted as they occur during dredging. Dredging method can then be altered to reduce the impact.

With the completion of the harbour benthic study, fish and shellfish studies, quantified tuaki bed loss, and development of a monitoring programme, Port Otago will have addressed the ecological issues, and the potential impacts of the channel widening and deepening programme on flora and fauna, for Kāi Tahu Whānui.

Contents

1.0 Introduction

In response to the ever increasing size of shipping arriving at Port Chalmers, Port Otago intend to deepen and widen the main channel and enlarge the turning basin at Port Chalmers. Port Otago have named the programme 'Project Next Generation'. This will require a substantial dredging programme of capital works. To ascertain the effects that such an operation may have on the adjacent environment, Port Otago have completed a comprehensive research programme including macro benthos, fish, bird, marine mammal, and geophysical investigations.

To assist Ngai Tahu Whanui in their response to Project Next Generation, Kai Tahu Ki Otago Ltd contracted Dr Terry Broad through his business Eco-Dynamic Systems Ltd. to complete an advisory report.

The aim of the work was to:

- **Review the ecological reports commissioned by Port Otago,**
- **Scope the issues for Manawhenua from Project Next Generation, and**
- **Prepare this report.**

A thorough review, as best as could be achieved during the time available, of the Port Otago's environmental reports was completed. Lincoln Coe, General Manager Infrastructure for Port Otago Ltd., was contacted several times for clarification of information and to this end he provided additional reports and papers. Further information was obtained through computer web searches. Concise summaries of Port Otago's reports are provided so readers are not required to refer to source documents. The resulting document is able to be read as a stand alone document.

Section Two of this report briefly outlines the effects that dredging may have on the environment and how these effects can be divided into primary and secondary processes. Primary effects are those directly caused by a dredging operation on physical habitats. Secondary effects are the changes to animal and plant communities influenced by the change in the physical habitat.

Section Three deals with the environmental reports of work carried on behalf of Port Otago. Firstly however, it was vital to highlight fish and shellfish species that have been identified as important to Ngai Tahu. A small number of key species were selected to determine the potential adverse effects at this ecological level. Some of the reports focused on one particular topic while others combined a number of related topics. Therefore, subsections are

used to discuss the topics of Physical Habitat Parameters, Macro Benthos, Fish, Marine Mammals, and Birds.

Although the biological reports were the initial focus, it quickly became apparent that changes to physical habitats were the potential result of the proposed dredging programme and therefore much of this review is directed to the physical processes rather than only biological. This is a reasonable approach considering ecology is the science of the relationships between organisms and their environments and considers both biotic and abiotic aspects.

Section Four outlines the dredging operation and considers geotechnical design. The focus of this section is identifying intertidal and shallow sand flat areas that could potentially be affected by the dredging process and to consider the stability of the designed channel batter slopes.

Section Five considers the potential physical effects of the dredging programme in the Harbour and Offshore. It examines the key species and then using a matrix identifies significant issues.

Outstanding issues and recommendations are discusses in Section Six and a Concluding Section ends the report.

2.0 Potential Effects Of Dredging And Dredge Waste Disposal

Primary adverse effects of dredging and dredge waste dumping are of a physical nature and can include complete loss of habitat and change to others. The following factors are examples of physical effects and will be used to evaluate the effect of dredging on the physical environment.

Discharge of sediment into the water column leading to:

- **Increased suspended solid concentrations**
- **Reducing water clarity and sunlight penetration**
- **Increased sediment deposition or sedimentation**
- **Release of contaminants**

Channel widening leading to:

- **Loss of intertidal and sub tidal habitats**
- **Channel wall slips and slumps**
- **Channel wall batter regrading through surface erosion**
- **Effects of blasting**

Hydrological changes leading to:

- **Erosion**
- **Deposition**
- **Increased velocity leading to increased mean sediment grain size**
- **Decreased velocity leading to reduced mean sediment grain size**

Although of a physical nature, these effects have the potential to influence and change the biota that are supported by the physical environment through changes to that environment which are beyond the extremes that a species can survive. These are secondary effects associated with dredging through action of the primary effects outlined above.

3.0 Review Of Ecological Reports

3.1 Identification Of Key Species

At the outset, the high profile fish and shellfish species that are highly valued by various groups should be identified. Most people are likely to show little interest in some obscure and little known invertebrate. However, although the great abundance and diversity of the macro benthos is highly valued by ecologists and others, it is also the component of the marine environment that supports healthy and sustainable fisheries. Therefore, determining if the dredging programme will have adverse effects can be approached from two positions. From the ecologist's perspective, determining potential changes to the environment and the resulting impacts at the base of the food chain, or from the fisher's perspective, understanding the impacts on a few key fish species at the upper end of the food chain.

Ngai Tahu has more than five hundred years of association with the Otago Harbour and offshore fisheries. Boyd (2008) identified tuaki were highly important, as were flounder, rock lobster, paua and kina. Results from interviews (provided by Kai Tahu ki Otago Ltd) with Ngai Tahu members additionally identified blue cod, greenbone, hapuka, sea perch, gurnard, elephant fish, rig, dog fish, blue moki, grey shark, blue shark, the shellfish oysters, tuatua, mussels, cooks turban, pupu (*Turbo smaragdus*), pipi, and the seaweeds bladder kelp (*macrocystis pyrifera*), bull kelp, karengo, and seagrass.

Additional species identified as important by recreational and commercial fishers includes Chinook salmon, red cod, trumpeter, mussels, barracouta, warehou and arrow squid (Boyd, 2008).

Among the many species identified by Ngai Tahu in their sea fisheries report (Ngai Tahu, 1992) which are likely to be common in harbour or coastal waters are: barracouta, grouper, elephant fish, rig, school shark, spiny dogfish, blue cod, red cod, gurnard, kahawai, yellow eyed mullet, New Zealand sole, lemon sole, turbot, brill, yellow belly flounder, sand flounder, black flounder, greenback flounder, the shellfish tuatua, pipi, tuaki, paua, oyster and rock lobster.

Identification and location of physical habitat parameters of different key species such as tuaki, tuatua, pipi, or flounder in the harbour and common sole and gurnard offshore is important. It is not realistic to sample every square metre of sea bed. However, by using factors at different scales such as: depth; flow models; sediment size, grading, degree of compaction and quality; distance from sea; water clarity; and exposure; etc, the habitat of key species can be identified and located on a map. GIS, principal component analysis and logistic regression are all tools designed for this type of work. As mentioned above the

primary effect of dredging is to change the physical factors. Therefore, it important to know where the habitats for different species are located so potential changes can be determined. In other words the adverse effects of the dredge programme can be determined.

It is important to note that abundance of a species in the harbour today may be a mere shadow of historical levels and the result of influences outside the control of Port Otago e.g. over fishing. Future management methods such as Mataitai should have the opportunity to restore a species. For this to successfully occur, the habitat must remain intact and healthy.

3.2 Physical Habitat Parameters

3.2.1 Harbour Habitats

Currents and Tidal Heights

Peak spring tide currents of 1.59 m/s occur on flood tides at the southern end of the spit on the western side of the channel (James et al, 2009) and 1.36 m/s on ebb tides at Beacon 6 in the centre of Harrington Bend (Old, 1998). Whereas the maximum ebb tide current in the same area is 1.2 m/s which means the entrance flows are flood dominant (James et al, 2009). Peak spring velocities after channel deepening are predicted to change by ±0.02 m/s with the greatest change being in the channel off Careys Bay where there would be a localised reduction of 0.1 m/s (James et al, 2009). A modest increase of 0.02-0.05 m/s is predicted for the inside of Harrington Bend (James et al, 2009).

Tidal range is 1.98 m for springs and 1.22 m for neap tides at Port Chalmers and predicted high tides at Port Chalmers occur 15-20 minutes after high tide at the spit (James et al, 2009). Deepening of the channel is expected to result in slightly increased tidal range of 8-10 mm at Port Chalmers (James et al, 2009). Timing of high water at Port Chalmers is expected to be 3 to 4 minutes earlier (James et al, 2009).

