BEFORE THE OTAGO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of an application for resource consents for Project Next Generation
BY	**PORT OTAGO LIMITED**
	Applicant

STATEMENT OF EVIDENCE OF MARK RICHARD JAMES
ON BEHALF OF PORT OTAGO LIMITED
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INTRODUCTION, QUALIFICATIONS AND EXPERIENCE

1. My full name is Mark Richard James. I am an aquatic ecologist holding the following degrees, BSc Victoria University, Wellington; BSc (Hons) Victoria University, Wellington and PhD (Aquatic Biology), University of Otago, Dunedin.

2. I have a background in basic and applied research in marine and freshwater ecology and biology with over 30 years experience in research, consulting and management of science organisations.

3. Following two years with the Institute of Nuclear Sciences, Department of Scientific & Industrial Research (DSIR) I was employed in 1982 by the Taupo Research Laboratory, DSIR, and became involved in ecological research in marine and lake environments. From 1982 until 1992 my research specialised in the ecology of plankton and benthic invertebrates and their role in aquatic food webs. These studies included physiological and ecological studies on benthic invertebrates and plankton ecology in both marine and freshwater ecosystems.

4. With the restructuring of DSIR I moved to Christchurch in 1992 as a scientist with the National Institute of Water & Atmospheric Research (NIWA). In 1994 I was appointed as a Project Director and led large multi-disciplinary Foundation for Research, Science & Technology (FRST) funded programmes on “Lake Ecosystems” and “Sustainability of Cultured and Coastal Shellfisheries”. In 2000 I moved to Hamilton to take up the position of Regional Manager with NIWA and in 2002 was appointed as NIWA’s Director Operations. In 2008 I retired from this position taking up a brief position as Chief Scientist for Environmental Information before leaving NIWA in late 2008 and setting up as a private environmental consultant and ecotour operator.

5. Since 1982 I have been involved in research on the ecology of marine systems. These studies aimed to gain a better understanding of ecological processes in coastal and open ocean systems. The FRST programme I led on “Sustainability of Coastal and Cultured Shellfisheries” was focussed on gaining a better understanding of ecological processes and the sustainable use of coastal systems. I have worked in New Zealand,

Finland, Denmark, Australia and in Antarctica. My research has been published in over 45 papers in scientific journals and books. These publications have included scientific papers in international journals on the ecology of marine invertebrates and coastal sustainability as well as the effects of sediments and other anthropogenic activities on aquatic ecosystems.

6. During my 30 years experience I have been involved with Regional Councils, government departments and industry in establishing guidelines for ecological assessments, providing descriptions of marine communities and assessments of potential ecological effects for a wide range of projects throughout New Zealand.

7. I have led a number of multidisciplinary ecological projects including studies on the management of coastal systems, effects of dredging, effects of discharges into lake, river and coastal systems and sustainable development of marine farming activities.

8. I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Consolidated Practice Note 2006 and I agree to comply with it. I have complied with it in the preparation of this statement of evidence.

BACKGROUND INFORMATION

9. I have been involved in Project Next Generation since 2007 as a Science Advisor and Marine Ecology expert. My evidence is based on extensive experience in marine ecology, published and unpublished reports, reports completed and work undertaken for Port Otago Ltd ("Port Otago") for Project Next Generation to fill gaps in our knowledge, the Assessment of Environmental Effects and statements of evidence of other experts giving evidence. I have visited the harbour on several occasions and completed my PhD on plankton ecology at Otago University.

10. There has been a considerable amount of work undertaken on the ecology of the Otago Harbour and offshore, particularly as part of university theses. However, these studies have been undertaken over some 50-60 years and often only focus on one part of the harbour or one

biological group. A review of the known information and discussions with stakeholders identified gaps which needed to be filled including the following:

a. A comprehensive survey of the benthic habitats, plants and animals in the Lower Harbour to provide the basis for an assessment of effects.

b. A survey of the benthic environment to describe the spatial distribution of habitat types and biological assemblages at potential disposal sites and the wider area that may be impacted by the disposal operation.

c. Observational surveys of foraging and roosting behaviour of birds around Aramoana and Port Chalmers.

d. A review of available information on the fish and shellfish resources of Otago Harbour and adjacent Otago coast.

e. Monitoring of background turbidity levels in Otago Harbour.

f. Based on the new studies and existing information an assessment of the potential effects of Next Generation on the ecology of the harbour, disposal site and downstream receiving environment.

11. I have overseen these scientific studies and in conjunction with other scientists I have prepared reports summarising existing information on Otago Harbour and offshore, and made an assessment of the potential ecological effects. The assessment report and my evidence relied on work carried out by a number of scientists including benthic ecology by Dr Brian Paavo (Benthic Science Ltd), Associate professor Keith Probert (University of Otago), and Dr Trevor Willis (NIWA). The assessment report and my evidence has been reviewed by Dr Drew Lohrer (NIWA). Reports from studies that have been used for my evidence are listed at the end of my evidence in Appendix 1.

SCOPE OF EVIDENCE

12. I have been asked by Port Otago to prepare evidence in relation to their proposed dredging and disposal of material from the Lower Otago Harbour and specifically to provide:

    a. A description of the aquatic ecology of the area of the proposed disposal site A0 and the wider receiving environment with a focus on benthic ecology and plankton ecology;

    b. An assessment of potential effects of the proposed dredging and disposal operations on the ecology of the aquatic communities in the Lower Otago Harbour and disposal area offshore.

13. A description of the benthic communities in the Lower Harbour will be provided by Associate Professor Keith Probert and Dr Paul Sagar, Martin Cawthorn and Rick Boyd will provide descriptions of the birdlife, mammals and fish respectively and assess effects on these groups.

14. In my evidence I first provide a very brief background to the dredging operation as it relates to potential ecological effects, give a general description of the Lower Otago Harbour, briefly summarise the benthic environment in the Lower Otago Harbour and benthic and planktonic communities offshore then provide an assessment of the potential effects on these habitats and communities.

EXECUTIVE SUMMARY

15. Port Otago has undertaken the most comprehensive survey of the benthic community in Otago Harbour and Blueskin Bay to date with over 180 sites examined and 190 species identified. Up to eleven habitat and community types were identified in the Harbour but generally the Lower Harbour is a mosaic of habitats with similar species occurring in most of the eleven habitat types. The exceptions are the deep-sessile and mudstone pavement communities which were only found in deeper pockets of the channel and near Wellers Rock.

16. The channel was dominated by rippled sand and sand with shell hash. The intertidal areas contained extensive areas with algal mats, seagrass

and cockles. The highest abundance of cockles found in the surveys was on the banks opposite Acheron Point and Pulling Point and near Harwood. No rare, unique or endangered species were found in samples of the soft-sediment or during surveys of rocky shores. The rare brachiopod *Pumilus antiquates* has been found in the past but was not found in targeted surveys carried out in 2010.

17. Effects of higher suspended sediments and increased sedimentation from capital dredging will be inevitable close to the channel in areas that are being dredged. In most of the intertidal areas levels are expected to be below thresholds that most of the benthic community can tolerate for short periods (2-4 weeks). Significant effects in the channel and on the margins are expected mostly to be short to medium-term and communities are expected to recover once major capital dredging is completed, but this could take several months to a few years. Incremental capital dredging is not expected to have a significant effect because of the low intensity and ability to manage the dredging programme to minimise impacts, if they were to occur.

18. Suspended sediment concentrations and deposition in sensitive and key areas like Te Rauone Beach and Aramoana are predicted to be low when capital dredging using a large contract dredge nearby (less than 200 mg/l and for less than 2% of the time, and less than 4 mm deposition over the dredging period). This is expected to have no more than a minor impact on the overall ecology of the Harbour. These areas would be subject to considerably lower concentrations when undertaking incremental capital dredging using New Era (up to 10 mg/l in patches, other areas would be negligible, if at all) and will be well below the levels that have been shown to impact on benthic communities.

19. Seagrass beds are recognised as critical habitat for a range of invertebrate species and as a nursery area for some fish species. The main beds are found in the middle of the intertidal flats with significant beds also close to Harwood. With major capital dredging most of these areas would experience less than 20 mg/l for periods up to 14 days and less than 20 mm sedimentation over the whole dredging period. Only small areas would receive higher concentrations and only for short periods

(less than 5% of the time). Most of the seagrass beds would be expected to persist as they can tolerate these levels for short periods. When undertaking incremental capital dredging with the smaller New Era type dredge, concentrations would be considerably lower (negligible but up to 10 mg/l in patches) and at levels that would not be expected to impact on seagrass beds.

20. Shellfish species of interest to recreational, cultural and commercial fishers include the cockle (tuaki), pipi and tuatua. These species are able to tolerate relatively high suspended sediment concentrations (up to 400 mg/l for cockles and 75 mg/l for pipi) for short periods (up to 13-14 days before condition declined) and although there could be some loss of populations where the channel is to be widened the major beds would be expected to persist and recover from any effects of the dredging operation. Of the total intertidal area (0-1 m above chart-datum) available in the Lower Harbour the area of intertidal sandflats to be widened represents less than 0.15%.

21. There may be limited areas of rock substrate (<1% of area) that will require blasting. It is expected that invertebrates and fish in the immediate vicinity of the blasting will be impacted. With appropriate mitigation most mobile species can avoid the blasting.

22. Some of the adverse effects of dredging cannot be avoided, particularly with major capital dredging. These effects though will generally be localised with direct effects on the benthic community mainly in areas to be widened and deeper parts of the channel. Recovery would occur over the short-term (several months) for many species (eg some polychaete worms and small bivalves) but could be several years for longer-lived species (eg sponges and tunicates). No community or habitat types will be lost long-term and there will be no large scale irreversible changes in the benthic community.

Surveys of the benthic community and sediment composition were carried out in the vicinity of the proposed disposal site (A0) and the wider Blueskin Bay area. These surveys confirmed a habitat of fine sand throughout the region.

23. The density and diversity of benthic animals was highest just north of the Otago harbour entrance and lowest in central and inner Blueskin Bay. The fauna in the offshore region was dominated by molluscs (gastropods and bivalves) and polychaete worms. Evidence for horse mussel beds nearby and deep burrowing heart-urchins were observed on recent surveys. Holes and burrows of shrimps were common throughout the region.

24. Recent targeted surveys around the disposal site A0 and to the north found abundance and diversity of the benthic community was higher at the site and up to 6 km to the north (extent of surveys) compared with to the south of the site. The fauna in the region of the proposed disposal site is typical of nearshore sand zones and no rare or unique species were recorded.

25. The offshore disposal site AO has been carefully chosen to avoid the sensitive bryozoans beds further offshore and to the southeast, and to be far enough offshore to have minimal impact on the coastal reefs and rocky areas.

26. Adverse effects on ecology from disposal of large volumes of spoil cannot be avoided. The main effects on the benthic community from disposal at the offshore site are smothering and increased turbidity. It is inevitable that with major capital dredging there will be significant short- to medium-term effects at the site itself with sedimentation predicted to be up to 1.7 mm/d (up to 1.7 m in total) and total suspended sediments concentrations up to 2100 mg/l on the seabed. There would still be an impact for a few kilometres to the north but concentrations would drop progressively to less than 20-30 mg/l. Most taxa could not survive repeated deposition in the vicinity of the disposal site and would be destroyed. Recovery of some groups, such as polychaete worms, could be in the order of up to a year but some larger, longer lived taxa could take several years to recover at the site itself once dredging was completed.

27. Sedimentation and suspended sediment levels would be considerably lower with incremental capital dredging using the smaller New Era dredge (0.04 mm/d if dredging continuously). The present macrofaunal community is made up of early successional species as well as larger

species characteristic of more mature communities. I would not expect significant changes in the community and functioning but there could be some changes and more subtle shifts to more of an early successional/opportunistic stage benthic community. Most groups would be expected to persist when dredging with the smaller dredge.

28. Concentrations of suspended sediments and deposition, if the plume were to reach the coastline, would be negligible. Predictions are that suspended sediment concentrations would be less than 3 mg/l and sedimentation 0.5 mm above background over the dredging period for major capital dredging. Suspended sediment concentrations would be no higher than 0.05 mg/l north of Cornish Head or 0.6 mg/l at the Otago Heads for incremental capital dredging using the smaller New Era type dredge. These concentrations would not be expected to have more than a minor impact, if any, on coastal communities.

29. Because of the low levels of major contaminants at the dredging sites, the effects from release of contaminants during dredging in the harbour, or at the disposal site if they were to occur, are likely to be at low levels and very short-term.

