BEALE CONSULTANTS

South Port Syncrolift Maintenance Dredging Resource Consent Application

Prepared for South Port New Zealand Limited

March 2024

Credit: South Port NZ Limited

Contact Details

Name: Simon Beale
Beale Consultants Limited
34 Waipuna Road, Springvale, RD 1,
Alexandra 9391

Mobile: 027 230 7788

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Simon Beale | Senior Planner

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Resource Management Act – Form 9

Application for Resource Consent under Section 88 of the Resource Management Act 1991 (the Act).

To: Environment Southland
Private Bag 90116
Invercargill 9840

We: South Port NZ Limited
PO Box 1
Bluff 9842

applies for the following resource consents for a term of 25 years:

Coastal Permits (s.12 RMA) to:

- Disturb the seabed pursuant to Rule 10.1.6 of the Regional Coastal Plan (RCP);
- Discharge water and contaminants to coastal waters pursuant to Rule 7.2.2.1 of the RCP; and
- Deposit dredged spoil on the seabed pursuant to Rule 10.2.4 of the RCP.

1 The names and addresses of the owner(s) and occupier(s) of the land to which this application relates are:

- The Crown, c/- Department of Conservation, PO Box 743, Invercargill.

2 The location to which this application relates are:

The Syncrolift facility, Island Harbour.

Grid reference (NZTM 2000): 1242423E 4829913N.

Discharge Site:

Grid reference (NZTM 2000): 1242819E 4829903N.

Legal description: Crown land comprising seabed.

3 Description of the activities to which the applications relate is:

- Discharge of dredged soft sediment to coastal waters in Bluff Harbour,
- Deposition of dredged soft sediment on the seabed in Bluff Harbour.

4 No additional resource consents are required in relation to this application.

5 Attached is an assessment of any effects that the proposed activity may have on the environment in accordance with Section 88 of, and the Fourth Schedule to, the Act.

6 Attached is the information required to be included in the application by the district or regional plan, the Resource Management Act 1991 or any regulations made under that Act.

Frank O’Boyle, South Port NZ Limited

Signature of applicant

Date: 5 March 2024

Address for service:

Beale Consultants Limited
PO Box 50
Clyde 9341

Attention: Simon Beale

Email: simon@bealeconsultants.co.nz

Phone: 027 230 7788

1. Introduction

1.1. Background

The Port of Bluff (the Port) has been operating since 1877. The company South Port New Zealand Limited (South Port) was formed in 1988, having taken over the assets and liabilities of the former Southland Harbour Board.

South Port operate a vessel maintenance facility on the northeast side of Island Harbour (251 Foreshore Road) in Bluff Harbour. At the facility, a ship lift and transfer system (Syncrolift) is used to take vessels out of the water and move them to dry dock sheds for inspection, repairs, blasting or painting. Since the facility became operational in 1983, sediment has built up under the Syncrolift platform, preventing the platform from being fully lowered into the water to a target depth of 7.5 m C.D.

The proposed maintenance dredging is required to allow for the full range of the Syncrolift system operations and for this target depth of 7.5 m C.D. to be maintained.

Due to the limited access under the platform where the sediment build up has occurred, South Port have proposed to use a venturi suction dredge to remove the sediment.

1.2. Purpose and Scope of Application

This application describes the proposed maintenance dredging project and the receiving coastal environment, assesses the actual and potential effects of the project on the coastal environment and recommends avoidance measures and mitigation measures that address adverse effects of the project.

The application includes a marine environmental effects assessment (MEcIA) report prepared by e3Scientific Limited (e3s) (Appendix 1), a report on sediment plume modelling prepared by Oceanum Calypso Science (OCS) (Appendix 2), correspondence with Te Ao Marama as required under Section 62 of the Marine and Coastal Area (Takutai Moana) Act 2011 and a set of draft conditions (Appendix 4).

1.3. Term of Permit

South Port has applied for a term of 25 years to undertake maintenance dredging to maintain the target depth of 7.5 m CD over the duration of the consent.