The tidal prism (total volume over a typical 6.25 hr tidal cycle at the Entrance) is about 6.6×10^7 m^3 (Old & Vennell, 2001). This is equivalent to 2900 m^3/s which for comparison, is more than four times the normal Matau Clutha River flow of 600 m^3/s.

Sediments

Sediments in the harbour grade from finer muddier sediments in the Upper harbour to coarser sands towards the entrance, with fine sand on the intertidal flats (James et al, 2009). Although this is a reasonable assumption, the only quantitative evidence presented is from 37 vibrocore holes and 6 rotary drill cores at 43 locations within the existing channel and areas targeted for channel widening (Table 1) (Greene & Hanz, 2008). (Refer to Section 9.2 for geological detail)

Section Name	Geological Description Of Materials
Swinging Basin	**Grey, sandy SILT and fine SAND. Silt is soft to very soft and nonplastic. Sand is loosely packed**
Deborah Bend with Rocky Point	**SILT in the southern part close to Carey's Bay and silty CLAY closer to Acheron Head. Sediments soft to very soft and plastic where clay present. Completely to moderately weathered basalt in borehole 3 along the north side of the existing channel.**
Hamilton Bend with Acheron Head and Pulling Point	**Clayey SILT with some sand, soft to very soft, non-plastic to slightly plastic. Silty CLAY, soft to very soft and plastic close to Acheron Head. Completely to moderately weathered basalt in boreholes 4 at Acheron Head. Basalt cobbles at Pulling Point**
Taylors Bend	**Clayey SILT at Dowling Bay end of section and sandy SILT at Waipuna Bay, soft to very Soft, plastic where clay content high.**
Cross Channel	**Clayey SILT, soft to very soft, slightly plastic sand content increasing toward eastern end of section.**
Harington Bend	**Fine SAND near Otakou changing to clayey SILT near Harrington Point and the Spit.**
Howletts	**Fine SAND with some Silt near the eastern side around Pilot Beach.**
Entrance	**Fine SAND**

Table 1: Overview of geological description of materials found in boreholes grouped by channel section. (Greene & Hanz, 2008)

Most importantly, only a visual assessment of sediment type and grade of all benthic samples was made. No quantitative measures were carried out for locations beyond the channel. In the absence of any quantitative data Paavo & Probert (2008), and Paavo (2009a) categorised the harbour into 11 habitat types dominated by:

1. **Relict shell on medium sand with sparse patches of algae**
2. **Relict shell on medium sand with sparse patches of algae but with silty or flocculent layer, no sand ripples, recent bioturbation obvious**
3. **Medium sand with ripples**
4. **Thick algal mats**
5. **Sea grasses on medium sands**
6. **Macrofauna burrows/mounds (including ghost shrimp and lugworms) indications of burrowing bivalves minimal**
7. **Living tuaki**
8. **Sediment surface dominated by closely packed macrofaunal tubes**

9. **Deep habitat with cobble-sized stones and mollusc shells fused together, signs of high water flows, with sessile (attached) animals such as sponges, hydroids and tunicates**
10. **Shell hash**
11. **Mudstone or consolidated clay pavement**

Unfortunately these categories are a confused mix of physical and biological characteristics. What is required to assess the impacts of dredging is a well defined set of physical features that define different broad habitat types that support different assemblages of flora and fauna. This is important because without good quantitative data it is very difficult to assess potential changes that may result from the dredging activity.

Sediment Contaminants

Because dredged material will be removed from the shipping channel and disposed of elsewhere, information regarding the presence or absence of contaminants, within the dredged material, is essential (Greene & Hanz, 2008). Samples were submitted to Hill Laboratories Ltd. from 5 different locations along the length of the shipping channel where material is proposed to be dredged (Refer to Table 2) (Greene & Hanz, 2008). Samples were combined from 0 - 500mm, 500 - 1000mm and 1000 - 1500mm depth below the existing seabed (Greene & Hanz, 2008). The upper 0 - 500mm composite was analysed first and based on the results from this level, further testing of the deeper composite samples was deemed unnecessary (Greene & Hanz, 2008).

Parameter	Detection limit (mg/kg)	Guidelines (mg/kg) ANZECC	Sample Concentrations (mg/kg)				
			VC5	VC12	VC21	VC34	VC47
Metals							
Arsenic	2	20	7.1	7.9	<2.0	<2.0	3.3
Cadmium	0.1	1.5	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium	2	80	17	16	2.5	2.6	8.9
Copper	2	65	6.7	6	<2.0	<2.0	4.4
Lead	2	50	7.1	6.7	0.76	0.81	4.3
Nickel	0.4	21	11	10	2.2	2.1	7.2
Zinc	4	200	44	42	8.1	6.8	27
Organic Compounds							
PCB	0.02	0.023	<0.001	<0.001	<0.001	<0.001	<0.001
TPH	60	-	<60	<60	<60	<60	<60
Anthracene	0.002	0.085	0.002	<0.002	<0.002	<0.002	<0.002
Fluroanthene	0.002	0.6	0.0021	<0.002	<0.002	0.002	<0.002
Phenanthrene	0.002	0.24	<0.002	0.0025	<0.002	<0.002	0.0049
Inorganic Compounds							
Cyanide	0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrogen	0.051	-	<0.051	<0.051	<0.051	<0.051	<0.051

Table 2: Summary of Chemical Testing for Port Otago's "Next Generation" Dredging Project (PCB=Polychlorinated Biphenyls; PH=Total Petroleum Hydrocarbons)(Greene & Hanz, 2008)

Contaminant testing found that none of the parameters analysed exceeded the guideline values used and based on these results, the materials to be dredged are not contaminated (Greene & Hanz, 2008).

3.2.2 Offshore Habitats

Currents

Two offshore eddies are present. The Blueskin Bay eddy involves most of the bay from 20 m to 30 m deep, about 13 km in diameter with an average velocity about the outer third of 0.06 m/s. A lesser known eddy immediately north east of Taiaroa Head has a diameter of about 5 km and velocity of about 0.07 m/s. The Southland Current is located from about the 30 m depth contour seaward, and moves northward at velocities increasing from 0.10 m/s to more than 0.69 m/s. Although this is the normal situation, weather conditions can temporarily change these parameters.

Sediments

96 randomly located grab samples were analysed for sediment quality including grading and organic mater (Willis et al, 2008). Off shore sediments were generally well consolidated, homogeneous, well sorted, fine sands (Willis et al, 2008). Silt content and organic matter were highest in the centre of Blueskin Bay (Willis et al, 2008) i.e. the centre of the Blueskin Bay eddy. Medium sand was uncommon only occurring east of Taiaroa Head in deep water with stronger current and steeper gradient (Willis et al, 2008).

3.3 Macro Benthos

Macro benthos are fauna and flora (animals and plants) that live on or are buried in the sediment. They can be seen with the naked eye but a microscope is often used to assist in identification.

3.3.1 Harbour

665 benthic photographs (5 at each sampling site) were recorded in surveys of the soft bottom sediments (Paavo & Probert, 2008; Paavo, 2009a). Eight transects of five to eight sites were taken at different locations across the channel and the remainder were located using a stratified random system about the sand flats to achieve effective coverage of all sub and inter tidal areas (Paavo & Probert, 2008; Paavo, 2009a). Within 25 m of these sites 127 benthic grab samples were collected and an additional 25 core samples were collected from Aramoana (Paavo & Probert, 2008; Paavo, 2009a).