30. Fish and birdlife can be impacted directly through impacts on foraging success and indirectly through effects on their food resources. The increased levels of suspended sediments and reduced water clarity will affect the disposal site itself (A0) and immediately downstream as well as dredging sites but the levels of suspended sediments will be rapidly diluted away from these sites. Except in the immediate vicinity of the disposal site and during major capital dredging the levels predicted would not be expected to affect planktonic animals (food for seabirds and fish) and will be below the level set in the Port of Melbourne case to protect birds like terns and gannets (25 mg/l).

31. Most seabirds found in the area off Otago feed well offshore (e.g., endangered grey-headed mollymawk and northern royal albatross) or are predominantly bottom feeders at depths over 40m (e.g., sooty shearwaters and yellow-eyed penguins). However some birds such as shags and gulls may feed in the disposal area and along with some fish

species that feed on plankton or benthic biota may be affected in the immediate area, over the medium term, and may have to forage more widely during major capital dredging.

32. Although significant long-term effects are not expected, in order to minimise impacts if they do occur and to follow recovery, a comprehensive monitoring programme has been developed which includes measurements in the plume during dredging, the benthic community at representative and key sites in the harbour and offshore.

33. Mitigation measures proposed include managing the dredging operation where possible to avoid the critical part of the recruitment and breeding period for birds over spring and summer at Aramoana and off Taiaroa Head. This will also help mitigate impacts on benthic biota in the region if they were to occur. It is also proposed that when godwits are foraging on the intertidal flats at Aramoana in February and March that capital dredging is only undertaken when tidal height is above half-tide.

PROPOSED DREDGING AND DISPOSAL OPERATION

34. My evidence is based on the proposed dredging and disposal operation set out in detail in the application documents and as covered by other witnesses. I will not cover this in any detail here but essentially the proposed modification involves dredging the approaches to Port Chalmers and berth area and deepening of the channel. A few areas would also require widening (opposite the Port and at Harrington Bend). Less than 8,000 m^2 of intertidal area will be removed for the channel widening and mostly in the area immediately opposite the Port.

35. It is proposed to use a mixture of low intensity incremental capital dredging to remove up to 1.45 M m^3 per annum and dispose of the spoil using the existing disposal grounds (up to 450,000 m^3) and the proposed site at A0. At present three nearshore sites at Heyward Point, Aramaona and Shelly Beach are consented for disposal of maintenance dredge spoil up to a maximum annual volume of 450,000 m^3.

36. Depending on the final plans up to 7.2 M m^3 of sediment will need to be dredged and disposed of. Port Otago plan on using the existing disposal grounds for up to 450,000 m^3 per annum but the majority of it will be disposed of at site A0, about 6.5 km to the NE of Taiaroa Head. Precisely how much material ends up at A0 will depend upon the timing and the dredging plant used.

37. Most of the assessments in earlier reports focussed on the impacts of the major capital dredging programme. Port Otago require flexibility in their approach and ability to use a low intensity New Era type dredge with 600 m^3 hopper capacity for incremental capital works over a number of years, or a large trailer suction hopper dredge (TSHD) with the large dredge only being used when there is demand from shipping lines. While the modelling for incremental capital dredging assumes a continuous 24/7 operation with a New Era type dredge the most likely scenario is about 50% utilisation on an annual basis with intensive periods and then periods of no dredging due to maintenance requirements or when the dredge is being used elsewhere.

GENERAL DESCRIPTION OF LOWER OTAGO HARBOUR

38. Otago Harbour is a long and narrow inlet about 22-23 km long and generally about 2 km wide. Peninsulas at Port Chalmers and Portobello and their adjacent islands divide the Harbour into upper and lower basins referred to in my evidence as the Upper and Lower Harbours (see Figure 1). Other than the main channel, Otago Harbour is mostly shallow with an average depth of 3.3 m and with extensive tidal flats. Outside the main channels water depths are mostly less than 2 m and nearly 30% of the Harbour comprises exposed sediment flats at low spring tides. Other than in the main channel, naturally deep areas (up to 30 m deep) are found between Quarantine and Goat Islands.

39. The Harbour is the only large non-estuarine inlet on the south-east coast of New Zealand and thus has a number of sheltered water habitats that are not widely represented elsewhere in this biogeographical region. Most of the harbour, however, has been significantly modified by human activities including reclamation of a number of areas, catchment activities and dredging and most areas experiences episodic inputs and

resuspension of suspended sediments, which increase turbidity, through natural events.

40. Sediments in the Harbour graduate from finer muddier sediments in the Upper Harbour to coarser fine sand towards the entrance, with fine sand on the intertidal flats. Offshore sediments are fine, well-compacted sands with higher silt content in the middle of Blueskin Bay (see Figure 2 from Willis et al. 2008).

41. Most estuarine and harbour environments experience periods of high turbidity during periods of runoff, resuspension by winds and waves and other point source discharges. There is no ongoing monitoring of suspended sediments or turbidity in the harbour but three months of monitoring by NIWA for Port Otago at two sites, one in the Lower Harbour and one in the Upper Harbour, found that turbidity varied between 1 and 6 NTU with highest concentrations of 6.4 NTU and 6.5 milligrams per litre (mg/l) suspended sediments during a storm event. Kd (a measure of the rate of reduction of light with depth) varied from 0.11 m^{-1} to 0.33 m^{-1} but rose to 2.14 m^{-1} during the storm event. Occasional measurements in the past have recorded concentrations in the range 5.6-215 mg/l in the Lower Harbour and up to 1146 mg/l in Sawyers Bay in the Upper Harbour.

42. Contaminants will be covered by other witnesses but in the Port area and channel to be dredged levels were generally found to be low and below the New Zealand Guidelines for Sea Disposal of Waste (NZGSDW) and the ANZECC guidelines for maintaining biological systems. Arsenic levels in a small area of the basin slightly exceeded the low range criteria in the NZGSDW. The NZGSDW were developed to implement the provisions of the London Convention (2006).

43. A full description of the existing hydrodynamic and physical features of the harbour will be presented by other witnesses and are not repeated here. Similarly the physical features of the offshore environment have been presented by Drs Rob Bell and Martin Single. Associate Professor Keith Probert has covered a description of the benthic community in the Lower Harbour which I briefly summarise below.

Lower Harbour Benthic Community

44. Port Otago has undertaken the most comprehensive survey of the benthic community in Otago Harbour and Blueskin Bay to date with over 180 sites examined and 190 species identified. Up to eleven habitat and community types were identified in the Lower Harbour with a mosaic of habitats with similar species occurring in most of the eleven habitat types. Thus the Lower Harbour can essentially be treated as "one system". The exceptions are the deep-sessile and mudstone pavement communities which were only found in deeper pockets of the channel and near Wellers Rock.

45. The channel was dominated by rippled sand and sand with shell hash. The intertidal areas contained extensive areas with algal mats, seagrass and cockles. The highest abundance of cockles was on the banks opposite Acheron Point and Pulling Point and near Harwood (see Figure 1 for locations). No rare, unique or endangered species were found in samples of the soft-sediment or during surveys of rocky shores. The rare brachiopod *Pumilus antiquates* has been found in the past but was not found in targeted surveys carried out in 2010 (Robinson 2010).

EVIDENCE

BENTHIC HABITAT OFF THE OTAGO COAST

46. Recent surveys of the benthic environment off the Otago Coast, undertaken for Port Otago as part of the ecological studies, found well consolidated, homogenous, well-sorted fine sands throughout most of Blueskin Bay. Silt content and organic matter were found to be highest in the centre of outer Blueskin Bay (see Figures 2 and 3). Shallower parts of the Bay and the area east of Taiaroa Head had slightly coarser, fine sand. The adjacent continental shelf is relatively narrow but widens to about 30 km in Blueskin Bay to the north. Most of the sands in the nearshore region and in the Lower Harbour are derived ultimately from the Clutha River to the south.

47. The benthic environment of the Otago coast consists of wave-exposed sandy beaches with a typical, but until recently poorly known, fauna

dominated by amphipod crustaceans, gastropod molluscs, bivalves and polychaete worms and rocky shores characterised by kelp beds and higher up the rocky shores by barnacles and periwinkle snails.

48. Before being able to make an assessment of potential effects on an environment it is essential to have a good description of the distribution and abundance of existing benthic biota. To gain a better understanding of the habitats and communities at the offshore AO and wider receiving environment of Blue Skin Bay NIWA undertook surveys in April/May 2008 (Willis et al. 2008).

49. The fauna was dominated by the gastropod (snail) *Antisolarium egenum*, followed by three polychaete worms and the ubiquitous bivalve *Nucula nitidula.* Depth and type of sediment appeared to be the main determinants of the benthic assemblage. For example, certain polychaete worm families and a small cumacea (a small crustacean) occurred in their highest densities in the very fine sand/silt basin the middle of Blueskin Bay. Conversely, the snails *Antisolarium egenum* and wheel shell *Zethalia zelandica* were associated with shallow, inner bay regions. Amphipoda (small crustaceans) and Tellinidae (a bivalve) characterised coarser, deeper habitats (see Figure 4). The wheel shell and amphipods have also been found to dominate the macrofauna community at the inshore maintenance disposal sites (Paavo and Probert 2005)

50. Although not sampled as part of the recent surveys the coarser gravelly sediments of the middle and outer shelf are known to provide a diverse habitat with attached epifauna and most notably several species of bryozoans or “lace corals” are found at depths of 70-110 m (see Figure 5). These communities along with queen scallop beds are found well offshore and mainly to the south of the proposed disposal grounds. The disposal site AO finally settled on was carefully chosen to avoid any potential impact on these sensitive communities and, therefore these communities are not considered further here.

51. As shown in Figure 6 total faunal densities were found to be highest in the area just north of the Otago Harbour entrance and lowest in the middle of the Bay, close to the coast in Blueskin Bay and offshore. Species richness

ranged from 10 to 39 taxa per site with the most diverse area being just north of the Harbour entrance and the least diverse in inner Blueskin Bay and well to the east of the Peninsula (see Figure 6).

52. The surveys undertaken in 2008 (Willis et al. 2008) included two potential disposal sites identified as either Box A or Box B (later referred to as A1 and A2) some 4 km and 9 km off Taiaroa Head respectively (see Figure 2 for locations). The closer site (Box A/A1) was more turbid and total faunal densities were higher than the site further offshore (Box B/A2), but the latter contained more epifauna (large tubeworms, whelks). Tube worms appeared to be in higher densities shoreward of the 30 m depth contour. Box A/A1 was subsequently discarded as a potential disposal site because of the persistent eddies and potential onshore movement of a sediment plume. A0 some 4 nm north-east of the Mole (see Figure 7 for location) was subsequently selected as the disposal site based on it having no special ecological features and outside the influence of eddies off Taiaroa Head.

53. In late 2010 Port Otago commissioned Benthic Science Ltd to undertake a targeted survey around the disposal site A0 and to the north (6km) and south (2km) (see Figure 7 for sites). These surveys confirmed that the benthic habitat in the study area was rippled fine sand but with slightly finer substrate to the north.

54. Total faunal abundance and diversity was higher at site A0 and up to 6 km to the north (extent of surveys) compared with to the south of the site. The dominant species were the same as those recorded from the wider Blueskin Bay in earlier surveys (the ostrich-foot shell *Struthiolaria papulosa*, ubiquitous bivalve *Nucula nitidula*, small gastropod snail *Antisolarium egenum* and polychaete worms). The carnivorous knobbed whelk *Austrofusus glans* was also common and there is some evidence of patches of horse mussels near the site and to the north. The deposit feeding heart-urchin *Echinocardium chordatum* was also recorded.

55. A range of macrofaunal burrows or holes were observed throughout the area with highest densities at the southern sites (south of A0). These

holes were most likely created by different species of mantis and ghost shrimp.

56. The macrofaunal abundance and taxon richness in the depositional area in the vicinity of site A0 did not show strong spatial variability but abundance and diversity tended to be lower at the sites south of A0. Macrofaunal assemblages were relatively uniform over the area unlike the inshore maintenance sites which vary greatly over small distances depending on bathymetry, sediments and wave exposure (Paavo and Probert 2005).

57. The fine-sand habitat in the vicinity of AO is part of an extensive northerly aligned submergent sand deposit. The fauna found in the vicinity of the disposal site AO and to the north are typically robust mobile species typical of nearshore sand zones in water depths of about 30 m. The fauna also has similarities with comparable habitats elsewhere, except that gastropods rather than bivalves dominated the molluscan community. No rare or unique species were recorded in recent surveys at the level of taxonomic detail used and commonly applied. I note that in Clause 387 of the ORC Officers Report it states that sensitive or rare species or communities were identified in the surveys around disposal site A0 but I am not aware of any threatened or rare species identified in surveys.