2. Description of Proposed Activity

2.1. Location

The Syncrolift and associated vessel maintenance facility is situated on the northern side of Island Harbour near Berth 8 as shown Figure 2-1.

The dredged spoil will be discharged at a point located approximately 320 m from the Syncrolift as indicated on Figure 2-1.

The dredging and discharge activities will take place entirely within the Bluff Port Zone.

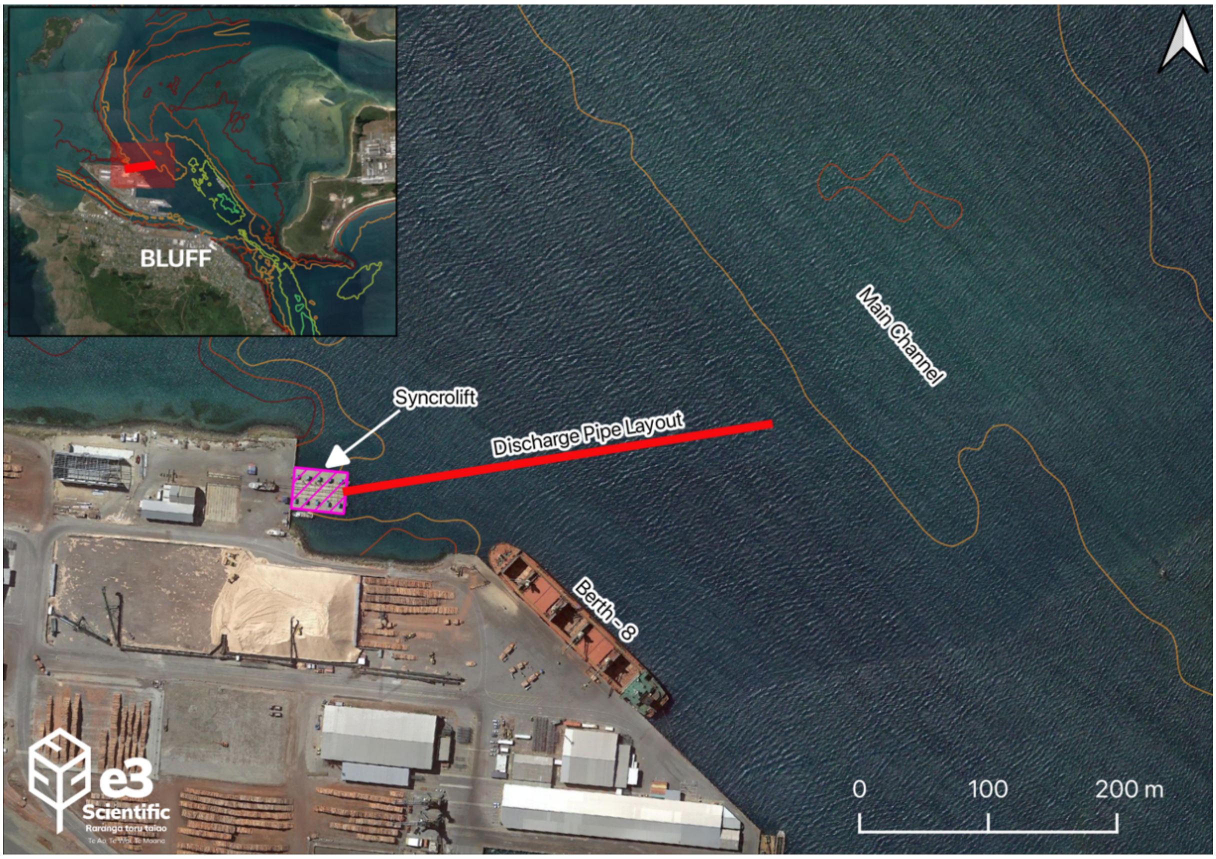

Figure 2-1: Syncrolift dredge sit and approximate discharge pipe layout
Reproduced from Figure 5, Assessment of Marine Environmental Effects, e3Scientific Limited.