Over 33,000 animals were identified from 190 invertebrate taxa (Paavo, 2009a). The soft sediment community was dominated by amphipods and molluscs (James et al, 2009). A small patch of horse mussels were found near Wellers Rock (James et al, 2009). Oysters were discarded from grab samples by Paavo & Probert (2008) believing that they were somehow accidentally caught, not realising that although common on rocks, oyster beds are also present in the harbour (Ralph & Yaldwyn, 1956). James (2009) reported there were surprisingly few benthic animals on the Aramoana flats with the commonest being small bivalves. Unfortunately, Paavo (2009a) replicated a study by Voice et al (1976) designed to collect small infauna with a 125 mm diameter corer. Had Paavo excavated sediment from 0.25 m² quadrats further down shore he may have come across the 10 to 15 tonnes of tuaki and small beds of tuatua and pipi that are reputed to be located in that area.

James et al (2009) also reported tuaki occurred in patches throughout the tidal flat areas and densities ranged from zero to 625 per m² (James et al, 2009). Densities on channel margins close to the swinging basin (areas to be removed as part of the widening operation) were less than 10 per m² (James et al, 2009). Markedly higher densities were found opposite Acheron and Pulling Points, up to 300 per m², and 625 per m² south of Harwood (James et al, 2009). However, the physical factors associated with tuaki abundance were not quantified. Accordingly it is very difficult to determine what changes may occur during dredging and whether these changes are within the normal range of tuaki habitat. That is, is the habitat change likely to result in tuaki deaths leading to population decline or local extinction?

Paava's (2009) final analysis was that most species were found across a range of habitats, thus the Harbour can essentially be treated as "one system". The habitats referred to were seven types condensed from the 11 outlined in Section 3.2.1 above. It is not surprising that Paavo (2009a) could not resolve discrete relationships between particular species and physical environmental variables. The habitat types were his assessment, not associations derived from quantitative habitat sampling and analysis. Consequently, the analysis had inherent limitations from the outset.

There are relatively few rocky shores in the harbour. Surveys were carried out by Paavo (2009b) at Quarantine Island, the most sheltered, Rocky Point, Acheron Point, and Pulling Point the most exposed shores. Typical intertidal and subtidal zonation patterns were evident at all sites (Paavo, 2009b). No particularly rare or unusual species or communities were identified in the survey areas (Paavo, 2009b).

3.3.2 Offshore

More than 15,000 individual animals in 120 taxa were recovered from 96 randomly located grab samples (Willis et al, 2008). Depth and type of sediment appeared to be the main

determinant of faunal groupings (Willis et al, 2008). For example, worms in the polychaete genus *Aricidea* and the families Cirratulidae and Scalibregmatidae, and an unidentified cumacean (a small crustacean), occurred in their highest densities in the very fine sand/silt basin in the middle of Blueskin Bay (Willis et al, 2008). Conversely, the snails *Antisolarium egenum* and *Zethalia zelandica*, and the polychaete worm *Armandia maculate* were all associated with shallow, inner regions of Blueskin bay (Willis et al, 2008). Amphipoda (small crustaceans) and Tellinidae (a bivalve) were associated with coarser, deeper habitats (Willis et al, 2008).

Overall, the density of benthic invertebrates was lowest in the centre of Blueskin Bay where the silt content of the sediment was higher than elsewhere (James et al, 2009). Density and diversity of benthic invertebrates were highest just north of the Otago Harbour entrance (James et al, 2009). The fauna was typical of near shore sand zones with no rare or unique species observed (James et al, 2009).

The preferred disposal site was characterised by high densities of large tube worms and other epifauna including knobbed welk and ostrich-foot shell (James et al, 2009). A multivariate analysis of variance did not suggest that the infauna in the preferred disposal site were different from the surrounding areas within 4 km (Willis et al, 2008).

Large colonies of bryozoans forming reef-like thickets were located to the south of the proposed disposal site in depths of about 70-110 m (Probert et al, 1979; Batson & Probert, 2000; Jones, 2006). Also distinctive of the outer shelf are queen scallops which were located well off shore and south of the proposed disposal site (James et al, 2009).

3.4 Fish

The fishery resources report (Boyd, 2008) has resulted from a desk top literature review. It provides very little information which can be used to determine what effect dredging may have on any species. It does provide two excellent tables of fish species and shellfish species caught in the harbour and offshore. It does not attempt to provide any information about critical habitat requirements, breeding cycles or locations, or key elements to be considered, or species at greatest risk. Information is available for key species. For example, Yellow-belly flounders prefer the muddy, turbid, low-salinity upper reaches of estuaries, and avoid seagrass (Francis, et al, 2003). In 1938, Graham reported 119 fish species (not including shellfish) from the Otago Harbour and adjacent seas. They ranged from species identified from single samples or gut contents to exceeding common species. 41 were common or abundant in the harbour and 96 offshore. Some of these species are common to both harbour and offshore areas. He also noted some habitat features for many species.

James et al (2009) noted "There is a diverse coastal fish fauna in the Otago Harbour and the waters adjacent to the Otago Peninsula. The fish and shellfish fauna present in these waters is predominantly comprised of common species that are widely distributed throughout central New Zealand. The extensive intertidal areas contain significant populations of tuaki."

3.5 Mammals

Elephant seal, Hectors dolphin, southern right whale, New Zealand sea lion, and bottlenose dolphin all have special conservation status and are among the four seal, and six whale and dolphin species which have been reported from the Otago coast (James et al, 2009). Several species of seal use areas on the Otago Peninsula as haul-out areas and breading grounds (James et al, 2009).

Seals and whales forage over large areas and depths greater than 20 m and thus are unlikely to be significantly impacted by dredging or the dumping of the waste material at the proposed disposal site (James et al, 2009). Four dolphin species are found off the coast with Hectors dolphins at a very high risk of extinction (James et al, 2009). A pod of Hectors dolphins spend their summers inshore in Blueskin Bay foraging opportunistically to the north and west of Taiaroa Head while winters are spent at depths over 60 m (James et al, 2009). Deaths in fishing nets, in particular gillnets but also in trawling, have been identified as the most serious threat to Hectors Dolphin (DoC & MFish, 2007).

Concentrations in the plume in the water column will be diluted to less than 20 mg/l within a few kilometres from the disposal site so except for in the vicinity of the disposal site and immediately downstream, there are unlikely to be impacts on whale, dolphin or seal foraging (James et al, 2009).

3.6 Bird Life

One nationally critical species (grey-headed mollymawk), two nationally endangered species (black-fronted tern, black-billed gull), six nationally vulnerable species (including yellow-eyed penguin and Stewart Island shag), and five species in decline are among the 34 bird species reported from the Otago coastal waters (James et al, 2009). 13 breed on the coast and six commonly frequent the intertidal areas (James et al, 2009).

Large numbers of shorebirds feed within the Otago Harbour and on sand flats of Aramoana (James et al, 2009). The majority of the birds foraged along the water's edge and followed the ebbing tide (Sagar, 2008). The main exception to this was banded dotterels and spur-winged plovers which tended to feed over drier areas of sand/mud and in lightly vegetated areas (Sagar, 2008).

Islands provide roosting birds with greater protection from disturbance and predation (Sager, 2008). The sand/shell banks off Port Chalmers are important for both high tide roosts and feeding sites for a variety of bird species (Sagar, 2008).

Most areas would be subjected to turbidity levels below that recommended to protect sea birds (James et al, 2009). Avoiding dredging during the breeding period and in the Aramoana area when godwits are preparing for their migration would mitigate impacts on birdlife (James et al, 2009).

Birds in the harbour are acclimatised to regular ship movement and maintenance dredging and showed little response to ship movement during observations at Aramoana (Sagar, 2008).

4.0 The Dredging Programme and Geotechnical Detail

7.1 million cubic metres of material will be dredged from the channel during a period of 120 days in total (Bell et al, 2009). 28.5% from Harrington Bend, 10.8% from the cross channel, 21.2% from Taylers Bend, 9.2% from the west side of the swinging basin, and 30.3% from the east side of the swinging basin (calculated from Bell et al, 2009). Channel depth will be increased from about 13 metres below chart datum to 15 metres at Port Chalmers, and to 17.5 metres at the channel entrance (James et al, 2009). On average the base of the channel will be widened by 22.4 metres. Generally, readjustment of the batter slopes will be within the existing slope alignment and will not change sub tidal grades that are less than 5 metres below chart datum. In two locations however, realignment of the batters will impinge into shallower waters and the intertidal zone. (Refer to Section 9.3 for dredging depth detail).