58. The open coastal area north of Otago Peninsula to Cornish Head is comprised of wave-exposed sandy beaches and rocky shores with reefs characterised by large kelp beds. These kelp beds are a very important habitat for a range of faunal species and contain a highly diverse macroinvertebrate and fish community. Many species are important to local iwi including occupants of the kelp beds and rocky reefs such as red rock lobster, paua and kina. The coast also contains the largest beds of *Macrocystis* around the New Zealand main land. The extent of these beds is highly variable with time depending on recent storm history, wave climate and light availability.

PLANKTONIC HABITAT

59. The Otago Harbour in general supports a range of planktonic taxa, including crustacean copepods which are generally the most abundant members of the permanent community. At certain times of the year, particularly spring and summer, the community can contain large numbers of temporary larvae including the euphausiid *Nyctiphanes australis* and lobster-krill *Munida gregaria* which are an important food source for birds.

60. The planktonic environment off the Otago coast is complex and dynamic with at least three major water masses. Inshore waters contain mainly neritic species (neritic being the zone between low tide and the edge of the continental shelf) with the community in the middle of Blueskin Bay being mainly meroplankton larvae (spend only part of their life in the plankton).There is a mixed fauna of oceanic and neritic species over the mid-shelf and north of Blueskin Bay. A similar mixed community would be expected to occur at site A0. Physical processes rather than biological processes appear to structure the spatial patterns of zooplankton in the region with the eddy systems acting as a recruitment and retention mechanism for coastal species.

POTENTIAL EFFECTS OF THE DREDGING

61. Biological communities in estuaries and inlets are adapted to dynamic environments with strong physical processes and episodic events such as storms, wave activity and high runoff.

62. Some adverse effects from capital dredging cannot be avoided. The main potential effects of capital dredging on the ecology of the Otago region are shown schematically in Figure 8. They are:
    a. Direct impacts through removal and disturbance of benthic communities in the channel itself and areas to be widened.
    b. Smothering of benthic communities through settling out of suspended sediments wherever a plume disperses.
    c. Increases in suspended sediments causing increased water turbidity and reduced water clarity.
    d. Release of contaminants.
    e. Direct effects of blasting.
    f. Potential for spread of invasive species.

63. Each of these potential impacts, both direct and indirect, have been considered for the benthic communities, fish, birds and mammals. Impacts on fish, birds and mammals will be being dealt with by other witnesses.

64. The impact of dredging and disposal of dredged material largely depends on the nature of the material being dredged and characteristics of the disposal area. The most significant effects are likely to be through direct removal of organisms, and the increase in suspended sediment and sediment deposition. These can potentially be of high severity but are generally restricted in extent (near field or less than 1 km) and duration (short-medium term or up to a few years).

65. The approach taken by Port Otago with assessing the potential effects of dredging and disposal of material is in accordance with the NZ Guidelines for Sea Disposal of Waste (MSA 1999) - NZGSDW. These guidelines were modelled on the guidelines produced by Environment Australia (2002) which were subsequently updated in 2009 – National Assessment Guidelines for Dredging (Australian Government). The NZGSDW give effect to the London Convention (1972) and Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (London Convention 1996 and updated 2006).

66. It should be noted here that some of the London Convention, 1996 protocol, and other European guidelines which give effect to the London Convention, were largely designed around disposal of spoil with high contaminant loads which is more common in that part of the world and would not be expected to be an issue with the Port Otago dredging.

67. In terms of assessment of effects and evaluation of potential impacts the guidelines and protocols promote the importance of deposition and transport of material outside the disposal site and the physical effects on marine benthos, sediment fluxes and processes. The nature, temporal and spatial scales and duration of expected impacts need to be defined based on reasonably conservative assumptions (London Convention 2006). Disposal sites should be sufficiently removed from ecological sensitive or incompatible areas to avoid or minimise adverse

environmental effects. Monitoring should be used to verify consent conditions i.e compliance monitoring and that assumptions made were correct and sufficient to protect the environment (London Convention 2006). This approach has been taken in the preparation of reports on the assessment of ecological effects of the proposed dredging by Port Otago.

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68. Each of the potential effects in relation to the proposed dredging programme is discussed below. The physical changes as a result of the proposed dredging are discussed by Dr Rob Bell in his evidence and are only summarised here, where required, to put into context.

Classification of Effects – Methodology

69. A useful and common way to classify effects is using severity, duration and extent.

Severity

70. Although there are no hard and fast rules for this classification severity looks at threats to critical food, impact on species important for structure or functioning of the system, changes in diversity and environmental quality.

Duration

71. Short-term effects can be classified as those lasting less than one year, medium 1-5 years and long-term greater than 5 years.

Extent

72. Site specific effects are those limited to the site itself, near-field or localised as those less than one km from the operation and far-field or regional those effects greater than one km away.

What are the effects of dredging on benthic communities in the Lower Harbour – physical disturbance and recovery?

73. Capital dredging operations, such as those proposed by Port Otago Ltd, do cause physical disturbance of the benthic environment through destruction, removal or disturbance of animals and plants living on or in the sediments.

Benthic community

74. Habitats and communities in the channel are already modified through channel formation over many years and maintenance dredging. However, most of these communities, except a few very deep burrowing animals or mobile surface animals that can avoid the operations, will be significantly impacted in areas that are dredged during major capital dredging and marginal areas where the channel is to be widened. These impacts will be site specific but with major capital dredging most animals and plants from Port Chalmers to the entrance, where it is to be dredged will be removed, destroyed or heavily disturbed resulting in loss or modification of communities and habitats, in the short to medium-term duration i.e up to several years.

75. The effect is expected to be considerably less when undertaking incremental capital dredging with a New Era type dredge and an opportunistic community plants and animals would be expected to persist.

76. The only intertidal area of the Lower Harbour that will be directly, significantly impacted in terms of severity is the channel margins close to the Port. Most of the area to be widened in the immediate vicinity of the Port is composed of medium sand with sparse patches of algae and relict shells. Cockles or tuaki (true name is little neck clam) were found in relatively low numbers close to the channel opposite the Port (less than 10 per m^2) with denser populations on the flats to the north-east (opposite Acheron Point) and close to Harwood. The widening will directly impact up to 8000 m^2 of intertidal area but to put this into context this is less than 0.15% of the extent of the area of the Lower Harbour between 0.0 and 1.0 m above chart datum or less than 2% of this type of habitat classified by Paavo et al. (2008) in the Lower Harbour.

77. The area to be widened at Harington Bend is mostly sub-tidal and smaller than in the Swinging Basin. A small area of subtidal habitat which contains seagrass and reportedly tuatua beds will be lost during widening but the benthic communities would be expected to re-establish once capital dredging has been completed. Tuatua are more characteristic of surf beaches and larvae would readily re-establish in the area as long as the

conditions were suitable, thus the effects in terms of duration and extent would be short to medium term (1-5 years) and likely to only impact on a small area.

78. Sediments in the channel are already highly modified and disturbed by natural events and maintenance dredging in many areas. However even though dense mats of compacted tube worms and some deep sessile communities prevail under present disturbances some of these communities will be lost during major capital dredging and possibly to a limited extent with New Era type dredging.

Recovery

79. Recovery of animals in the channel and areas to be widened following dredging depends on the extent of the disturbance, nature and potential for recolonisation. Recolonisation can occur through advection or settlement of larval stages and through horizontal bed transport of juveniles and adults. Recovery will be most rapid where the channel is predominantly silt/muds with opportunistic/early succession species like polychaete worms recovering on a timescale of a few weeks to months. Recovery of coarser sediment habitats and longer lived species could take two to three years and deep sessile communities several years to recover. Areas around the Port are predominantly finer material and the pre-dredge community is likely to recover quicker than outer regions which are predominantly coarser sand.

80. Recovery of these communities following major capital dredging would be expected in the medium term (1-5 years) to longer term (several years). Similar communities of sponges and tunicates are found around Wellers Rock where there will be no direct disturbance and some parts of rocky habitat and some deeper areas with deep sessile communities will not be directly physically impacted by the dredging because they are below the level to be dredged. These latter areas will be subject to sedimentation, however in time (months to a few years) these would be flushed of finer sediment and be expected to recover.

81. It is unlikely that new habitats will be created by the dredging operation or that existing habitats will be lost. Most of the communities found in the

Lower Harbour are well represented elsewhere in the Harbour except for the deep, sessile communities in the deeper sub-channels and hollows. Many of these communities would be impacted either directly (dredging itself) or indirectly (sedimentation) and would be lost but would start recovering once dredging was completed and would be expected to recolonise but it could take several years to re-establish.

82. I would not expect any community types to be lost from the Harbour because there is a mosaic of communities with no type restricted to only one habitat. Thus areas subject to local disturbances would be gradually recolonised from neighbouring areas. The most sensitive communities would be the deep-sessile ones in the channel which consists of large numbers of filter feeders and exist because of scouring of the bed and strong tidal flows. Some of the pockets with this type of community will not be directly affected but will infill with fine sediment until it is flushed out by the strong flows. I would expect these areas to recover but it could take several years because the fauna in these communities tend to be long-lived and slow colonisers.

What are the effects of dredging on benthic communities in the harbour – suspended sediments and turbidity?

83. An increase in suspended sediments and resulting higher turbidity and lower water clarity is associated with most dredging operations as a result of physical disturbance of the seabed, release of sediment/water mix during dredging and disposal, and subsequent resuspension of settled sediments by wave activity. A summary of potential direct and indirect effects from suspended sediments and turbidity is shown schematically in Figure 8. Harbours are naturally turbid at times and most communities can tolerate periods of relatively high suspended sediment concentrations and low water clarity, but many for only short periods (weeks). With incremental dredging these effects can be mitigated by managing the dredging operations to ensure sensitive areas are not exposed to high levels for long periods.

84. Direct physical effects of suspended sediments on biota include clogging of gills and impairment of respiration and feeding for filter feeders. Many

taxa, including some polychaete worms, cockles (tuaki), mussels, brachiopods and zooplankton feed by filtering plankton cells out of the water column and can thus be vulnerable to high sediment loads. In extreme cases high sediment loads can lead to changes and a community dominated by deposit feeders rather than filter feeders.

Benthic animals

85. Taxa which are important for food gathering in the Otago Harbour, such as cockles (tuaki), pipis and tuatua feed on small particles (<20 um) and while they are able to tolerate relatively high concentrations of suspended sediments, which can occur naturally, continuous exposure at high concentrations can impact their feeding, condition and growth. Some taxa actually benefit from small amounts of sediment. Experiments over a 14 day period have shown that a peak in condition for the cockle *Austrovenus stutchburyi* can occur at about 400 mg/l before condition starts to decline, oyster eggs were impacted at levels over 188 mg/l and oyster larvae at levels over 750 mg/l. In general suspended sediment concentrations of 100 mg/l with high organic content, can be beneficial for *Austrovenus* unless it persists for more than 25% of the time.

86. Some species like the greenshell mussel *Perna canaliculus* can tolerate up to 1000 mg/l, the wedge shell (*Macomona liliana*) 300 mg/l, the polychaete worm *Boccardia syrtis* and snail *Zeacumantus lutulentus* at least 750 mg/l. Some taxa like the horse mussel (*Atrina*) and pipi (*Paphies australis*) are more sensitive and condition is impacted at levels over 75-80 mg/l, if it occurs at this level for over 13 days.

87. The most obvious initial impact is a turbid plume and deposition associated with the dredging operation. Modelling of concentrations during <u>major capital dredging</u> with the large capital dredge predicts that levels in the plume could be an order of magnitude higher than with incremental capital dredging with over 1000 mg/l for short periods (but for <5% of the time over a 14 day period) in patches in the immediate vicinity close to the main channel around the Port. Apart from this region intertidal areas would be subject to high levels (400 mg/l or 320 mg/l dry-weight) for less than 8 % of the time in spells of 14 days or less. The intertidal area opposite the Port could receive over 400 mg/l but for less than 8% of the

time over a 14 day period of dredging, except when the dredge was operating continuously in this area when it could be up to 24 % of the time over a 14 day period.