2.2. Dredging Methodology

The suction dredging beneath the Syncrolift will involve the use of a floating and movable dredging pontoon, which houses a winched dredging unit (Figure 2-2 A & B). This pontoon will be anchored laterally to the adjacent Syncrolift piles during operation, allowing movement of the dredge in all directions (Figure 2-2C). The suction created by the dredge pump is sufficient to dislodge a mixture of seabed material and water through the cutter head and to discharge this mixture to adjacent coastal waters via a discharge pipe.

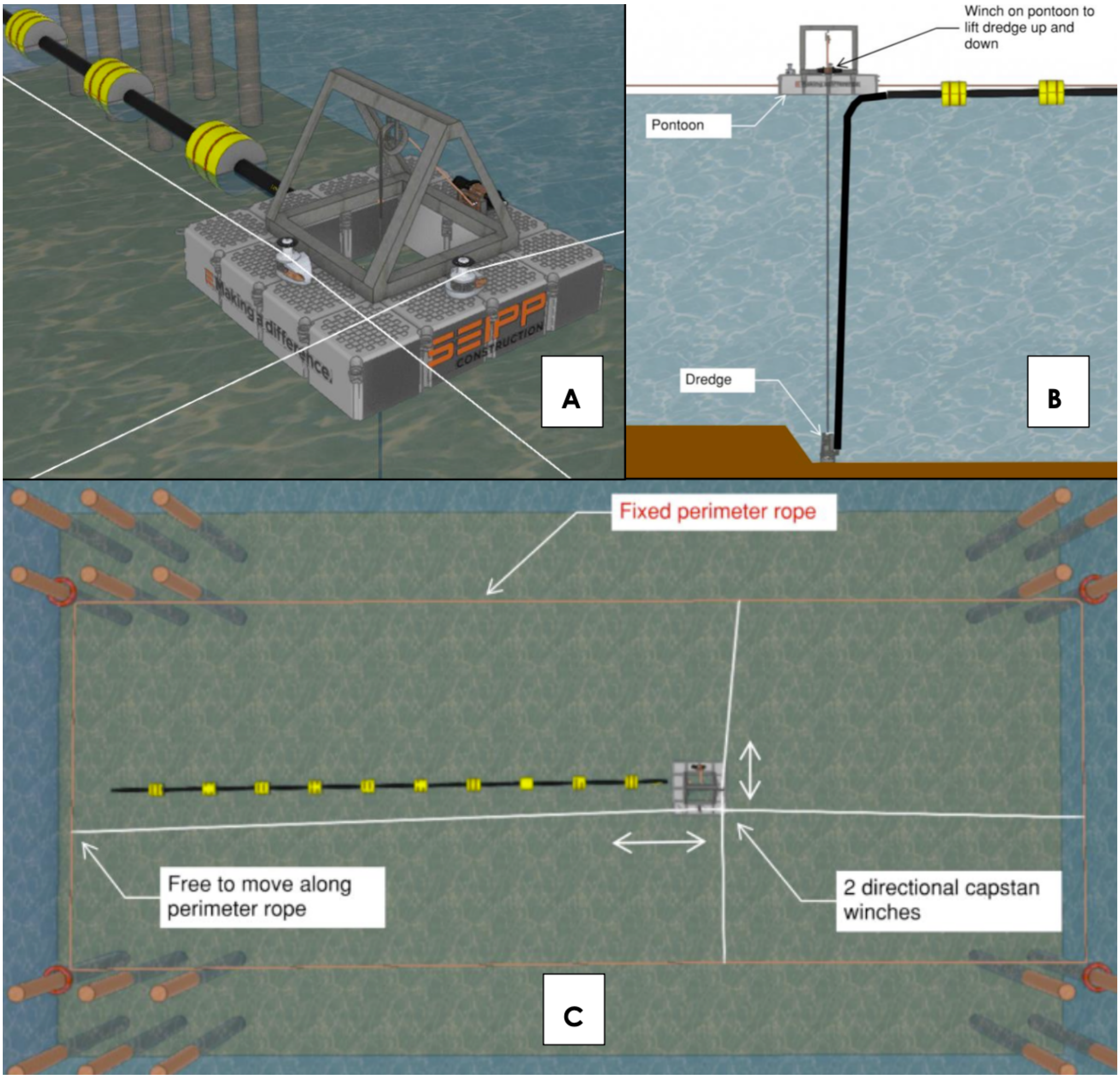

Figure 2-2: A) Example dredging pontoon, B) vertical suction head profile, and C) plan-view lateral movement configuration.