Along the starboard side of the channel opposite Te Rauone for a distance of 600 m, a 50 m wide strip of gently sloping (40:1) sand bed from 1 m to 4 m below chart datum will be dredged to a 7:1 grade. As a consequence of this regrade, an additional strip of sand bed up to 50 m wide will progressively regrade over time to a natural transition from the Aramoana sand flat to the new batter slope. (Refer to Section 9.4 for batter slope detail)

On the port side of the channel from opposite Deborah Bay to the end of the swinging basin a 600 m long strip of sub tidal and intertidal sea bed from 50 m to 100 m wide will essentially be removed by lowering it to meet the channel bottom. In this location, the existing batters are stable at a 3:1 grade and the transition from the new batter to the sand flat will be relatively short affecting only a strip of sand flat 20 m to 50 m wide.

Stability and natural regrading of the batter slopes to the existing sand flats is a process controlled by currents, wave disturbance, gravity, grain weight, size and shape, and forces of cohesion and friction. Shear stress on the face of a slope induced by the orbital motion of water during passage of waves has the effect of fluidising the surface layer of the slope (Burt, T. N., 1991). The effect is greatest in shallow water at the top of the slope (Burt, T. N., 1991). Loosened material has a tendency to run down the slope resulting in a shallower slope grade (Burt, T. N., 1991). Provided velocities are high enough, the top of a slope can be eroded, but this reduces with depth due to increasing shear strength with depth (Burt, T. N., 1991). It is almost impossible to predict the final slope (Burt, T. N., 1991) at the top except to allow for a naturally stable incline to form as a result of the active forces of wave and current at each location.

Near the entrance where sands are coarse and unconsolidated, grades less than the angle of repose have been designed (Table 3) (Port Otago, 2009). Grade design at the entrance is 12:1 steepening to 7:1 at Howletts. From Taylors Bend the batter slopes progressively

steepen from 7:1 until the swinging basin where they are at their steepest (3:1). These grades are consistent with long term monitoring of the channel (Refer to Section 9.5 for historical cross section detail) and the sediment type from the entrance being sand, to clayey sandy silt at Port Chalmers (Port Otago, 2009). The presence of fine sand and clay along with silt increases the threshold shear stress, resistance to movement and density of the bed material, accelerating the consolidation process (Jagadeesh et al, 2004) and results in a stable sediment able to maintain steep slopes. The only exception to these batter slope grades is at locations where rock exists and slope grades up to 1:1 are designed.

	Soil Material	Side Slope H:V
Preferred side slopes	All Materials, minimum required side slopes	1:1
	Firm Rock	1:1
	Fissured rock, more or less disintegrated rock, tough hardpan	1:1
	Cemented gravel, stiff clay soils, ordinary hardpan	1:1
	Firm, gravely, clay soil	1:1
	Average loam, gravely loam	3:2
	Firm clay	3:2
	Loose sandy loam	2:1
	Very sandy soil	3:1
	Sand and gravel, without or with little fines	3:1- 4:1
	Sand and gravel with fines	4:1 - 5:1
	Muck and peat soil	4:1
	Mud and soft silt	6:1 - 8:1

Table 3: Recommended Side Slopes (Canadian Coast Guard, 2008)

5.0 Analysis and Discussion of Potential Impacts

5.1 In Harbour Impacts

5.1.1 In Channel Impacts

Habitats and communities in the channel are already modified through maintenance dredging (James et al, 2009) and will continue to be so. Although, fauna and flora in some isolated deeper patches will continue to exist undisturbed, in the scheme of things, it is best to consider the base of the dredged channel was lost from the system when dredging begun. Any restoration of habitat that occurs intermittently should therefore be considered a bonus. However, dredging will increase sub-tidal rocky bottom habitat at Acheron Head and Pulling Point. This habitat will be relatively stable and maintained by maintenance dredging of the surrounding soft bottom preventing it from being smothered.

Blasting, which has a number of potential impacts, may be required during the excavation of rocky material (James et al, 2009). The method will only be used if all other means have proved ineffective. Marine mammals and fish with swim bladders are particularly sensitive to blast compression waves (James et al, 2009). Port Otago Ltd. have previous experience with this method which includes keeping a good lookout for marine mammals and not blasting if any risk is present (James et al, 2009).

5.1.2 Suspended Sediment And Turbidity

Harbours are naturally turbid at times and most communities are tolerant of high sediment concentrations and low clarity, but only for short periods (James et al, 2009). Modelling indicates suspended sediment concentrations (SSC) could reach over 1000 mg/l for short periods adjacent and close to the main channel (James et al, 2009). Most intertidal areas would experience concentration less than 200 mg/l for short periods and areas far from the channel (e.g. off Harwood) would experience levels from zero to 20 mg/l (James et al, 2009). In contrast, natural background SSC in the lower harbour, range from 5.6 mg/l to 215 mg/l (Currie & Robertson, 1987).

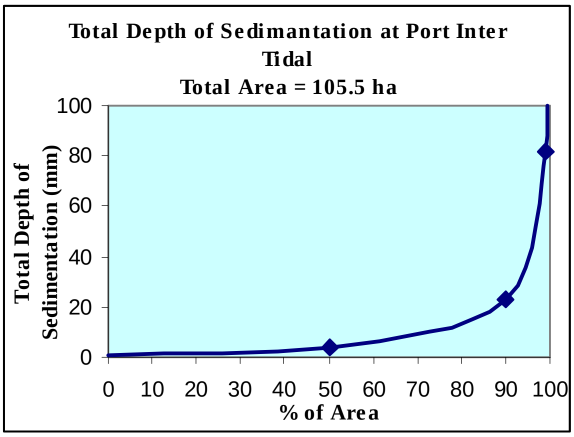
Hurst et al (2000) showed that harbours and protected areas tend to be the main areas where the greatest numbers of eggs, larvae or juveniles of many inshore species are found. Fish larvae have been reported as common in the Otago Harbour at different times of the year, for example sand flounder, speckled sole, and greenback flounder (Robertson, 1980; Roper & Jillett, 1981) and also fish eggs of ahuru, lemon sole, and spotty (Robertson, 1980). September/October is the period when the greatest number of fish species in Otago area spawn (Robertson, 1980)

Appleby and Scarratt (1989) summarised a number of studies that assessed the effects of SSC on fish. Most fish eggs and larvae did not show significant effects until concentrations rose above 500 mg/l and adult fish could tolerate at least 2000 mg/l for extended periods. Tuaki and some other invertebrates can tolerate concentrations up to 400 mg/l (James et al, 2009).

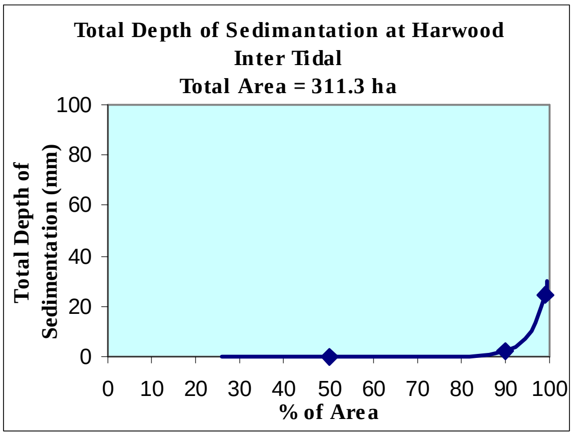
Therefore, most species will be able to tolerate the short durations of higher SSC resulting from dredging and generally these levels will be within the normal background range. Also, most birds, fish and mammals could avoid areas of high SSC but dredging should avoid the breeding period over spring and summer to minimise potential adverse effects (James et al, 2009).