88. Concentrations in the intertidal areas, including the cockle beds opposite Acheron Point, are predicted to be up to 200 mg/l (high only on channel margins near the Port) and there could be short periods when concentrations could be over 1000 mg/l above the beds opposite Acheron Head and Pulling Points when dredging Harrington Bend. This could lead to reduced condition in cockles over a period of a few months. Concentrations in sensitive areas like off Harwood would be undetectable most of the time, with only small areas experiencing over 20 mg/l (see Figure 9).

89. Depth-averaged suspended sediment concentrations averaged over a two week period during incremental capital dredging with the smaller New Era type dredge and working continuously are predicted to reach 20-50 mg/l above background (which is 2-4 NTU or about 2-5 mg/l, Baddock 2008) in the main channel with smaller patches from 50-100 mg/l where the dredge is operating. Concentrations in the intertidal areas are predicted to only reach 20 mg/l with limited areas up to 50 mg/l. The area from Te Rauone Beach to Portobello Bay is not predicted to be affected except for a few small patches which could experience up to 10 mg/l above background.

90. The important large cockle beds opposite Acheron and Pulling Points would be unlikely to be subjected to these high levels for long periods (i.e > 14 days). Most of the intertidal areas would experience less than 20 mg/l during incremental capital dredging with New Era with many areas such as along the coastline from Te Rauone to Portobello being largely unaffected (refer Figure 9). Levels of up to 20 mg/l are well below concentrations known to impact on benthic biota. There could be some subtle changes in community composition and production but these would be unlikely to significantly affect the functioning of the system or to persist once dredging ceased or moved to another area.

91. The only rare or endangered benthic species that has been identified in the Harbour from past surveys is the small brachiopod *Pumilus antiquatus*. No *P. antiquatus* were found in recent comprehensive

surveys, including surveys targeted at this species (Robinson 2010). As a group brachiopods are known from muddy sediments and have been recorded on turbid headlands in Otago Harbour and from turbid parts of Lyttleton Harbour. Feeding experiments found brachiopods were adversely affected at suspended sediment levels of 50 mg/l.

Seagrass

92. Increased suspended sediment concentrations will lead to lower water clarity (refer Figure 8) which in turn can impact on photosynthesis and growth of aquatic plants. The most sensitive communities are likely to be the seagrass communities, with the beds close to the channel where it is to be dredged and widened the most vulnerable. The aerial extent of the turbid plumes will partly be determined by prevailing wind and state of the tide but generally the most significant impacts will be restricted to the channel areas in the near-field east of the Port (<1 km) and far-field (few kms) to the south-east of the Port and south towards Latham Bay where seagrass are not common (but they have been recorded on the north-east side of Quarantine Island).

93. Predictions are that most of the tidal flats would be largely unaffected but close to the channel seagrass beds could experience up to 100-200 mg/l (likely to be 80-160 mg/l dry-weight) during major capital dredging using the larger dredge (see Figure 9 for comparison of distribution of habitat types and the predicted plume of suspended sediments). In areas like Harwood where seagrass beds can cover an area up to 80 ha, and intertidal flats away from the channel (large beds were found in the middle of the main sandflats - see Figure 9), increases in suspended sediment concentrations would be undetectable most of the time and there would only be short episodic periods when concentrations would be above 20 mg/l. Concentrations during dredging with the New Era type dredge are predicted to be under 20 mg/l and many areas such as the beds off Harwood would be largely unaffected.

94. Plants respond to decreased water clarity rather than suspended sediment concentrations. Recent studies in New Zealand have indicated seagrass require 15-40% of surface irradiation to protect them. Recent measurements of light attenuation in the harbour range from 0.1-2.0 m^{-1}

which at 15% of surface light, corresponds to 18.5 m to 0.9 m water depth. Most of the community in Otago Harbour appear to be intertidal beds which would still receive sufficient light at low tide.

95. Parts of the intertidal area opposite the Port and Acheron Point could be subject to levels above 75 mg/l (50-60 dry-weight SSC) for 1-5 % of the time during major capital dredging using the larger dredge, particularly when dredging nearby (see Figure 9) and thus could be termed at least as a "moderate" impact. The impact in areas like Harwood where the most significant beds occur and other intertidal areas would be termed as "slight" impacts. I would not expect to see changes in the seagrass beds as a result of incremental capital dredging with New Era type dredge. The existing beds have developed with New Era undertaking maintenance dredging and when using this for incremental capital dredging there would be substantial periods when there was no dredging operations.

96. In terms of recovery new shoots of seagrass have been observed within 2 months of removal of surface stems (Miller 1988) and thus I would expect the seagrass beds, if they were impacted, to have started recovering within a year after major capital dredging had finished. If whole plants were impacted recovery could take several years but this is not expected to be the case.

97. I have recommended that the large seagrass beds off Harwood and possibly other sites are monitored before and after the dredging programme and a site nearby is continuously monitored for turbidity to ensure levels are not higher than predicted in this region or exceed an environmental trigger level of 25 mg/l or 25 NTU (see monitoring section).

What are the effects of dredging on soft sediment and rocky shore communities – settlement of suspended sediments?

98. When sediments settle out of the water column they can smother benthic organisms and depending on the amount and type of material can change sediment characteristics and community structure (see Figure 8 for schematic diagram). Small and recently settled life-stages of many species are especially vulnerable to smothering as are organisms that must maintain contact with the sediment-water interface.

99. Habitats around the Port and out to Cross Channel have higher proportions of finer sediments and thus settling of finer suspended sediments is unlikely to cause significant shifts in community structure in these areas. In the lower regions of the channel towards the entrance, characterised by coarser sand sediments, there could be a temporary change to more of a deposit-feeding community. However, high current flows in these areas would be expected to gradually remove the finer material and return the community to its previous state.

100. Similarly the deep sessile communities found in sub-channels and holes along the main channel (refer Figure 9) would be impacted in the short to medium term (likely to be up to 5 years) until sediment is flushed out and animals and plants can recolonise. During major capital dredging in these areas there could be over 3.8 mm over a 14 day period depositing in the channel and channel margins (i.e over 0.27 mm/d) and possibly even more in the sub-channels and holes where these communities are found. Studies have found that levels less than 1.7 mm over a 14 day period did not have an impact on sessile communities, similar to those communities found in the Lower Harbour. If the communities were lost then I would expect it would be some time before they recolonised (several years).

101. Incremental capital dredging with a smaller dredge would have a much reduced impact with predictions being that settlement of 0.3 mm/d would be confined to the immediate vicinity of the shipping channel. Most of the eastern part of the Harbour would be subject to negligible or no deposition except west of Latham Bay when dredging in the turning basin when there could be 0.4 mm deposition over a 2 week period. Intertidal flats are predicted to receive less than 0.03 mm/d during dredging. The existing community appears to be able to survive and prosper under the existing regime of maintenance dredging with New Era and would probably continue to do so with incremental capital dredging using a similar dredge.

Benthic animals and algae

102. Benthic animals and plants found in intertidal flat areas of the harbour are exposed to periodic high sediment loads during storms and high discharges from catchment runoff. Experiments in harbours in the

Auckland region have demonstrated that clay layers as thin as 3-7 mm had some impact on macrofauna but were relatively short-term. Rapid accumulations of 20 mm however, can smother entire benthic communities (Norrko et al. 1999) with recovery taking in the order of a few months for opportunistic taxa like some polychaete worms but several months to a few years for larger taxa like gastropod snails. It needs to be remembered that many of these experiments were with clay-size particles which formed a cap over the marine sediments and thus can be considered a worst case scenario.

103. Shrimps and some crabs can survive up to 9 cm of deposition but cockles and other molluscs generally start responding at levels of 20-30 mm, depending on the grain size. Cockles (tuaki), pipis and tuatua are important for recreational gatherers in the Harbour and can be found in sediments with 10-85% silt content but the optimum range is 5-10% mud content. Pipis are less tolerant and although being found in sediment with up to 60% mud/clay their optimum level is <5% mud (Gibbs and Hewitt 2004). Experiments have shown that cockles can survive burial under several centimetres of sand but only up to 30 mm of fine silt. Pipi are active burrowers and can be found buried in up to 100 mm of sand and larger ones can even tolerate up to 400 mm.

104. While limpets and whelks are highly sensitive to the silt /clay content of the substrates some surface grazing animals like the gastropod snail *Zeacumantus lutulentus* are relatively robust to high levels of settled sediments and some crabs show a preference for fine silts and muds.

105. Most of the fine material in the turbid plume will remain in the channel for a short period or be flushed out to sea but some of the fine silt and clay will disperse beyond the channel on to intertidal flats during high tide. Because of the dredging of shallow areas close to the Port during widening, and the finer sediments which occur in this area, there will be the potential for higher sedimentation rates and significant localised effects. Predictions are that with <u>major capital dredging</u> the average deposition over the dredging period in this area will be 9 mm but up to 10% of the intertidal zone in this area (10.5 ha) could receive over 23 mm

and very small areas (<1% of the area or 1.1 ha) would be subject to over 80 mm over a 14 day period of dredging in the immediate vicinity.

106. Predictions are that with major capital dredging most intertidal areas away from the margins will receive little (< 1.0 mm/d) or no deposition. Less than 10% of non-channel areas (except opposite the Port) are likely to receive 6 mm or more over the whole dredging operation. The average deposition in areas like Aramoana, Te Rauone beach and inner Harwood would be less than 1.0 mm over the whole dredging period but very small areas (<1% of sub-areas) could receive over 4 mm at Te Rauone Beach (0.5 ha), over 1.2 mm at Aramoana (3.1 ha) and 24 mm at Harwood (3.1 ha). Ninety-nine percent of these areas however will receive deposition rates of no more than 1 mm/day thus even with major capital dredging sedimentation is not expected to have a significant impact on the communities and habitats in areas away from the channel.

Algae

107. Average deposition in the intertidal area of the Upper Harbour is predicted to be less than 2 mm over the dredging period so there is likely to be little impact as a result of the dredging. It must also be kept in mind that these communities are generally dominated by polychaete worms and molluscs which are often deposit feeders and can tolerate the finer sediments in the Upper Harbour.

108. Deposits of up to 3-7 mm can have a negative effect on microphytes (microscopic benthic algae) and repeated additions of 3 mm over several months elsewhere have been found to have a cumulative effect. Most of the micro-algal beds in the intertidal regions should survive the sedimentation rates predicted during the dredging. If some patches were lost they would be likely to recolonise in the short-term (less than a year).

109. The deposition levels discussed above were all for major capital dredging. Incremental capital dredging with a New Era type dredge will result in negligible or very low deposition rates (<0.03 mm/d). Such low levels would not be expected to have any observable impact on benthic communities including benthic plants and the animals such as paua that feed on them.

Seagrass

110. Settlement of fine material may result in smothering and burial of seagrass beds. Smothering can have direct physical effects and can also reduce light availability and thus photosynthesis. Most seagrass species can survive moderate levels of settlement. Although there is no data for New Zealand seagrasses, overseas studies of similar species suggest that they can grow through 2 cm in 4 months and thus it has been recommended in overseas studies that to maintain seagrass beds, short-term sedimentation (i.e over time spans less than 2 months) should not exceed 5 cm. From the modelling to date large areas occupied by seagrass and important beds close to Harwood are unlikely to be subject to this level of sedimentation, except perhaps the small beds around Quarantine Island. Seagrass beds can trap sediments resulting in additional accumulation. This was not quantified in the model but even with major capital dredging it is unlikely to result in levels that would significantly impact on seagrass beds, well away from the channel. As long as the plants are not destroyed then they would be expected to recover over time as the sediment was dispersed and new growth occured.

Macroalgae and rocky shores

111. In general the deleterious direct impacts of sedimentation for macroalgae and rocky shore communities are associated with settlement, recruitment, growth and survival. Indirect effects include loss of photosynthetic capacity with a film of a few millimetres of sediment potentially reducing photosynthesis of plants. While most established alga can survive burial for short periods attachment of germlings can be impacted by a light dusting of sediment while relatively heavy settlement (2 mm) can prevent attachment altogether. Predictions are that most of the rocky areas in the Lower Harbour (except around Quarantine Island) would receive less than 1 mm of sedimentation over a 14 day period when <u>major capital dredging</u> was taking place nearby. Thus I would not expect these communities to be significantly impacted and any sedimented material would be rapidly mobilised by current flow.

112. Invertebrates which graze on algae are generally not affected by small amounts of sediments and the likes of limpets and some gastropods are

very effective at moving sediment around so that they can access the algae below. One of the few references to the large dredging programme in the 1970s was that grazing molluscs were able to keep the substrate free of mud build-up during experiments that were being run at the time (Raffaelli 1979), which is consistent with observations above.