2.3. Discharge Activity

Sediment plume modelling of the proposed dredging activities conducted by OCS assessed both the persistence and depositional footprint across Bluff Harbour and Foveaux Strait. A key objective of the modelling was to identify optimal discharge locations and tidal release timing for minimal impacts to sensitive environmental habitats. Modelling revealed an optimal release scenario is at a location (400 metres from the Syncrolift, mid channel) at a depth of 7 m C.D. This location is denoted P3 by OCS where the optimum discharge window is determined to be 1 hour before to 4 hours after high water (ebb tide). If any shipping movement constraints arise during the dredging this discharge location will be moved to a point 320 m from the Syncrolift denoted P4. At this location, the optimal dredge window is modelled at 30 minutes before to 4 hours after high water (ebb tide) to reduce sediment re-accumulating within the Syncrolift site.

Sediment slurry (water and benthic material) from the Syncrolift suction dredging operation will exit the pipeline through a diffuser at the pipe end, where it will join the outgoing tidal water column near the seafloor.

Based on initial assessments by South Port during a trial operation in 2022, a maximum volume of 6,000 m^3 of sediment is to be removed initially, with a similar volume expected to be removed during subsequent maintenance dredging operations. These volumes will be informed by ongoing bathymetric surveys.

Pumping rates for solids are estimated at between 150 - 250 m^3/hour or 750 - 1250 m^3 per tidal cycle.

2.4. Biosecurity

South Port shall undertake the maintenance dredging operation in accordance with Environment Southland's biosecurity requirements. These require inspection of all dredge equipment for fouling organisms prior to entry into Bluff harbour, removal of any fouling organisms, reporting and post works monitoring of the harbour seabed.

2.5. Programme of Works

South Port propose to undertake the initial dredging operation between April and September 2024. Dredging over this period of the year avoids any potential adverse effects on sensitive ecological receptors such as the seagrass beds and penguin breeding seasons.

The work is estimated to take 2 to 3 weeks, but this is subject to Syncrolift operations, contractor availability, tidal conditions and weather conditions.

Dredging and disposal activities will be restricted to 1 hour before to 4 hours after high water (ebb tide) at the P3 discharge location and to 30 minutes to 4 hours after high tide (ebb tide) at the P4 discharge location to reduce sediment re-accumulating within the Syncrolift site.

If conditions permit dredging and discharge activities will be undertaken, Monday to Sunday within the tidal restrictions as discussed above.

3. Description of Receiving Coastal Environment

3.1. Physical Characteristics

The proposed receiving environment of Bluff Harbour and Motupōhue Mātaitai encompasses a range of high energy and ecologically important marine habitats and species. These include rocky reefs, seagrass beds, fringing intertidal coastlines and dynamic subtidal environs associated with the harbour mouth and estuary. The high rate and volume of tidal flushing likely maintains the high water quality.

The sediment characteristics of the proposed Syncrolift dredge material include a high proportion of silt/clay (~40%) and very fine sand (~32%), representative of a depositional area. Sediment chemistry results found that ANZG (2018) GV-High and CCME (1999) PEL (*probable* effect guideline levels) were exceeded occasionally across samples for copper and tributyltin. ANZG (2018) DGV and CCME (1999) TEL (*possible* effect guideline levels) were exceeded occasionally for arsenic, nickel and zinc. This area is predominantly utilised by large international vessels and all results are most likely attributable to vessel maintenance work. Nutrient, total organic carbon (TOC) and polycyclic aromatic hydrocarbons (PAH) sampling tests were below ANZG (2018) DGV guidelines for the protection of aquatic species, across all sites. Within the modelled deposition areas (main channel), only tributyltin was found to occasionally exceed DGV thresholds, with one site (Berth 8a) exceeding GV-High thresholds in 2019 and 2021.