5.1.3 Increased Sedimentation

Most animals and plants found in harbours and estuaries including sea grass can survive up to 20 mm of sediment deposition in a single event (James et al, 2009). To model sediment deposition the harbour was divided into 30×30 metre cells (Bell et al, 2009). Results of the modelling indicated that for non-main channel areas, the area of greatest deposition is predicted to be the intertidal flats opposite Port Chalmers (Bell et al, 2009). Mean deposition across all the 30×30 metre cells in this sub area were predicted to be 9.2 mm total during the entire dredging programme (Bell et al, 2009). Maximum depth in 99% of the cells was predicted to be 81.7 mm which is equivalent to 1.7 mm per day dredging occurs in and about the swinging basin (Refer to Section 8.1 & Graph 1). Maximum predicted depth in 99% of the Harwood intertidal area was predicted to be 24.4 mm which was equivalent to 0.3 mm per dredging day (Refer to Section 8.1 & Graph 2). Pulling Point and Taylers Point intertidal sites were both predicted to receive similar maximum daily sediment depths of 0.3 mm (Refer to Section 8.1). Other parts of the harbour are predicted to receive similar or lower levels.



Graph 1: Port Inter Tidal Sedimentation



Graph 2: Harwood Inter Tidal Sedimentation

Although in 1% of the 30×30 metre cells sediment depths are predicted to be higher, overall, the daily sedimentation depths are predicted to be low, and may cause little if any adverse effects. This should be tempered by the fact that sediment characteristics of the Lower Harbour except the channel were not determined. Larger particles will settle at a greater rate compared to finer particles resulting in coarse sedimentation closer to the channel and finer sedimentation farther away. This may lead to changes in sediment grade which could influence the biota living on or in the sediment. For example, assuming that tuaki are associated with medium sand, increasing the fine sediment fraction in sediment of a tuaki bed far from the channel may result in a declining population. This should be a point of particular interest when considering impacts on tuaki beds located south of Harwood in Portobello Bay.

5.1.4 Impacts on Key Species

Tuaki

Tuaki densities on channel margins close to the swinging basin (areas to be removed as part of the channel widening operation) were less than 10 per m^2 (James et al, 2009). This area which encompasses about 5000 m^2 is less than 0.5% of the intertidal habitat in the Lower Harbour (James et al, 2009). Simple calculations suggest 50,000 individual tuaki could be involved. However, anecdotal reports suggest the actual population is somewhat less than this. As mentioned above (Section 3.3.1) the abundance and distribution of tuaki has not been well quantified. It is especially important to have good characterisation of tuaki populations in areas where the probability of an impact is likely to be greater, e.g. adjacent to the channel edge, Aramoana, Te Rauone, opposite Deborah Bay and the swinging basin where smothering could occur, or south of Harwood where fine sediment may change sediment grading. Although, results from modelling shows sedimentation levels on a daily basis are likely to be minimal, there remains a risk that some small areas may differ from larger scale modelling parameters and sedimentation could be higher than predicted. Therefore, an important aspect of the dredging programme should be simultaneous monitoring with the ability to rest an area or change dredging timing relative to tidal cycle so as to diminish the effects.

Tuatua And Pipi

Tuatua and pipi have been reported from the Otago Harbour (Ngai Tahu, 1992) but the macro-benthic survey was unable to locate their presence. This may have been a result of the way the lower slopes of the Aramoana sand flats were surveyed. It would be poignant if these species are no longer present in the harbour, however, suitable habitat may remain and should be identified and protected for future restoration options.

Flounder

Several flounder species were very common in the harbour and supported large customary fisheries. Much the commonest was sand flounder (*Rhombosolea plebeian*), greenback (*R. tapirina*) and yellowbelly (*R. leporine*) were common, and black flounder (*R. retiria*) uncommon (Graham, 1938). The fisheries resources report (Boyd, 2008) did not elaborate on the preferred habitat of these species and their location within the lower harbour. Consequently, it is very difficult to ascertain or predict the effects that dredging may have on these important species that are so closely associated with bottom sediments.

5.2 Offshore Impacts

Three different offshore sites were investigated and the preferred site was chosen because impacts at that site were predicted to be significantly less than the other options. Critical concerns were the Queen Scallop beds in deep water to the south east, bryozoan beds in deeper water to the south, increased suspended sediment concentration and sedimentation along the coast and into Blueskin Bay, and location of commercial fishing grounds.

No unique or special communities were identified in the preferred site or surrounding areas (Willis et al, 2008). Location of the preferred disposal site, A0, is about 6.5 km NE of Taiaroa Head (Fig 1) (James et al, 2009). It is about 2 km in diameter and in 28 m of water on the north east side of a steeper slope rising from 30 m to 25 m. Therefore, sediments will not tend to move into Blueskin Bay but will disperse northwards.

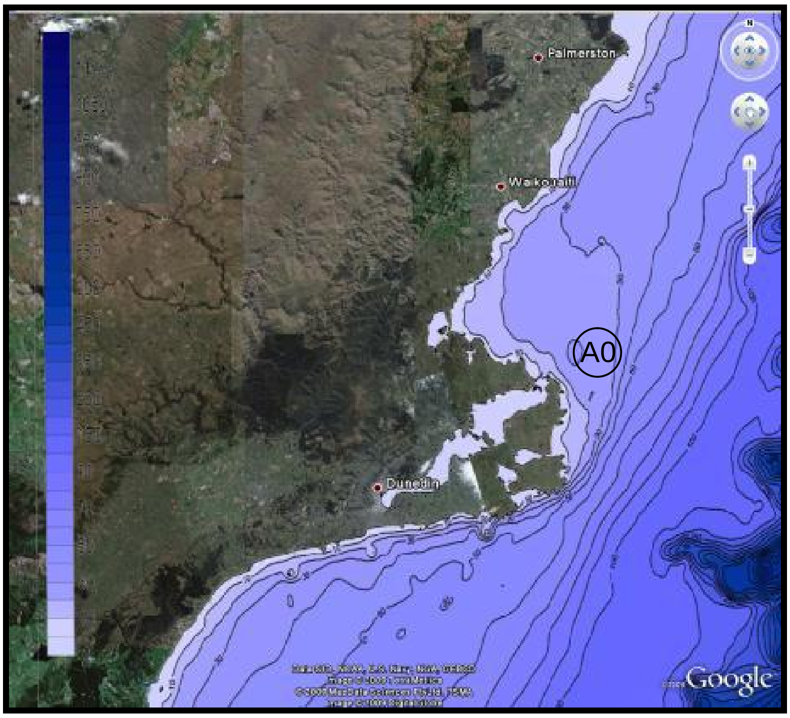


Fig 1: Proposed Dredge Site A0 (Puller & Hughes, 2009)

A number of invasive species have been reported from Otago ports with 25 species (mostly sponges) not previously described from New Zealand waters (James et al, 2009). The sea weed *Underia* has been present since at least 1990 (James et al, 2009) and is well established at many locations. It is highly unlikely that *Underia* will establish at the proposed disposal site because of the lack of hard substrate, depth, and exposure (James et al, 2009).

5.2.1 Suspended Sediment And Turbidity

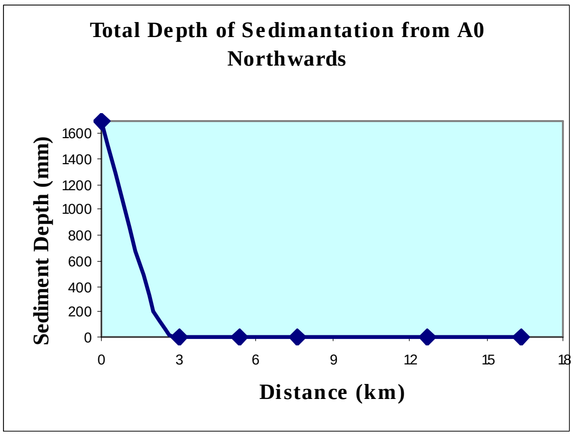
The increased levels of SSC and reduced water clarity will affect the immediate disposal site but these levels will be rapidly diluted away from the site (James et al, 2009). Within a few kilometres north of the disposal site, SSC will be less than 20-30 mg/l, which is a level that should not affect plankton or fish and is similar to a level set to protect birds like terns and gannets (James et al, 2009). Surface layer SSC off Taiaroa Head and northern coastal areas is predicted to be less than 3 mg/l (James et al, 2009). Background levels at the disposal site and in the middle of Blueskin Bay varied from 0.3 to 4.1 mg/l (James et al, 2009). Referring to section 5.1.2 above, it is likely that the eggs, larvae, and adults forms of most fish species will be able to tolerate the periods of higher SSC.