113. Studies elsewhere have found sedimentation can also affect rocky reef areas because kelp spores need a hard surface to attach themselves to. Juvenile paua also find it hard to establish on surfaces covered by a fine layer of mud or silt.

114. I am not aware of any guidelines or broad generalisations about levels of sediment that macroalgae can tolerate but some open coast species of macroalgae can survive extended periods of burial with cycles of beach building and erosion. For example, the open coast species of *Gracilaria* can be buried for days to weeks and photosynthetic capacity can re-activate once the plants are uncovered through scouring and wave activity. Some intertidal algae can remain intact after 3 months of burial but growth is inhibited, while others do not survive burial under thick sediments for a month.

115. Coralline crusts have been found to be unaffected by burial in sand for a few months but there can be significant mortality of the sea lettuce *Ulva*. The invasive *Undaria* can compete with other macroalgae such as *Macrocystis*, particularly at low light levels, but as it is already established in the harbour the relatively short period of dredging with the larger dredge is unlikely to alter the distribution of these species in the Harbour. Overall impacts on macroalgae are likely to be low to moderate and localised in the Lower Harbour. Paua and kina are herbivorous animals which feed on drift and attached macro- and micro-algae and could be impacted if these communities were significantly affected by the dredging. However, impacts, if they were to occur would be localised and short-term and when dredging in the immediate vicinity.

116. In summary there will be little if any impact during <u>incremental capital dredging</u> with a New Era type dredge. With <u>major capital dredging</u> there could be significant impacts on the soft-sediment communities in the

Lower Harbour but they will be localised, short-medium term and confined to the immediate margins around the Port, in the main channel and some side channels (eg around Portobello Peninsula). Communities in most intertidal areas would be expected to survive and patches that were lost would be expected to recolonise in the short to medium term (i.e within a few years).

What are the effects of dredging on zooplankton?

117. Many benthic taxa and most fish species have a larval phase which is critical for dispersion and recruitment. These stages along with permanent crustacean zooplankton are adapted to the relatively high suspended sediment concentrations found in inlets and estuaries.

118. Experiments have shown that mortality can be high at levels over 10,000 mg/l and that zooplankton and larval fish can tolerate levels up to 500 mg/l and even higher. There is some evidence though that concentrations greater than 100 mg/l can affect egg hatching time and reduce hatching success and survival. The planktonic communities would only be likely to be impacted in the region opposite the Port and during major capital dredging. These are very dynamic populations so would be rapidly moved around by currents and physical processes. No significant effects have been shown at the levels experienced from dredging (Clark and Wilber 2000).

What are the effects of dredging on contaminants and nutrients?

119. Contaminants and nutrients in the sediment can be released during dredging operations causing toxicity effects and unwanted algal growth. These contaminants can potentially bioaccumulate and become concentrated in species at the top of the food web (large benthic fauna, birds, fish, and mammals) and ultimately human health, if levels are high enough. This accumulation can be a concern where there has been a considerable build-up in the sediments, particularly in harbours close to large urban populations.

120. Water quality around much of the Otago Harbour has improved in recent years with the closure of sewage works and the reduction or closure of industrial discharges but there was concern that there could still be high

residual levels in the sediments that would be dredged. To address this issue the level of contaminants was measured in sediments from different parts of the channel. These measurements showed that levels were well below the NNZGSDW and ANZECC guidelines for protection of biological communities and thus contaminants were not considered a signficant issue. The only exception was at two sites in the middle of the turning basin where arsenic levels were slightly higher (10 and 14 mg/kgDW) compared with the NZGSDW guidelines (8.2 mg/kgDW).

121. Recent studies have shown that there can be community responses at contaminant levels below the guidelines but because the levels in the Harbour are well below these guideline values, contaminants are not likely be a significant issue in this instance.

122. Nutrients are necessary for plant growth but excess nutrients can cause algal blooms and unwanted periphyton growth. Darker sediments indicative of organically enriched sediments were only recorded in cores from a site close to the Port itself.

123. Dredging will disturb these sediments and release nutrients and other contaminants and trace metals but this is unlikely to cause significant issues because of dilution from high flows and the restricted area where the higher levels of organic enrichment and more recently slightly elevated arsenic levels were recorded.

What are the effects of noise and blasting on aquatic animals in the harbour?

124. There may be limited areas of rock substrate (<1% of area) around Acheron Head and Rocky Point that will require blasting. With appropriate mitigation most mobile species can avoid the blasting. Although benthic invertebrates do not have gas vacuoles they are generally immobile and will be impacted by the direct physical effects of blasting. Surveys undertaken during other blasting operations in the harbour confirmed that invertebrates in the immediate vicinity (10s of meters) of the blasting were often destroyed.

What are the effects of dredging on biofouling and invasive species spread in the harbour?

125. Surveys of invasive species carried out in Port Otago and Port Chalmers in 2003 found *Undaria* and 25 other species, not previously described from New Zealand waters. These invasions included 23 species of sponge, an amphipod and a polychaete worm. *Undaria pinnatifida* was first identified in the Harbour in 1990 and has since spread along much of the hard shoreline. The most recent survey in Feb 2009 provides the first record of the seasquirt *Styela* in Otago Harbour but at that point it was confined to the Town Basin.

126. Transferring and disturbing sediment during dredging can potentially spread invasive and biofouling species through fragmentation and removal of whole plants/animals. Invasive species are already present in the port areas and no new species would be likely to invade as a result of this operation as long as accepted best practice biosecurity guidelines are adopted. The sea tulip is already spread throughout the Harbour, where ever it can gain a holdfast. Strong water flows in the channel and maintenance dredging over a number of years would have already resulted in any potential spread within the harbour thus any further impacts as a result of the proposed dredging would be considered to be low.

DISPOSAL OF DREDGE SPOIL

What are the effects of the disposal of dredged material offshore - direct effects on benthic community?

Background on effects

127. The main effects on the benthic community at the disposal site (A0) and immediately downstream are predicted to be the direct effects of smothering of the benthic community, increased levels of suspended sediments and reduced water clarity. Sudden and repeated disposal of sediment deposits at the site, particularly during major capital dredging, mean that some effects on the benthic community are inevitable. (Refer to Figure 8)

128. Unfortunately there was no monitoring during or after the major capital works and disposal in the 1970s but monitoring in 2005 at the sites used

for maintenance dredging indicated that benthic assemblages were similar inside the present Heyward Point site as that found outside. However, there is some evidence that the accumulating mound at Aramoana (Spit Beach) may have resulted in lower species richness and abundance compared to adjacent habitats (Paavo and Probert 2005).

129. Experiments at the maintenance dredge sites by Paavo and Probert (2005) provide some indication of processes associated with at least the smaller dredge although we need to keep in mind the depth and physical differences between these sites and the proposed site offshore. The experiments deposited muddy spoil from Dunedin Harbour in an area beside the Aramoana disposal grounds and followed recovery. After 26 days only traces of mud were found at the perimeter of the disposal site and after 41 days traces were found only at the disposal site itself. Surveys showed that 119 days after depositing muddy spoil, the community was still depauperate compared with predump and it took up to 180 days for the disposal site to recolonise and have a similar community to a site protected from disposal. Recolonisation was much quicker for sand disposal with the community being similar to predeposition within 12 days. Transplanted animals survived for more than 40 days and thus could increase diversity and abundance initially and provide additional food for fish, at least in the very short-term.

130. Recent surveys (Sept 2010) carried out at the Heyward Point and Aramoana disposal sites found lower abundances inside the Aramoana site compared with outside (Paavo pers. comm..). There was considerable variation at the Heyward site with some locations in the disposal site having lower abundances and diversity than sites outside. The observations from these recent surveys suggest the communities at these sites reflect the bathymetry as well as possible disposal of sediments. Generally the community was one of early successional/opportunistic species due to frequent bottom disturbance not related to spoil disposal.

131. Although some benthic taxa, such as the bivalves *Nucula* and *Macomona* and some polychaetes, can survive and escape burial under at least 20-30 cm of sand 50% of *Zethalia zelandica*, a common snail in fine sand off the Otago coast, did not survive burial in 17 cm of sand or 3.8 cm of mud

(Paavo and Probert 2005). This clearly demonstrates the difference in effects between sandy versus muddy spoil. Experiments have shown that generally most soft-bottom species can only escape a maximum burial of 2-10 cm, depending on the species.

132. Surveys following dredging at the Port of Auckland and disposal of 262,000 m^3 in the Hauraki Gulf found there was an initial increase in abundance and diversity of benthic communities then a decline. Abundance, diversity and the successional stage composition returned to levels similar to control sites away from the disposal site within three years. In the experiments at the maintenance dredge sites off Aramoana there was an initial high density of the opportunistic polychaete *Spiophanes* but then a decrease of this and other polychaete species over time. Monitoring at disposal sites in 1992 off the Port of Tauranga found that large scale irreversible changes in benthic fauna had not occurred and I am not aware of large-scale irreversible changes with other dredging operations in New Zealand.

Effects of disposal off Otago

133. Most benthic animals in the immediate disposal area (i.e around A0) would not survive smothering during a <u>major capital dredging</u> programme (1.1 to 1.7 m depth on average over the dredging period or 15 mm/d). To some extent the impacts will be mitigated because the bulk of the material settling out at the site is likely to be heavier fine sands, i.e like on like, although there could still be over 10 mm/d depositing at the site itself. Downstream of the disposal site there would be a gradual reduction in effects but there would still be up to 11 km^2 receiving over 1.7 mm/d, with the material tending to be finer than at the disposal site itself. It needs to be kept in mind that this is the worst case scenario and if all the dredging was carried out at once using the large capital dredge.

134. Under this scenario recovery at the site could take up to a year for some animals (eg polychaete worms) and longer for some larger animals (eg bivalves, heart urchins), depending on the disposal operations. Some animals may survive through continuous burrowing but most of the

community at the site would be impacted at least in the short to medium term (1-5 years) and larger long-lived taxa may take several years to recover from major capital dredging.

135. The continual disposal by smaller vessels (New Era/Vulcan) during incremental capital dredging, as opposed to a one-off major capital dredging, would be over a longer period but be far less intensive. This operation would involve a maximum of 1 million m^3 per year being disposed at A0 potentially resulting in an average coverage of 320 mm or less than 1 mm/d. The actual deposition is likely to be smaller than this as most of the fine material will disperse to the north during the disposal operation.

136. Most benthic animals can tolerate this level of deposition but as it could occur over several years the community at the site itself could become dominated by taxa more characteristic of early successional or opportunistic stages. Most of the macrofauna found in the vicinity of A0 are morphologically robust to physical disturbance or are highly mobile. Some of the polychaete worm species are well-known for colonising recently disturbed sediments and are early colonists of disturbed sediments. The larger infauna (living below the surface) represent a more mature community but one which relies on frequent disturbance events for feeding.

137. I would expect most of the community both at the disposal site and downstream should be able to persist during incremental capital dredging.

138. Careful consideration has gone into the selection of a disposal site to avoid important biogenic sites offshore (bryozoan community) and the potential for significant dispersal inshore to Blueskin Bay and the outer Otago peninsula. No unique or special communities were identified within the footprint of the disposal site or immediate area to the north of the site, at the level of taxonomic detail used.

139. Based on modelling it is unlikely that the benthic community in the Blueskin Bay area and northern coastline will be impacted by the plume of

fine material. If the plume did extend that far the coastal area on the outside of Otago Peninsula and to the north would receive negligible amounts of sediment and only under certain wind conditions. Predictions are that sedimentation would be less than 0.5 mm over the dredging period with large capital dredge (assumes no resuspension). Even with major capital dredging these levels are well below thresholds that would be likely to impact on biota. Material that may be resuspended and flushed out of the harbour would be well spread out in Blueskin Bay and deposition would be unlikely to be more than a few mm after settling out in the middle of the Bay. This is an area where finer sediments are found than in the surrounding area.

What are the effects of the disposal of dredged material offshore – suspended sediments and turbidity?

Disposal site and immediate vicinity

140. The increased levels of suspended sediments and reduced water clarity as a result of spoil disposal will affect the immediate disposal site but the levels of suspended sediments will be rapidly diluted away from the site (A0). With major capital dredging the predicted suspended sediment concentrations for all silt classes may reach 900 mg/l just downstream of the disposal area in bottom waters and 270 mg/l above background in surface waters but are likely to be less than 100 mg/l in the plume once you get a few km away from the site and will rapidly dilute to less than 20 mg/l. It should be noted that these are conservative estimates and dry-weight, which is commonly used for environmental limits, is about 70-80% of these values.