3.2. Biological Characteristics

Rocky reef habitats in Bluff Harbour and at the harbour entrance contribute to habitat complexity and provides abundant interstices for small invertebrates, fish, and algal species. These reefs and fringing coastal habitats support seabird and penguin feeding grounds. Marine mammals and shark species utilise these dynamic habitats in pursuit of fish and prey.

The inner harbour and Awarua Bay support At Risk – Declining seagrass, sponge, and intertidal sand flat habitats supporting a range of species throughout their lifecycle. Wading and shore birds, as well as sharks, utilise the soft sediment intertidal and subtidal areas as feeding habitats during the summer months.

Ecologically important species identified within Bluff Harbour include Threatened and At-Risk birds, sharks and marine mammals. During a 12 month acoustic monitoring programme in Bluff Harbour (in 2021/2022), Hector's dolphins (Threatened – Nationally Vulnerable) and Southern right whales (At-Risk - Recovering) were infrequently recorded over the monitoring period. 59 bird species were identified in the area with a threat category of At-Risk, Naturally Uncommon or above. Other rocky reef species found were generally common and resilient including cushion stars, sea tulips, sponges, topshells, brittle stars, wandering anemones, kina, pāua and coralline algae. No unique, threatened or rare soft sediment fauna were identified.

The seabed beneath the Syncrolift is characterised by common and resilient flora and fauna. No Threatened or At-Risk marine invertebrate species were identified, and Shannon Diversity Index values were consistently low, ranging from 0.3 to 2.1.

3.3. Natural Character and Landscape Values

The harbour entrance and Port area was assessed by Mike Moore, Landscape Architect for the Bluff Harbour capital dredging project (in 2020) as having a moderate to low natural character rating reflecting the significantly modified character of the harbour environment.

Moore noted that the harbour however retains significant marine biotic values and processes such as the tidal flows, good water quality and habitat complexity.

Moore considers the harbour landscape as memorable for its stark juxtaposition of the natural and built elements, although naturalness and wild and scenic values are low. The port area rates highly in terms of cultural and social values, related to its importance to tangata whenua and its heritage significance according to Moore.

3.4. Social and Economic Values

The Syncrolift is an important component of the vessel maintenance facility port operated by South Port on Island Harbour. Island Harbour provides for safe berthage in all weather conditions for up to ten large overseas vessels and a large number of fishing vessels and oyster trawlers. Other supporting infrastructure on Island Harbour includes mobile container cranes, mobile hoppers, a wood chip stockpile loaders, a washdown facility, a bulk liquid complex, weighbridges and mobile plant such as wheel loaders and forklifts.

The port infrastructure both on Island Harbour and adjacent shoreline areas is integral to the Southland economy. Bluff's economy is dependent on the port's operations with many of the residents employed by South Port, the fish processing industry and secondary service sectors while some residents are employed at the smelter.

Part of the upper harbour north of Island Harbour is used on occasion for temporary stationing of crayfish holding pots by the CRA8 Rock Lobster Industry Association.

3.5. Cultural Values

The cultural importance of Awarua (Bluff Harbour) is highlighted in the Cultural Impact Assessment (CIA) prepared by Te Ao Marama for the capital dredging project.

The assessment refers to the importance of the harbour as a source of kaimoana for the local Māori people referring to an abundance of seafood gathered in and around the harbour by tūpuna, such as Pipi (cockles), Kūtai (mussels), Roro, Pāua, Kina (sea eggs), Pātiki (flounders) and many other fin fish, including Inanga and Tuna. Tangata whenua of the area were therefore able to live well with these resources and to treat manuhiri (visitors) to these delicacies. For example, the type of kelp found at the harbour entrance is noted in the assessment as suitable for making poha (a kelp bag) in which muttonbirds were preserved and stored.