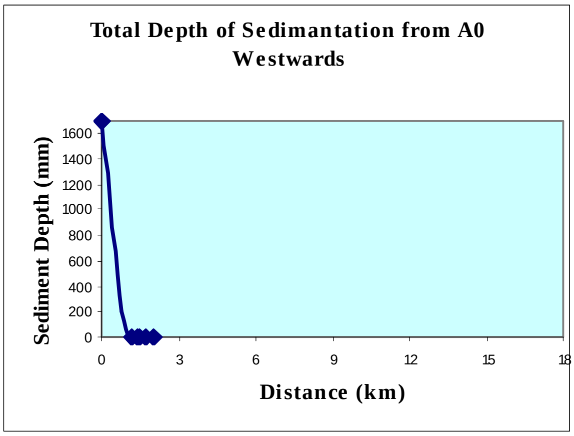
Most birds, fish and marine mammals are highly mobile and can avoid areas of high SSC but dredging should avoid the breeding period over spring and summer to minimise potential adverse effects (James et al, 2009).

5.2.2 Increased Sedimentation

Virtually all benthic plants and animals in the immediate disposal area would not survive smothering (James et al, 2009). Sediment mounds will be up to 1.4 m to 1.8 m on average higher than the existing sea bed (Bell et al, 2009). Recovery may take up a year for some animals and longer for others (James et al, 2009). However, most animals within the dredged material will be alive on arrival at the disposal site and many will survive for months until the natural balance and species distribution returns to the offshore normal environment. This process will be the result of predator prey, and sub optimal habitat relationships.

Sand would predominantly settle out at the disposal site (Bell et al, 2009). Increasingly finer sediments would settle out over increasing large areas generally to the north of the disposal site (Bell et al, 2009) (Refer to Graphs 3). A small area of 11 km² immediately to the north of the disposal site would receive 1.7 mm/day, an area encompassing 18 km² further north would receive 0.8 mm/day and 0.4 mm/day would settle on a 29 km² area further north of this (Bell et al, 2009). As a function of the northerly flowing Southland Current, sedimentation westward from the disposal site is predicted to be very limited (Refer to Graph 4). Deposition along the coastline at Otago Heads and Cornish Head are predicted to be less than 0.5 mm total over the entire dredging period (Bell et al, 2009).





Graph 3: Sedimentation A0 Northward **Graph 4: Sedimentation A0 Westward**

Note: Vertical Axis Exaggerated

Although the open water dumping of dredge waste is often associated with a presumption of negative impacts, evidence exists that with appropriate precautions dredge material can be used to effectively create or restore fisheries habitat (IMO, 2009). Stable berms have anecdotally been linked with high fishery resource use (IMO, 2009). However, little quantitative evidence has appeared in the scientific literature (IMO, 2009). Nevertheless, fishes have been shown to associate with variable bathymetric relief (IMO, 2009). Placement of dredged material can potentially increase habitat complexity by forming areas that differ from surrounding substrate (IMO, 2009) leading to enhanced secondary production increasing availability of prey items (Rhoads et al, 1978; Rhoads & Jermano, 1986). Reefs with lower profiles and substantial horizontal spread seem to attract demersal (near bottom dwelling) fishes (Grove and Sonu, 1985).

It is clear that in the immediate area of the disposal site most species will be smothered. However, within a short distance of kilometres down current predicted sedimentation rates are markedly lower. Beyond the disposal site but within a few kilometres it is possible that no adverse effects will be detectable and indeed, some fish populations may increase. However, sedimentation will tend to be composed of finer grade silts which when combined with the existing sand grades may result in a change sediment grading leading to a change in the associated biota. No predictions were provided by the ecological reports to resolve this issue.

5.2.3 Impacts on Key Species

Flatfish and Gurnard

The adverse effects of dredge spoil dumping could have considerable impacts on fish populations particularly as a result of changing habitat features. Boyd (2008) identified gurnard and common sole as important commercial species but did not quantify how spoil dumping might affect them. Graham (1939) provided a wealth of information regarding the prey of many species from the Otago Harbour and adjacent seas. Gurnard may be more adept at surviving spoil dumping as a function of its wide and varied diet of 8 fish, 7 mollusc, 9 crab, 3 crustacean, and 4 annelid species. Whereas, common sole prey upon a smaller range of species including 1 fish, 2 molluscs, 2 grabs, 1 crustacean, 4 annelid, and 2 echinoderms. Consequently, common sole populations may be not so common for a period of time prior to restoration of the bottom fauna. No predictions of habitat change caused by dredge spoil dumping, leading to estimated impacts on fish, were posed.

5.3 Potential of Significant Effects

The potential of significance effects caused by dredging was evaluated based on three criteria:

- **Severity; degree of harm, without consideration of duration or spatial extent,**
- **Duration; time from initial effect to recovery, and**
- **Extent of impact; spatial distribution of the impact.**

Emmitt (2002) recommended that in general, impacts are considered signific if:

- **Severity ranks high,**
- **Duration is long term and Severity is medium or high, or**
- **Extent of impact is regional and Severity is medium or high.**

Also, if information is not provided or unavailable then the factor will be marked as significant until it can be shown to be otherwise.

The following rating levels for each of the three criteria have been adapted from Emmitt (2002) (Refer to Table 4).

Severity	
Low	• No threat to critical food supply, species life cycles • Minimum impact on species important for structural function • No significant changes to species diversity and abundance/biomass • Minimum impact on habitat complexity/diversity/productivity • Minor changes to ambient environmental quality
Medium	• Loss of non-critical food supply/reduction in critical food supply • Displacement of non-reproductive activity • Species important for structure or function may be lost or impacted • Changes to species diversity and abundance/biomass • Reduction in habitat complexity/diversity/productivity • Changes to ambient environmental quality
High	• Major changes to fauna and flora (e.g. through loss of critical food supply, interpretation of reproductive life-cycle) • Substantial reduction in abundance/biomass of species important for structure and function • Significant impact to biodiversity and ecological functioning • Loss of complex or vital habitat • Major impacts on ambient environmental quality
Duration	
Short Term	• Impacts less than 1 year
Medium Term	• Impacts 1 – 5 years
Long Term	• More than 5 years
Extent Of Impact	
Site Specific	• Impact or disturbance is restricted to the site at which the activity is occurring
Local	• Impact or disturbance extends up to 1,000 m beyond the boundary of the site at which the activity is occurring
Regional	• Impact or disturbance extends further than 1,000 m beyond the immediate boundaries of where the activity is occurring

Table 4: Ratings, Levels, and Criteria (James et al, 2009)