141. Most animals at the disposal site itself (A0) and immediately downstream would not be expected to survive either these concentrations or the level of sedimentation discussed above. This would include horse mussel beds that have been recorded just to the north of the site.

142. Recovery time after major capital dredging is completed would largely be dictated by the recolonisation processes discussed above for sedimentation but would be expected to be several years for the longer lived groups and later successional stages of these communities. I would

expect the community at distances more than a few kilometres downstream to be characterised by early successional/opportunistic stages and deposit feeders (eg polychaete worms and some molluscs) with recovery to pre-dredging communities predicted to take up to at least several years for larger more sensitive species (eg horse mussels).

143. The predicted concentrations with incremental capital dredge operations are lower than those for major capital dredging because of the size of the loads that are disposed at the site. The predicted concentrations in the water column for fine silts at the disposal area will be 5-7% of the maximum produced by major capital dredging in light and moderate WSW winds and light NNE winds. If the edge of the plume reached the coastline (north of Cornish Head or Otago Heads) levels would be very low (less than 0.6 mg/l at the Otago Heads cf up to 3 mg/l with major capital dredging). Suspended sediment levels with continuous dredging using New Era, for all three silt-size classes, are predicted to be less than 47-57 mg/l near the seabed at the disposal site itself with near-surface levels less than 11 mg/l, i.e below levels that are likely to impact on benthic biota. It is possible though that the community could be characterised by more early successional/opportunistic stage taxa at the site itself until the dredging is completed.

144. Effects on the food web from sedimentation, suspended sediments and turbidity are likely to be similar to those described for dredging and shown schematically in Figure 8**.** I would expect losses and changes in the benthic community as a result of major capital dredging to have an impact on the type and quantity of food available for higher trophic levels but this would only be over the short- to medium-term (up to 5 years) and at the site itself and immediately downstream.

145. The effects on birds and fish will be discussed by other witnesses but I would expect with the major capital dredging that there would be an initial increase in availability of some benthic taxa that would be transported to the site and provide a food resource for higher trophic levels but most of these would not survive long-term. Early successional/opportunistic stages which would include the likes of polychaete worms, an important

food item for many fish, would dominate until the typical sandy community re-established once dredging had finished.

146. The impact of incremental capital dredging on food resources for birds and fish would be lower but I would expect a similar pattern, at least at the site itself. I would expect impacts to be restricted in area to the site itself and immediately downstream where suspended sediment concentrations are over 20 mg/l and to species which are visual foragers.

147. Surveys following dredge disposal in the Hauraki Gulf found that some patches of reef-like communities (bryozoa, horse mussels and crabs) did establish at disposal sites. It is difficult to predict if this would occur at the disposal site but if it did it could establish a new food resource for some species.

Northern coastline

148. As discussed earlier, predictions are that if the plume reaches the northern coastline then concentrations of suspended sediments would be negligible with less than 0.1 mg/l of suspended sediments in surface waters for major capital dredging and even lower levels during incremental capital dredging with a New Era type dredge. To put this into context, recent measurements of background levels in the middle of Blueskin Bay varied from 0.3 to 4.1 mg/l and the human eye has been shown to detect increases above ~15 mg/l.

149. The coastline north of the Otago Peninsula has extensive areas of rocky shore and reefs supporting benthic algal and kelp beds which are a very important habitat for a range of invertebrates (including the likes of kina and paua) and fish. The kelp *Macrosystis pyrifera* has a “recruitment window” when light and temperature requirements are met and allow the establishment of sporophytes. Recruitment of *Macrocystis* has been observed along the coastline near Pleasant River through spring and summer months following thinning of the canopy during winter storms. I would not expect concentrations of less than 0.1 mg/l to have an impact on these processes. The inshore region along this coast is naturally turbid from terrestrial runoff, particularly in winter, and the increase due to dredging, if it were to occur as predicted, would not be measureable.

150. Concerns have been raised over the impact of even small amounts of suspended sediment reaching these rocky reefs and impacting on survival of grazing biota. Even short duration exposure to high sediment loads has been found to cause larval mortality in the likes of the sea urchin or kina (*Evechinus chloroticus*) and paua (*Haliotis iris*). However the sediment used in these experiments had a large fraction of clay and with turbidity at least two orders of magnitude higher (18-74 mg/l) than those predicted to occur as a result of either the major capital dredging (<0.1 mg/l at Cornish Head) or incremental capital New Era type dredging (<0.05 mg/l). At these predicted concentrations the dredging operation would not be expected to have any effect on these communities.

Effects of disposal on offshore plankton communities

151. Although coastal plankton communities are subject to episodic turbid events as a result of increased runoff and riverine input, elevated suspended sediment concentrations as a result of the disposal of dredge material can impact on both phytoplankton and zooplankton. Lower water clarity can mean less light penetrating the water column and reducing photosynthetic capacity. Primary production which drives the base of the food web in offshore areas (>20-30 m water depth) is predominantly associated with phytoplankton in the water column rather than benthic algae.

152. Turbidity associated with dredged material disposal would reduce light penetration at the offshore disposal site which could potentially in turn impact on phytoplankton (microscopic plants in the water column) or benthic algae. This impact is likely to be only significant for benthic algae at the site itself and immediately downstream. The impact on phytoplankton is difficult to assess because the environment is so dynamic and advective processes (currents) will rapidly dilute effects. There could be a minor effect downstream for some distance but significant effects are likely to be restricted to major capital dredging and the immediate vicinity where suspended sediment concentrations are predicted to be over 20 mg/l. Predictions with incremental capital dredging are that concentrations would be less than 11 mg/l in surface

layers and less than 57 mg/l in the bottom layers even in the immediate vicinity of the offshore disposal site.

153. Suspension and filter-feeding zooplankton (planktonic animals such as crustacean copepods, larval crustaceans and early larval stages of fish) can be affected by clogging of feeding apparatus at high suspended sediment concentrations. With major capital dredging surface concentrations of suspended sediments are predicted to reach a maximum of 270 mg/l, and with incremental capital dredging 57 mg/l at the site itself, which is well below the level that is known to have a significant impact on zooplankton communities, fish eggs and larvae (>500 mg/l and up to 10,000 mg/l in some cases). Any impact, if it was to occur, would be short-term as most zooplankton are short-lived (days to months) so recovery would be relatively rapid through recruitment, depending on the time of year, as well as advection from other areas.

154. The concentrations that are predicted to reach the coastline off the Peninsula will be under 3 mg/l and off the northern coast in places like Karitane, will be less than 0.1 mg/l (0.05 mg/l with incremental capital dredging). These are very low concentrations and I would not expect them to impact on photosynthetic capability for aquatic plants, including benthic taxa.

155. Generally the impacts on planktonic communities are expected to be "moderate" right at the disposal site but "low" away from the site, and of short-term duration with major capital dredging. Impacts on plankton would be expected to be low during incremental capital dredging because of the rapid dilution and advection by current flows.

Effects of disposal on spread of invasive and biofouling species and contaminants offshore

156. Contaminants that are present in sediments at the dredge site are at very low levels but some contaminants will remain bound to sediments and be transported to the disposal site. These contaminants could affect the offshore biota through direct toxic effects and bioaccumulation into the food web. However, sediments at the dredging sites have been tested and except for slightly elevated arsenic in a few locations are below the ANZECC and NZGSDW low level guidelines for levels that are known to

impact on biota. Any contaminants that were released into the water column would be rapidly diluted and dispersed.

157. A number of invasive species have been reported from Otago ports with 25 species (mostly sponges) not previously described from New Zealand waters. The seaweed *Undaria* has been present since at least 1990 while the seasquirt *Styela* has only recently been recorded. It is highly unlikely that species like *Undaria* would become established at the proposed disposal site because of the lack of hard substrate, depth and exposure. However this cannot be discounted if small reef patches were to establish. *Undaria* has already spread to the northern coastline such as off Cornish Head and Omini Point. The sea tulip also requires hard substrates and although dead ones have been found around the existing maintenance disposal sites there have also been reports of sea tulips living in parts of Blueskin Bay so it is possible they could establish at the offshore disposal site.

158. The dilution of nutrients in the open coastal sea (and the sporadic nature of the disposal schedule) will mean the chance of formation of phytoplankton blooms and associated issues are negligible.

MONITORING

159. Whilst most impacts of the dredging and disposal project are short-term and localised in extent, there can be marked effects on ecosystem structure and functioning, particularly where the channel is to be widened or at the disposal site itself, and recovery from such impacts is expected to take up to several years. To confirm the predictions of impacts and minimise unexpected impacts requires that a robust monitoring programme be developed for pre-dredging, during and post- dredging. This programme has been developed in consultation with the Department of Conservation and other specialists. The monitoring programme is consistent with internationally accepted practices (eg Port of Melbourne) and is in two parts. Firstly there are measurements designed to follow potential effects during dredging with associated trigger levels that would result in dredging management actions, after taking into account natural events. Secondly there is a monitoring programme that follows the ongoing health of key sensitive communities and their recovery, if they

were to be unexpectedly impacted. The following programme is recommended.

Monitoring pre-dredging and during dredging

Harbour monitoring

160. To provide contextual information and assess the veracity of the model predictions the extent of plumes from dredging in the harbour will be measured. More details of this monitoring have been provided by Dr Rob Bell.

161. Turbidity will be measured continuously at a minimum of six key, representative or sensitive sites. For both major capital dredging and incremental capital dredging measurements will be taken pre-dredging for at least 3 months and then during the dredging operation. In the case of New Era intensity operation, the monitoring programme will be reviewed after six months. In reference to the ORC Officers recommended conditions (Consent No:2010.195, particularly condition 5) as long as incremental capital dredging is periodically undertaken within the vicinity of the key monitoring areas over the 6 month period this will be sufficient to assess whether there are significant levels of turbidity reaching these areas. In the case of major capital dredging monitoring will be for the period of dredging until the water column effects have dissipated.

162. Condition 5 states:

The consent holder shall undertake fixed turbidity monitoring at the locations specified in condition 4 and any additional monitoring locations specified in the Environmental Management Plan in the following manner:

a. *a minimum of the first six months from commencement of any Incremental Capital works authorised by Coastal Permit 2010.193; and*

b. *if the report from condition 12 of this Coastal Permit indicates further monitoring is required, this must be undertaken for a minimum of 12 months commencing upon submission of the report from condition 12 to the consent authority; and*

c. *at any time when Incremental Capital works are being undertaken within a 2 kilometre distance down tide of any of the turbidity monitoring areas identified in condition 4 of this consent.*

163. In my view 5(c) is not necessary. The turbidity monitoring locations are spread along the length of the channel. Incremental Capital dredging will inevitably occur within a 2km radius of at least one of the monitoring sites almost continuously. Effectively this condition requires continuous fixed turbidity monitoring for the duration of Incremental Capital works. I am satisfied that 5(a) and (b) introduce sufficient monitoring to assess any effects from Incremental Capital dredging, particularly because the monitoring can be extended depending on initial results.

164. The locations and methodology will be finalised following discussions with scientific experts but will include as a minimum sites that will give an indication of the levels experienced by:

- Seagrass beds off Harwood
- Cockle beds on the intertidal flats opposite Acheron Point
- The Aramoana Ecological Area
- Rocky shores around Quarantine and Pudding Islands
- Vicinity of Wellers Rock and Omate Beach
- Control site unlikely to be affected by plume as per model (eg in Portobello Bay).

165. Monitors are to be located within the subtidal zone to enable a full set of readings to be obtained over a tidal cycle. ORC consent 2010.195 Appendix 1 is a plan (A1 11251) of the monitoring locations for turbidity meters, including a control site. On review I recommend a different control site within the subtidal zone which I prefer because it is subtidal, more representative of the Lower Harbour and in an area that will be largely unaffected. I produce a modified plan of indicative sites with the recommended control site marked in Appendix 1 of my evidence.

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166. In addition mobile monitors will be used as appropriate to measure levels when dredging close to sensitive areas such as Aramoana and to calibrate aerial photography of the extent of the plume during dredging. Light profiles will be measured at regular intervals in the vicinity of seagrass beds during dredging (6 months for incremental dredging).

167. Recommended environmental limits have been suggested based on internationally accepted levels for key assets. Suggested levels are listed below. Note that these are absolute limits but background levels at the control sites will need to be compared to assess potential extent of effects, if they are observed. It should also be noted that in the context of recent work on the Manakau Harbour, the proposed limits are at the lower end of the scale and the proposed approach of responding with active management of activities to these lower levels is a precautionary approach.