The statutory acknowledgement for Rakiura/Te Ara a Kiwa includes the estuaries, beaches and reefs off the mainland and islands. It also refers to the bounty of mahinga kai such as a wide range of kaimoana (sea food), including tuaki (cockles), paua, mussels, toheroa, tio (oysters), pūpū (mudsnails), cod, groper, barracuda, octopus, pātiki (flounders), seaweed, kina, kōura (crayfish) and conger eel. Estuarine areas such as Bluff Harbour additionally provided freshwater fisheries, including tuna (eels), inaka (whitebait), waikōura (freshwater crayfish), kōkopu and kanakana (lamprey). Marine mammals were harvested, including whales and seals.

The inshore waters and seabed between Stirling Point and Cable Bay lie within the Motupōhue Mātaitai Reserve. The mataitai was gazetted in 2014 following an application by Te Runanga o Awarua under the Fisheries (South Island Customary Fishing) Regulations 1999. These regulations as noted in the CIA, enable Tangata whenua to manage customary fishing by defining their rohe and nominating Tangata Kaitiaki to manage the fisheries resources and issue customary fishing authorisations.

4. Statutory Framework

4.1. Resource Consents Required

Table 4-1 summarises the resource consents required from Environment Southland for the maintenance dredging of the Syncrolift site and their status in accordance with the relevant rules in the Regional Coastal Plan (RCP).

Activity	RCP Rule	Activity Status	Assessment Criteria & Explanation
Discharge to coastal waters managed for People and Aquatic Life Water Standards (P & AL) Water being discharged must meet the following standards, after reasonable mixing of any contaminants or water within the receiving water and disregarding the effect of any natural perturbations that affect the water body: 1. the natural temperature of the water shall not be changed by more than 3 Celsius and the natural temperature of the water shall not exceed 25 Celsius. 2. any pH change and/or any discharge of a contaminant into water or water into water or onto the seabed shall not result in a loss of biological diversity or a change in community composition; 3. the concentration of dissolved oxygen shall not exceed 80% of saturation concentration; 4. fish and other aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants; 5. there shall be no undesirable biological growths as a result of any discharge of a contaminant into the water; 6. aquatic life is not adversely affected by the taking of any physical, chemical or biological constituent from that water; 7. visual clarity shall not be diminished by more than 20 percent;	7.2.2.1	Restricted discretionary	Discretion will be restricted to the following: 1. the adverse effects of the discharge on any of the standards for water and seabed classified for the purpose of P & AL; Refer Table 5.1 2. the size of the zone of reasonable mixing; Refer Table 5.1. 3. the environmental effects and the practicality of alternative means of discharge, including discharge to land; Refer Section 5 and 8. 4. monitoring requirements; Refer Section 6. 5. the General Principles and Policies in the New Zealand Coastal Policy Statement relevant to the discharges to coastal waters. Refer Section 9.1.

8. the water shall not be rendered unsuitable for bathing by the presence of contaminants; 9. the water shall not be altered in those characteristics which have a direct bearing upon cultural or spiritual values. Except as provided for elsewhere in this plan, the discharge of any contaminant into water or water into water being managed for the purposes of P & AL is a restricted discretionary activity.			
Disturbance of the seabed or foreshore Except for the purposes of maintenance dredging, described in Rules 10.1.1 - 10.1.3, the disturbance of the seabed or foreshore, where the disturbance is not rectified within one month of completion of the activity giving rise to the disturbance is a discretionary activity.	10.1.6	Discretionary	The proposed dredging will result in the disturbance of the seabed at the Syncrolift site. Ongoing disturbance of the seabed through maintenance dredging is required to maintain a target depth of 7.5 m CD.
Deposition of dredged material The deposition of any material on the seabed from activities occurring in the coastal marine area is a discretionary activity.	10.2.4	Discretionary	The proposed dredging activity will result in a temporary deposition of sediment on the seabed within the general plume footprint at select areas outside of Island Harbour berths 5 and 6 and east of the outer harbour rocky reefs for a short period of time.

In summary, the proposal is a discretionary activity that requires resource consent pursuant to the RCP.

4.2. Statutory Tests

Section 104 of the RMA sets out matters a consent authority must, subject to Part 2 of the RMA, have regard to when considering resource consent applications. The matters that are relevant in considering this application are outlined in Table 4-2.