5.4 Severity Duration and Extent of Effect Matrix

Factor	Potential Consequences	Additional Information	Significance Of Effect			
			Severity	Duration	Extent	Significant
Identification of Key Fish or Shellfish Species	Potential adverse effects on key fish populations not determined or assessed	Macro benthic survey did not record physical habitat variables	Information Required			Yes
Tidal Currents (Harbour)	Change in current velocities could result in erosion or accretion	Mean change ±0.02 m/s Max change -0.1 m/s	Low	Long	Local	No
Tidal Range (Harbour)	Increases to apparent sea level. Islands covered reducing bird roosting areas	Change + 8 to 10 mm	Low	Long	Regional	No
Tide Times (Harbour)	Changes to bird, fish and marine mammal feeding behaviour	Change -3 to 4 minutes	Low	Long	Regional	No
Sediment Grades and Quality (Harbour)	Knowledge of existing physical habitat variables	Good knowledge of in channel parameters. Poor knowledge of parameters beyond channel	Information Required			Yes
Sediment Grades and Quality (Offshore)	Good knowledge of Offshore physical habitat parameters	Offshore surveys have covered wind, waves, currents, turbidity, sediment grade and quality	Excellent Information			No
Macro Benthos (Harbour)	Good knowledge but no association with physical factors	Difficult to ascertain adverse effects	Information Required			Yes

Factor	Potential Consequences	Additional Information	Significance Of Effect			
			Severity	Duration	Extent	Significant
Macro Benthos (Offshore)	Good knowledge with association with physical factors	Combined knowledge of macro benthos and physical factors enables assessment of effects caused by spoil effects on fish	Excellent Information			No
Disposal Site Selection	Smothering of sensitive habitats and organisms	A0 site away from coast, scallop and bryozoan beds, fishing areas	Low	Long	Regional	No
Fish	Fish populations adversely effected by dredging	Unable to consider how dredging is likely to effect key species	Information Required			Yes
Marine Mammals	Rare and endangered species adversely effected by dredging	Species very mobile and can avoid dredge and plume. Dredging should be carried out during winter to avoid effecting Hectors dolphin	Low	Medium	Regional	No
Birds	Rare and endangered species adversely effected by dredging	Birds accustomed to ship movements. Birds require emergent islands for roosting. Loss of emergent sand bank adjacent to swinging basin. Avoid dredging in summer to reduce adverse effects	Medium	Long	Site Specific	Yes
Channel Batter Slopes	Slumps/slips causing loss of sub and intertidal sand flats, and loss of shellfish habitat	Batter slopes are within angle of repose and historical slope grades. Supported by good geophysical study	Low	Long	Site Specific	No

Factor	Potential Consequences	Additional Information	Significance Of Effect			
			Severity	Duration	Extent	Significant
Rock Blasting	Fish, marine mammal and bird kills	Port Otago Ltd is an experienced operator but fish kill	Low	Short	Site Specific	Not
Suspended Solid Concentration (Harbour)	Effect the breathing, feeding, predator avoidance of fish, shellfish, marine mammals, birds and shading of sea weed	Modelling predicts SSC levels within those larvae, eggs and adult fish. In most areas SSC caused by dredging within back ground levels	Low	Short	Regional	Not
Sedimentation (Harbour)	Smothering of fauna and flora and disruption of fish populations	Natural high levels at times in harbour. Most locations in harbour not significantly effected. Port intertidal may experience high levels	High	Long	Site Specific	Yes
Key species Tuaki	Regional or local depletion or local extinction	Survey did not effectively identify location of tuaki beds and tuaki preferred habitat features	Information Required			Yes
Key species Tuatua and Pipi	Regional or local depletion or local extinction	Survey did not identify location of tuatua or pipi beds or preferred habitat features	Information Required			Yes

Factor	Potential Consequences	Additional Information	Significance Of Effect			
			Severity	Duration	Extent	Significant
Key Species Flounder	Regional or local depletion	Survey did not establish physical parameters of sand flat habitats, determine habitat requirements of Flounder. Potential effects of dredging can't be determined	Information Required			Yes
Invasive Species	Invasive species carried to new environment	Species around harbour prefer hard substrate in shallow water	Low	Short	Site Specific	No
Suspended solid concentration (Offshore)	Effect the breathing, feeding, predator avoidance of fish, shellfish, marine mammals, birds and shading of seaweed	Within disposal site SSC high. Greater than 2 km 20 to 30 mg/l. Birds, marine mammals, and fish can move from area or not effected. Low levels may reach coast but within background SSC levels	Medium	Short	Local	No
Sedimentation (Offshore)	Smothering of fauna and flora and disruption of fish populations	At disposal site 100% smother of fauna/flora 2km diameter. Beyond reducing. Greater than 5 km very low. Mound may attract fish.	High	Long	Local	Yes

Factor	Potential Consequences	Additional Information	Significance Of Effect			
			Severity	Duration	Extent	Significant
Key Species Gurnard	Regional or local depletion	May be able to move from area. Opportunistic species able to take large range of prey. May take advantage of increased diversity mound provides	Information Required			Yes
Key Species Common Sole	Regional or local depletion	May be able to move from area. May suffer intraspecific competition because narrow diet.	Information Required			Yes

Table 5: Summary Table Used To Estimate Significant Effects And To Identify Where Further Information Is Required.

6.0 Outstanding Issues and Recommendations

Resolving the issues outlined below will provide greater certainty of potential outcomes. One can never be 100% sure of an outcome. But, by increasing the information from which potential effect estimates are determined, the likely-hood of imprecise predictions will be reduced.

The following outstanding issues have been derived from the Severity Duration and Extent of Effect Matrix (Section 5.4).

6.1 Physical Variables Describing Harbour Habitats

No associations between any macro benthos species and habitat variables were identified by Paavo & Probert (2008) or Paavo (2009a). Fortunately, they stored their grab samples for future work if required. Following the methods used by Willis et al, (2008), the following physical habitat factors should be determined for each of the samples:

- % organic content,
- sediment grain size, and
- rollability.

Other variables should also be measured at each sampling site including:

- depth,
- distance from sea and channel,
- mean, maximum, and minimum current velocity at set distance from the bottom (e.g. 50mm),
- compaction, and
- exposure.

The rocky shore data collected by Paavo (2009b) should also be integrated into this database. Shellfish species size and abundance, and algae species and abundance should also be measured at each site and included in the database.

6.2 Key Fish and Shellfish Species

Selection should include species indicative of:

- different habitat types,
- specialists and generalists,
- important to customary, recreational, and commercial fishers, and
- specifically important to Ngai Tahu whanau/hapu/Runanga.

Habitat of each species should be associated in some way with habitat types and locations that could potentially be affected by the dredging operation e.g. it is not logical to include a deep water species. Knowledge of fish diets is important as there is likely to be associations between fish species and some prey items. The selected key species in this report are examples but not a complete list. By establishing potential effects on a small but comprehensive list of species, the study may be concluded as indicative of potential effects on most, but not all, fish species.

6.2.1 Tuaki

Gather information describing:

- **Location [Focus on areas of greatest risk from adverse effects]**
  - **Aramoana**
  - **Port Inter Tidal adjacent to channel widening between opposite Deborah Bay to Swinging Basin**
  - **Te Rauone Beach**
  - **Harwood South**
- **Physical habitat parameters associated with tuaki presence or abundance**
  - **Map location of ideal habitat using GIS**
  - **Predict adverse effects of dredging on habitat e.g. sedimentation leading to habitat change**

Using this information and that describing the physical habitat variables in the Lower Harbour, identify locations of existing tuaki beds and areas were tuaki don't exist or are poorly represented but habitat appears ideal.

Considering potential adverse effects of dredging, estimate change to tuaki habitat which is likely to result in population change.

6.2.2 Tuatua and Pipi

Gather information describing:

- Location [Focus on areas of historical or likely presence]
  - **Aramoana**
  - **Spit Inter Tidal**
  - **Te Rauone Beach**
- Physical habitat parameters associated with Tuatua and Pipi presence or abundance
  - **Map location of ideal habitats using GIS**
  - **Predict adverse effects of dredging on habitats e.g. sedimentation leading to habitat change**

Using this information and that describing the physical habitat variables in the Lower Harbour, identify locations of existing tuatua and pipi beds and areas were tuatua and pipi don't exist or are poorly represented but habitat appears ideal.

Considering potential adverse effects of dredging, estimate change to tuatua and pipi habitat which is likely to result in population change.

6.2.3 Fish Species

Select discrete list of key species for Harbour and Offshore analysis.