168. Seagrass limits are designed to achieve sufficient irradiance for seagrass over 6 hour and 2 week periods.

169. Exceedance of Response 1 would involve reviewing natural events, areas of dredging activity, assessing intensity of plume and need for any additional monitoring. Response 2 would include potential suspension of dredging, relocation of dredge or other active dredging management to reduce suspended sediment levels. Note that all responses are expressed as 6 hourly averages (exponentially weighted).

Asset	Environmental limit	Response 1	Response 2
Benthic Biota	35 NTU (6 hourly average)	19 NTU	24 NTU
Seagrass	25 NTU as a 6 hourly average, 15 NTU as a 2-week moving average.	12 NTU	17 NTU
Rocky Shores	35NTU (6 hourly average)	19 NTU	24 NTU
Fish and shellfish	70 NTU (6 hourly average)	35 NTU	50 NTU

170. If blasting is required then appropriate surveys will be undertaken to monitor the impact of the blasting on invertebrates and record fish deaths.

Offshore monitoring

171. Offshore monitoring will be covered by other expert witnesses dealing with physical processes. It is not considered practical or meaningful to measure turbidity along the northern coast because of natural and anthropogenic activities which occur inshore along those coastlines. Rather we are recommending that monitoring focus on determining the extent and direction of the plume to the north of the disposal site under a range of wind conditions, at two depths.

172. Bathymetric surveys of the offshore environment have been covered by other witnesses but will be linked to the ecological monitoring.

Monitoring recovery

173. Monitoring the recovery of biota and habitats from predicted and unforeseen impacts will involve pre and post-dredging annual monitoring of key sensitive areas as well as broadscale comprehensive surveys for incremental capital dredging at 3 yearly intervals to detect variability outside that expected. The monitoring programme should be reviewed after 3 years.

174. Surveys of the benthic communities and habitats at sites in the Lower Harbour, appropriate to detect changes in key communities (including rocky shores), will be conducted annually. Sites monitored will include the communities listed above for turbidity, as a minimum.

175. Surveys of seagrass beds will be made quarterly at a minimum of four sites in each location for at least a year prior to dredging and for the first 3 years post-dredging with the major capital dredging programme or incremental capital dredging with New Era and then reassessed. Aerial cover, distribution, height and shoot density will be used as indicators of seagrass health. Changes to larger-scale distribution will be assessed based on aerial photography, ground-truthing and established transects.

176. We do not expect the saltmarshes around Aramoana to be impacted but to follow recovery from unexpected effects the health of the saltmarsh community at Aramoana should be monitored annually for at least 3

years. An assessment should be made of % cover and distribution from aerial photography and established transects.

177. The health of major cockle beds opposite Acheron Head and Pulling Point will be assessed annually based on surveys of the cockle population at a minimum of four sites and should include population density and size structure, biomass and condition.

178. Offshore a targeted monitoring programme will be used to follow recovery after major capital dredging. The locations and methods used will be such that they will allow an assessment of the effects of the dredging on the benthic habitat and community at the disposal site and downstream of the site. Changes will be compared along transect lines through and downstream of the site at sufficient distance to cover at least the wider Blueskin Bay, as well as unimpacted control sites. The surveys will be conducted pre- and post-dredging. It is anticipated that surveys will be conducted annually for at least 3 years post-dredging for major capital dredging and at least every 3 years during incremental capital dredging with a smaller dredge such as New Era. Sampling will involve use of sidescan to map seabed changes, video and splashcam to assess epifauna and grab sampling to assess infauna and sediment characteristics. The presence and establishment of invasive species offshore will be included in the surveys.

MITIGATION

179. Mitigation options for birds and mammals will be covered by other witnesses.

180. It is recommended that capital dredging around Aramoana and Taiaroa Head is managed to avoid the critical breeding period for birds and many other biota as covered in detail by Paul Sagar. No direct mitigation is proposed for benthic communities but an adaptive monitoring programme is proposed and if response levels are exceeded then mitigation options would have to be considered.

RESPONSE TO SUBMISSIONS

181. Most of the general issues raised in submissions have been dealt with above. Responses to comments on specific issues related to benthic communities that were raised are addressed below. A number of comments by other submitters are covered in the following responses.

Department of Conservation – Submitter 186

182. The Department of Conservation raised a number of issues and concerns in their submissions. One of the concerns was the lack of information regarding the offshore disposal site AO and receiving environment. Sampling and sidescan surveys at 30 locations in the wider Blueskin Bay area were undertaken in the first survey to describe the substrate and communities present and these have been described earlier in my evidence. A greater intensity was surveyed at the original A1 and A2 sites, the latter being downstream of the proposed A0 site. These gave an indication of what might be expected at A0 and no obvious special features were identified. Port Otago have since carried out further work focussed at A0 and to the north and south which confirm that there is nothing unique or special at the A0 site or to the north.

183. Issues around the *Macrocystis* beds have been dealt with in my evidence and as stated earlier predictions based on the best models and information available suggest that sediment concentrations, if the plume was to reach that far, will be negligible and well below levels known to impact on the reef communities along that coastline. It needs to be remembered that this coastline is already turbid during the winter because of local runoff. Port Otago have also included assessments of the plume extent in their EMP and they are committed to monitoring immediately downstream of the A0 disposal site.

184. Sensitive areas such as Aramoana, seagrass beds, rocky shores and cockle beds have been dealt with in my evidence. As described already the most significant beds will be subject to levels of suspended sediments and sedimentation below the thresholds for these biota. If impacts were greater than predicted then as long as the populations are not completely destroyed (predictions indicate this will not happen) then I would expect them to recover in the short to medium term (up to 5 years).

Friends of the Harbour – Submitter 179

185. Friends of the Harbour commented on a failure to investigate all adverse effects, that effects are potentially significant and the dredging is contrary to the London Convention 1972. Comments on the physical modelling, birds and mammals will be addressed by other witnesses but it is accepted that the edge of the plume could reach the northern coast under certain conditions. Predictions are that this will contain negligible levels of suspended sediments (<0.1 mg/l) and these will be even lower with a New Era type dredge (<0.05 mg/l). I am not aware of any benthic communities that have been significantly affected by such low levels.

186. Concerns about the spread of *Undaria* are raised but this species is already along the northern coast and thus will naturally spread along the coast where and when conditions are right. I would not expect an increase in *Undaria* in this region as a consequence of the dredging operations.

187. Port Otago has acknowledged that there will be a zone at the disposal site A0 and immediately downstream where deposition from major capital dredging would destroy most of the existing community but it needs to be acknowledged that there will be some benthic animals transferred with the spoil and the community will gradually recolonise the area over several years. The communities existing at A0 are not unique, exist elsewhere, and will not be permanently eliminated.

188. Using the best information available I would certainly not expect there will be “wholesale obliteration” of the communities in the harbour and the major areas of cockle beds, seagrass beds and flats are predicted to be subject to levels of suspended sediments and sedimentation that they can tolerate. These environments are already subject to episodic events with high levels.

189. Port Otago contracted Otago University to undertake targeted surveys for the brachiopod *Pumilus antiquatus* but none were located. As far as we know this species was found several years ago in the harbour. It should also be noted that this species is likely to occur in a number of other

habitats but has not been recorded because of its small size or misidentification (mistaking it as juvenile *C. inconspicua*). It has been recorded along the Karitane coast and in Lyttleton Harbour.

190. Destruction of small areas of rock around Acheron Point and Pulling Point during blasting are inevitable but these populations will recover in the short to medium term and no blasting is planned around the other rocky shores around the middle islands where similar communities exist. A comprehensive EMP has been developed to ensure that significant long-term impacts on the benthic communities do not occur.

191. With regard to the London Convention this was largely developed for use in harbours where there was substantial risk of contaminants hence the focus on non-dispersive environments. As noted by NZMSS several reports have addressed individual items included in the accepted protocols including the reports on benthic ecology and potential effects. The approach taken to Project Next Generation and the EMP is consistent with other programmes developed for Port of Auckland and more recently the Port of Melbourne case which followed the London Convention and other guidelines such as the New Zealand Guidelines for Sea Disposal of Waste (NZGSDW). I have referred to these protocols in my evidence.

Te Runanga o Otakou – Submitter 5

192. Te Runanga o Otakaou described the importance of the harbour and coastline to their cultural, spiritual, historic and traditional values. They raised issues around key species and ecosystems of importance to Kai Tahu and the need for development of a comprehensive monitoring programme and dredging programme. The EMP has been outlined in my evidence and covers the areas of concern to Te Runanga o Otakou including before and after monitoring of key and sensitive sites and communities, setting of trigger levels and development of mitigation measures.

Otago Conservation Board (OCB) – Submitter 158

193. The OCB were concerned about effects on the Aramoana Ecological Area and particularly concerned about effects on the salt marshes. Port Otago acknowledge the importance of this ecological area and have put in place

a monitoring and mitigation package (proposed conditions of consent and EMP) to address these concerns, including ongoing monitoring in that region to ensure levels of suspended sediments are not above threshold levels. If they were unexpectedly exceeded then the operations would have to be reassessed and altered accordingly. Mitigation options have been developed that would avoid the most critical times for bird breeding and foraging in the outer part of the Harbour. Effects at the disposal site A0 have been covered above.

NZ Marine Sciences Society (NZMSS) – Submitter 141

194. The NZ Marine Sciences Society were concerned about the lack of adherence to the London Convention, the fate of dredged material, contaminants, downstream effects on the coastal communities and effects on harbour communities. Here I will deal only with these issues as they relate to benthic biota. The issue of contaminants and fate of dredged material has been dealt with in my evidence and by other witnesses.

195. Comments on the London Convention have already been covered.

196. Bioaccumulation of contaminants is recognised as an issue with dredging and in some cases is a major issue (eg Port of Auckland) because of high levels in the sediments. The approach taken by Port Otago was to have contaminant testing carried out at a range of sites down the channel. Except for arsenic levels at a few sites in the basin these measurements were all below levels for the NZGSDW and ANZECC guidelines for maintaining biological systems and in some cases were at the level of detection. Arsenic levels were only slightly above the low range guideline levels.

197. Port Otago recognises the importance of the coastal habitat in Blueskin Bay for a range of biota and their sensitivities to sediment and turbidity and I have outlined these in my evidence. Based on the best information available predictions are that levels will not have an impact on these coastal communities because much of the fine material will be advected to the north and the offshore canyons. The plume mapping suggests that under certain conditions the plume may reach the coast but

concentrations will be negligible and at levels that are not expected to have the impacts outlined in the NZMSS submissions.

198. As suggested by the NZMSS sediment concentrations will be monitored downstream of the disposal site A0 for one month at the start of major capital dredging.

199. Concerns were raised about the lack of background turbidity levels in the harbour. Port Otago did collect a time series in the Lower and Upper Harbour over three months in August 2008. While this is a limited period it is the only time series that has been collected in this part of the harbour. Ongoing turbidity measurements are part of the EMP developed for this project and includes collection of further baseline data.

200. As stated by NZMSS the effects of sedimentation in the harbour are acknowledged in the AEE and reports. Further details of the EMP, which is intended to mitigate any effects, have been provided in my evidence and evidence of others.

Department of Marine Science, University of Otago – Submitter 165

201. The major concerns raised by the department are lack of information on present turbidity levels, effects on the pumping system at Portobello and lack of detail on the monitoring programme. Issues around turbidity and the lack of detail for the monitoring programme have already been dealt with and it is agreed that baseline data for background turbidity be collected prior to operations beginning. Port Otago is committed to assisting the Portobello Laboratory to minimise or mitigate the effects of the dredging project on the physical operation of the laboratory.

Ministry of Fisheries – Submitter 124

202. The Ministry's Comments on the harvesting of cockles will be responded to by Rick Boyd. The expected loss from the widening around the Port has been quantified in terms of similar habitat. Other populations are not expected to be destroyed. Uncertainties around trapping of sediments by seagrass beds is acknowledged but is not expected to result in significant

impacts away from the channel. The impact on different habitats has been acknowledged including time scales of dredging and potential effects.

203. These potential effects have been proactively addressed by Port Otago in their proposed conditions of consent and the EMP. Trigger levels have been recommended for different habitats and biota and an extensive monitoring programme developed pre-, during and post-dredging. The potential for impacts on the rocky shores to the north of Blueskin Bay have been covered in reports and my evidence. Monitoring of this environment to detect the small, if any, impacts predicted is extremely difficult but Port Otago is committed to monitoring to provide an indication of the magnitude and extent of the plume downstream of the disposal site.