Table 4-2: RMA Section 104 Requirements

Section 104 Requirement	Relevant section of this report
(a) any actual and potential effects on the environment of allowing the activity	Section 5
(b) (i) any relevant provisions of a national environmental standard	Not applicable
(ii) any relevant provision of other regulations	Not applicable
(iii) any relevant provisions of a national policy statement	Not applicable
(iv) any relevant provisions of a New Zealand coastal policy statement	Section 9.1
(v) any relevant provision of a regional policy statement or proposed regional policy statement	Section 9.2
(vi) any relevant provisions of a plan or proposed plan	Section 9.3
(c) any other matter the consent authority considers relevant and reasonably necessary to determine the application	Sections 9.4 and 9.5

5. Assessment of Effects on the Environment

5.1. Positive Effects

The Syncrolift dredging operations will allow for more efficient use of South Port's vessel maintenance facility.

The facility is a critical infrastructure as it provides for the servicing and maintenance of South Port's 3 tugs which are essential for being able to receive large international cargo ships. The Syncrolift is also important from a wider environmental stand point as it is used for the cleaning of hulls of vessels operating in sensitive marine environments (e.g. Fiordland) as well as for improving fuel efficiency.

5.2. Effects on Coastal Water Quality

The dredging and discharge of sediment from the Syncrolift site will generate a sediment plume at and beyond the discharge point resulting in elevated turbidity levels in the water column.

Modelling by OCS show decreasing total suspended solids (TSS) and sediment deposition moving southeast, or away from the discharge point being constrained within the main channel and through the harbour entrance into Foveaux Strait where rapid dispersion occurs.

During the proposed tidal release window, e3s report that the dredge spoil will be transported within the main channel entrance of Bluff Harbour and into Foveaux Strait, temporarily altering water quality, but with very few depositional sites found within ecologically sensitive areas. Based on this, measurable effects are not expected near seagrass beds, the mātaitai or within Awarua Bay. High value habitats such as rocky reefs will be largely avoided, and water clarity should be rapidly restored after each 4.5 to 5 hour dredging cycle.

Table 5-1 below summarises the People and Aquatic Life Water (P & AL) Standards which are required to be met under the RCP after reasonable mixing of sediment in the receiving waters during dredging operations. Commentaries are provided with respect to each standard to assist in determining the effects of the proposed dredging operation on coastal water quality.

Table 5-1: People and Aquatic Life Water Standards

Standard	Commentary
The natural temperature of the water shall not be changed by more than 3º Celsius and the natural temperature of the water shall not exceed 25º Celsius.	The temperature of the receiving waters is unlikely to be affected by the discharge of dredged sediment.
Any pH change and/or discharge of a contaminant into water or water into water or onto the seabed shall not result in a loss of biological diversity or a change in community composition.	The composition of pelagic and benthic communities will not be altered by the discharge of sediment into the coastal waters and deposition sites as assessed by e3s (refer Section 5.3).

The concentration of dissolved oxygen shall not exceed 80% of saturation concentration.	The discharge of dredged sediment is not expected to affect the percentage saturation of dissolved oxygen in the coastal waters in Bluff Harbour.
Fish and aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants.	Sediment sampling at the Syncrolift site undertaken by e3s indicate occasional exceedances of contaminants arsenic, copper, nickel, zinc and tributyltin using the adopted ANZG (2018) DGV guidelines. e3s notes that copper could have adverse impacts on flora and fauna (see Section 5.3.4 and Table 5-2) but based on dispersal methods ,expect any potential effects to be short-lived and comparable to natural disturbance events.
There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water.	Sediment sampling undertaken by e3s at potential deposition sites in Bluff harbour indicate that nutrient levels at the depositional seabed environments show comparable levels of the dredged materials. This indicates that the dredging is unlikely to cause any undesirable biological growths.
Aquatic life is not adversely affected by the taking of any physical, chemical or biological constituent from the water.	Not applicable.
Visual clarity is not to be diminished by more than 20 percent.	Sediment pluming may result in visual clarity being diminished by more than 20%. This reduction in visual clarity is expected to be of limited ecological effect relative to natural background levels given the low sediment volumes, being constrained to the main channel away from beaches, rapid dispersion due to tidal currents and wave action and short duration of dredging as reported by e3s.
The water shall not be rendered unsuitable for bathing by the presence of contaminant.	Not applicable.
The water shall not be altered in those characteristics which have direct bearing upon cultural or spiritual values.	The cultural impact assessment, Te Tangi a Tuira and statutory acknowledgement highlight the importance of Bluff Harbour and inshore waters for supporting mahinga kai resources. The marine effects assessment prepared by e3s recommends that dredging occurs during outgoing ebb tides to prevent suspended sediment generated during dredging from adversely affecting culturally important areas in the upper reaches of Bluff Harbour and the waters of the Motupōhue Mataitai reserve.