Gather information about each species describing:

- Location
  - **Focus on areas of historical or likely presence**
- Physical habitat parameters associated with presence or abundance
  - **Map location of ideal habitats using GIS**
  - **Predict adverse effects of dredging on habitats e.g. sedimentation leading to habitat change**

Using this information and that describing the physical habitat variables in the Lower Harbour and Offshore area, identify locations of existing fish populations and areas were these populations don't exist or are poorly represented but habitat appears ideal.

Considering potential adverse effects of dredging, estimate change to fish habitats which is likely to result in population change.

6.3 Localised Smothering Of Tuaki Beds

In addition to the large scale effects on tuaki, a relatively small area adjacent to the swinging basin where significant widening is planned may be at risk of greater than expected sedimentation and smothering. This could occur where localised variables are in variance to the variables used in the modelling. To detect and respond to unforeseen sedimentation depths, an active monitoring plan should be designed and in place to ensure immediate response and direct changes to the dredge routine.

6.4 Bird Loafing And Roosting Areas

Of particular risk to the dredging programme is an area adjacent to the swinging basin that is generally above or close to high water springs. This area is used by birds for roosting and may be at risk as a result channel widening in this area. A local survey and pegging of the proposed batter slope should be completed. Considering

natural re-grading of the sand flat to the batter, the continued existence of the roosting areas should be determined and remedial action proposed if required.

6.5 Monitoring Programme

A comprehensive monitoring programme should be developed to:

- **Measure the actual effects of the dredging programme and compare these with the estimated effects,**
- **Identify impacts that are beyond those predicted as they occur during dredging, and to**
- **Trigger changes to the dredging method to reduce the impact.**

7.0 Conclusion

The ecological studies endeavoured to address all issues and potential effects of the dredging programme. In part they did this well.

Macro Benthos and Sediment Studies

The Offshore macro benthos study was structured well. Sediment characteristics of grade and organic content were examined in detail. Benthic organisms were recorded and counted and a statistical analysis identified associations between some species and different physical features of the sediment. In contrast, the harbour study was not well designed. Physical parameters were not measured, and the survey of macro biota, especially shellfish, was insufficient. Consequently no associations between species and physical habitat factors were found.

Fish and Shellfish

Populations, of key Offshore or Harbour fish and shellfish species including their habitats and diets were not identified and the information was not associated with the macro benthic data.

Birds

Although brief, the bird study appeared to be adequate. Except for roosting islands adjacent to the swinging basin which maybe at risk, as long as the dredging programme occurs during the winter, bird populations are unlikely to be effected.

Marine Mammals

Marine mammals are highly mobile and are likely to be unaffected. However, further consideration of Hectors Dolphin which is critically endangered should be considered. Dredging should occur during winter when this animal feeds further offshore and away from the disposal area.

Suspended Sediments

Suspended sediments and sedimentation are the most obvious adverse effect of dredging. Comprehensive sediment modelling analysis was completed and predicted that except for areas adjacent to the dredging and disposal sites, suspended sediment concentrations are likely to be well within the normal background range. These levels have been shown to have little effect on fish eggs, larvae or adults. In the immediate area at the dredging and disposal sites suspended sediment concentrations are predicted to be relatively high but short term in duration and below levels that would effect fish.

Sedimentation

Sedimentation was intensively modelled and it was predicted that for most areas in the harbour daily sedimentation would be less than 0.1 mm and many areas would experience no sedimentation. Only in some locations immediately adjacent to the channel were higher levels predicted. However, these were still generally below 1.7 mm. There is a potential that is some small and discrete areas with environmental variables outside those used in the model, sedimentation could be higher. At the disposal site, sediments will smother the benthos. However, no unique or special communities exist at the site and the area will be recolonised from outside the area.

Invasive Species

A number of exotic species occur in the harbour. It is unlikely that they will establish at the disposal site because of the lack of hard substrates, depth and exposure.

Contaminants

Contaminant testing showed the materials to be dredged were not contaminated.

Geophysical Parameters

Batter slopes will be dredged within acceptable grades. In most areas along the channel, the new batters to facilitate channel widening will be within the existing batters. Only along the Aramoana side of Harrington Bend, and from opposite Deborah Bay to the swinging basin will the new batters rise into water shallower than 5 m deep. Changes in tidal flow velocity, range, and times will be insignificant.

Blasting

Port Otago Ltd. has previous experience with this method which includes keeping a good lookout for marine mammals and not blasting if any risk is present. The method will only be used to break up small rocky areas if all other means fail.

Monitoring

A comprehensive monitoring programme should be developed to measure the actual effects of the dredging programme and compare these with the estimated effects. Also, this programme should be able to identify impacts that are beyond those predicted as they occur during dredging. Dredging method can then be altered to reduce the impact.

With the completion of the harbour benthic study, fish and shellfish studies, quantified tuaki bed loss, and development of a monitoring programme, Port Otago will have addressed the ecological issues, and the potential impacts of the channel widening and deepening programme on flora and fauna, for Kāi Tahu Whānui.

8.0 Appendix

8.1 Calculation Of Mean Daily Deposition

Results from the following calculations are used in Section 5.1.3 Increased Sedimentation.

Dredge Zone	Model Output Factor (Sands)	% Dredging Days (Sands)	Model Output Factor (Silts)	% Dredging Days (Silts)	% Total Dredging Days
Harrington Bend	1.44	20.4%	0.57	8.1%	28.5%
Cross Channel	0.44	6.2%	0.32	4.5%	10.8%
Taylers Bend	0.28	4.0%	1.22	17.3%	21.2%
Basin West	0.03	0.4%	0.62	8.8%	9.2%
Basin East	1.18	16.7%	0.96	13.6%	30.3%

Table 5: Percentage of Dredging Days at Different Zones (Source data from Bell et al, 2009, p107)

Sub Area	% Area Deposition Zero	Mean Deposition (mm)	Maximum Deposition in 9% of Cells (mm)
Portobello Bay (Lower)	34.4	0.8	9.6
Deborah Bay	17.6	0.2	1.5
Spit Inter Tidal	34.6	0.1	0.9
Te Rauone Beach	36.2	0.5	4.0
Aramoana	63.3	0.1	1.2
Dowling Bay	18.8	0.1	1.2
Hamilton Bay	15.6	0.1	1.1
Harwood Inter Tidal	26.3	1.0	24.4
Port Inter Tidal	0.0	9.2	81.7
Pulling Inter Tidal	0.0	2.2	15.0
Tayler Inter Tidal	0.1	1.8	13.2
Centre Inter Tidal	0.0	0.6	4.8

Table 6: Predicted Deposition at Lower Harbour Sub Areas (Source data from Bell et al, 2009, p158)

Calculation of maximum mean daily deposition assumes 120 total dredging days and that maximum effect will be from dredging adjacent to sub area (Refer to Tables 5 & 6 for source values).

Port Inter Tidal

mm/day = 81.7 mm total for dredge programme ÷ [120 × (30.3% + 9.2%)]
= 1.72 mm

Harwood Inter Tidal

mm/day = 24.4 mm total for dredge programme ÷ [120 × (30.3% + 9.2% + 10.8% + 21.2%)]
= 0.29 mm

Pulling Inter Tidal

mm/day = 15.0 mm total for dredge programme ÷ [120 × (30.3% + 9.2% + 10.8% + 21.2%)]
= 0.17 mm

Tayler Inter Tidal

mm/day = 13.0 mm total for dredge programme ÷ [120 × (30.3% + 9.2% + 10.8% + 21.2%)]
= 0.15 mm

8.2 Drawings Of Geological Detail

8.3 Drawings Of Dredge Depths

8.4 Drawings of Batter Slope Detail

8.5 Historical Cross Sections

9.0 Acknowledgements

I would like to thank Tim Vial for editorial advice; Dr John Jillett and Dr Khyla Russell for advice and valuable discussion; and June Bridgeman for behind-the-scenes support.

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