Southern Clams Ltd – Submitter 135

204. The size and importance of the cockle beds in Otago Harbour has been acknowledged in reports and evidence. It has also been acknowledged that there would be losses of shellfish beds close to the Port and other beds close to the channel could be subject to suspended sediment levels that could affect condition in the short-term. These effects are unavoidable with the dredging required. It is noted that Southern Clams only have an experimental harvest licence at this stage and thus a full harvesting permit and impacts on exports and so on are speculative at this point.

205. The final dredging programme is yet to be decided but over the first few years at least, dredging will be with the smaller dredges which have less of an impact than major capital dredging and maintenance dredging with New Era is in place now. Dredging with the smaller dredge does provide greater flexibility in terms of timing and locations dredged.

206. Background turbidities have been measured and are relatively low (<5 NTU) except during storm events or heavy rain when levels of suspended sediments (SSC) can naturally reach over 200 mg/l. It is acknowledged that resuspension of sediments will occur and during high wind events the sediments will be dispersed and result in some elevation in SSC but these are periods when suspended sediments would be higher naturally. Dr Rob Bell and Lincoln Coe have addressed other comments about the dredging programme and the modelling predictions.

207. Southern Clams Ltd also commented on the effects of over 3 mm of silt and clay-like sediments which negatively affected bivalves over long term periods. The long term experiments by Norkko et al. referred to were with terrigenous clay which it is acknowledged will have a greater impact than other sediment types. Short term growth indicators for bivalves subject to repeated clay depositions of 3 mm were found to be significantly lower, compared with controls, but again this is where the deposition is clay only. It is acknowledged that growth and condition of bivalves close to the channel could be impacted during dredging in those areas but repeated deposition at this rate is unlikely to occur except in the short-term (days). Bivalves would be expected to recover within the short to medium term once operations with the large dredge stopped. Predictions for SSC and sedimentation using the smaller New Era type dredge are that concentrations would be well below those levels known to impact on shellfish keeping in mind that the experiments by Norkko et al. were with fine clays.

208. Cockle abundance on the margins opposite the Port, where widening is to occur, is low compared with the more productive beds referred to elsewhere (eg Breen et al. 1999).

209. Based on the best information and modelling to date predictions are that the levels of suspended sediments reaching Blueskin Bay and certainly Waitati Inlet will be very low, if even measureable, and will not have the affects claimed by Southern Clams.

210. The biomass estimates from extensive surveys for this purpose have been referred to in our reports. As discussed under monitoring above, baseline data will be collected before dredging begins. The surveys to date undertaken for Port Otago were to describe the communities and taxa present not to provide baseline or stock estimates. Thus we do not consider the extensive surveys carried out were inadequate for the purpose.

211. Regarding mitigation we have acknowledged there will be significant impacts during major capital dredging but in limited locations and in the

short to medium terms (1-5 years in most cases). Mitigation does include some of the options suggested by Southern Clams and these were part of early documentation (eg timing of dredging). As discussed under monitoring, sites near important cockle beds are included with active management responses if concentrations go above those anticipated. It is not expected that Response 1 trigger levels will be exceeded with the smaller New Era type operation.

East Otago Taiapure Management Committee (EOTMC) – Submitter 153

212. The EOTMC made a comprehensive submission raising a number of issues around the disposal of dredge material which they consider will impact on the maintenance and enhancement of fisheries and habitats for future generations. These issues focus largely on the deposition of sediment along the northern coastal areas. Drs Rob Bell and Martin Single have commented on the modelling and physical processes aspects and here I focus on the benthic habitat.

213. The EOTMC have documented some very good information on the ecosystems and how they function. If high levels of suspended sediments (>20 mg/l, 10 mm sedimentation) were to reach the coastline for long periods then effects would be significant.

214. Based on the best information and modelling predictions available I do not believe this will be the case, as the levels of suspended sediments reaching the northern coast and sedimentation rates will only occur under certain conditions and will not be at levels that would impact on benthic biota (as covered in my evidence). This coastline is already subject to periods of high turbidity and I would not expect additional levels of up to 0.5 mm over several months with major capital dredging to be detectable or have a measurable effect on the biota.

215. I have acknowledged the critical role and importance of the rocky reefs and kelp beds in my evidence and earlier reports. I do not consider the levels of suspended sediment and sedimentation predicted pose a risk to these communities. I do not agree with the statement that “any sediment can strongly affect rocky reef habitats by reducing light..., by directly smothering species and by providing a physical barrier to recruitment.” As

mentioned before these communities are subject to higher turbidity naturally and the small amounts of material predicted will not have a significant effect, based on published reports and other studies (see my earlier evidence). I do not consider that concentrations less than 0.1 mg/l will impact on the existing light climate and have the effects claimed on kelp forests and communities that rely on these kelp beds. I am not aware of any evidence that these levels would have the significant effects suggested by EOTMC. It should also be noted that concentrations of 0.3 to 4.1 mg/l have been recorded in the middle of Blueskin Bay under existing conditions.

216. As discussed above and in my evidence if high concentrations were to reach the coast then the likes of paua settlement and growth could potentially be impacted and that would be of concern. Again I do not believe the levels predicted will cause significant effects on these communities and monitoring has been recommended to ensure that unexpected levels do not occur in the plume immediately downstream of A0.

217. Port Otago has responded to EOTMC's concerns with an EMP that provides an adaptive management approach, as EOTMC recommended.

218. As discussed in my evidence and by others it is not feasible or practical to measure subtle changes on the coastal environment that would occur as a result of small amounts of material reaching the coastline. Port Otago are committed to providing a monitoring regime that would detect if unacceptable levels were likely to be downstream of A0. Initial incremental capital dredging will be with the smaller dredge and monitoring and establishment of baselines has been recommended as part of the management plan before major capital dredging starts.

SUMMARY

219. Extensive surveys have been carried out by Port Otago in the Lower Harbour and Blueskin Bay. A number of habitat types and communities have been identified. No rare, unique or endangered species were found in samples of soft-sediment or during surveys of rocky shores.

220. Effects of higher suspended sediments and increased sedimentation will be inevitable close to the channel in areas that are being dredged. In most of the intertidal areas levels are expected to be below thresholds that most of the benthic community can tolerate for short periods. Significant effects in the channel and on the margins are expected mostly to be short to medium-term and communities are expected to recover once major capital dredging is completed, but this could take several months to a few years. Incremental capital dredging is not expected to have a significant effect because of its lower intensity and ability to manage the dredging programme. No community or habitat types will be lost long-term and there will no large scale irreversible changes in the benthic community.

221. Adverse effects on ecology from disposal of large volumes of spoil cannot be avoided with significant short to medium effects at the site itself with major capital dredging. Recovery could be in the order of up to a year for short-lived species but longer lived species could take several years. Sedimentation and suspended sediment levels would be considerably lower with incremental capital dredging but there could be subtle shifts to more of an early successional/opportunistic benthic community at the site itself and immediately downstream.

222. Based on the best available information predictions are that levels of suspended sediments reaching the coastline will be negligible and at levels that would not be expected to have more than a minor impact, if any, on the coastal community.

223. Most of the impacts will be localised and significant long-term effects are not expected. In order to minimise impacts, if they did unexpectedly occur, and to follow recovery a comprehensive monitoring and adaptive management programme has been developed.

Dr Mark Richard James

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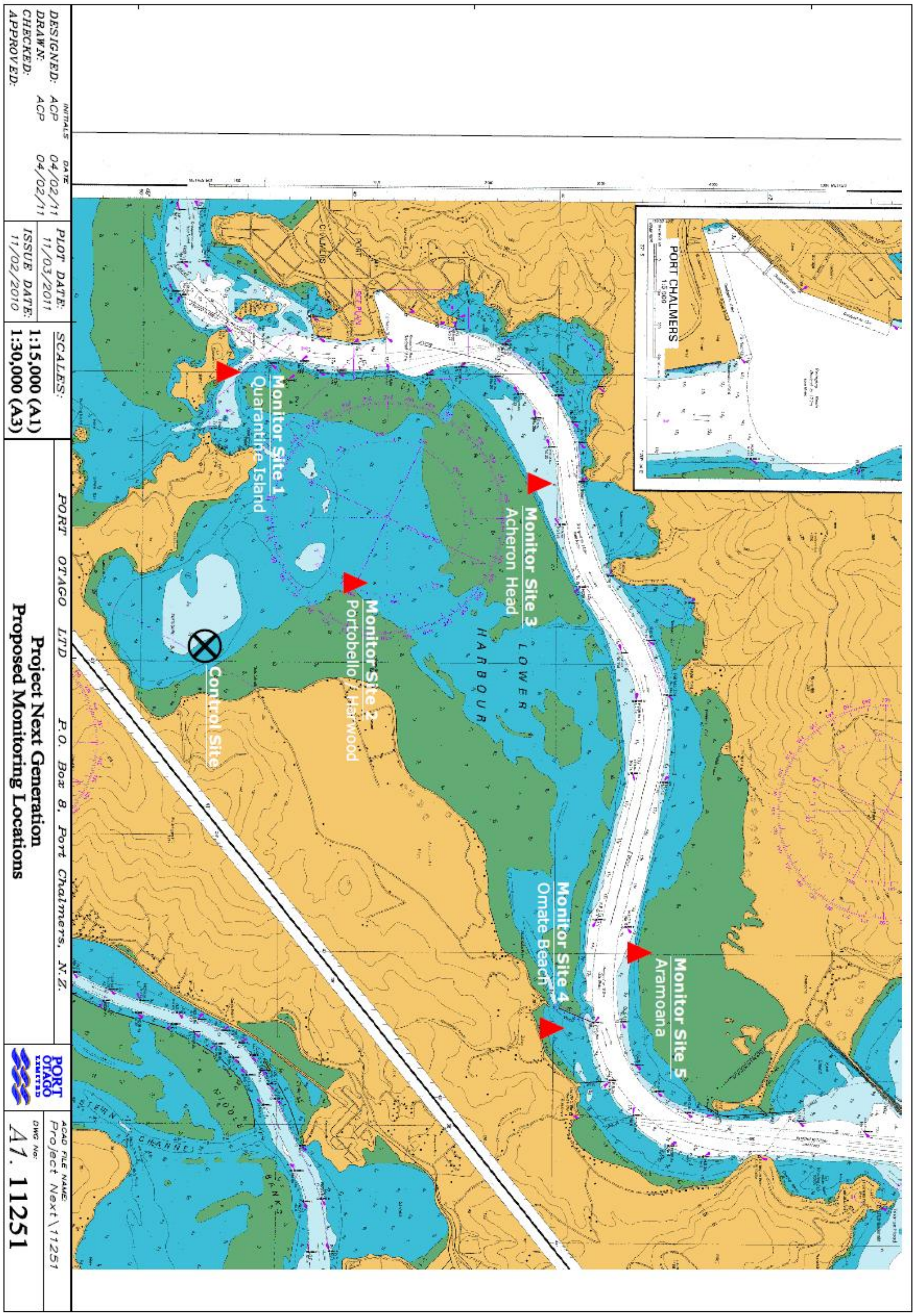
Appendix 1.



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Project Next Generation
Proposed Monitoring Locations
PORT OTAGO LIMITED
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DWG No: A1. 11251
PORT CHALMERS
Monitor Site 1
Quarantine Island
Monitor Site 2
Portobello / Harwood
Monitor Site 3
Acheron Head
Monitor Site 4
Omate Beach
Monitor Site 5
Aramoana
Control Site
LOWER HARBOUR

Figure 1. Map showing the different parts of the Harbour.

Figure 2. Map showing fine sediment in BSB

Figure 3. Map showing organic material in BSB

Figure 4. Map showing distribution of amphipods and Zethalia offshore.

Figure 5. Map showing bryzoan beds

Figure 6.

(a) Spatial distribution of invertebrate numbers based on the total collected per sample at each site. Three replicate samples were taken at each of 32 stations (Willis et al. 2008). Note that Box A and Box B in this diagram are referred to as Site A1 and A2 respectively in this and the physical processes report (Bell et al. 2009).

(b) Spatial distribution of number of invertebrate taxa based on the total collected per sample at each site.

Figure 7 Map showing survey area for Paavo 2010

Figure 8. Schematic diagram showing effects of dredging

Figure 9. Maps showing habitat types and extent of sediment plumes