In summary the effects of dredging and sediment plumes on coastal water quality is assessed as minor based on the low sediment volumes and short duration of dredging and rapid dilution through tidal flows and wave action.

5.3. Effects on Benthic Flora and Fauna

5.3.1. Seabed Disturbance

The South Port berth pockets and Syncrolift site are predominantly depositional zones, as they are deeper, outside the main channel and restrict tidal flows. Consequently, these locations tend to have higher proportions of silt and contaminants than the wider harbour. e3s consider these locations to be highly modified benthic environments.

Sediment, including silts and contaminants will be mobilised into the water column during dredging.

e3s expect that any mobile benthic species within the proposed dredging site will depart the works area due to noise vibrations from the pre-dredging set-up.

A sediment barrier is recommended by e3s during dredge operations to both contain sediment plumes locally, but also to assist with isolating the area from any high value mobile species that might utilise the larger Bluff Harbour area.

The level of ecological effect of disturbance of the soft sediment underneath the Syncrolift is assessed by e3s as low (minor) due to the existing highly modified benthic environment and through placement of a sediment barrier as recommended.

5.3.2. Removal of Benthic Flora and Fauna

The removal of soft sediment benthic habitat from under the Syncrolift as reported by e3s will entrain benthic flora and fauna in the process, with potential for adverse impacts on benthic species present. Based on previous monitoring and site investigations, fauna present in the proposed dredging sites are resilient, common and will readily recolonise the sites post-dredging. No Threatened or At-Risk marine invertebrate species were identified and Shannon Diversity Index values were consistently low, ranging from 0.3 to 2.1 over the sampled Berth sites. Due to their small size, some of these species will likely pass through the pipeline unaffected. Furthermore, no flora is attached to benthic substrate within the propose dredging sites.

e3s have assessed the level of effect on benthic flora and fauna as low (minor) based on a low ecological value of the affected infaunal and epifaunal communities within the Syncrolift site to be dredged and an initially high magnitude of ecological effect before species recolonise from nearby areas of seafloor.

5.4. Reduction in Water Clarity

Reductions in water clarity due to sediment pluming could impact flora and fauna by reducing their ability to locate food and/or photosynthesize. Modelled TSS concentrations were compared to ‘background levels’ from long-term water quality monitoring within Bluff Harbour. Background TSS within the harbour was shown to range from 11.4 to 1.3 mg/L, with downstream mixing-zone monitoring results from Capital Dredging operations only exhibiting a range from 3.88 to 6.22 mg/L with an average of 4.41 mg/L. This data suggests that even under high-volume, longer term capital dredging operations, only slight turbidity increases are observed within the mixing zone. Sediment pluming is therefore expected to be of limited ecological effect relative to background observations, and exceedingly short-lived.

The primary areas affected by reduced water clarity such as the harbour Swing Basin and Channel (entrance area) are considered highly dynamic regions. These areas are subject to storm and wave events with ebb tides flushing event-driven land-based sediments from the estuary. Species utilising these areas will therefore be accustomed to elevated suspended sediments, for similar short duration events.

Potential physical effects on receiving habitats and species includes reductions in photosensitive benthic productivity and the potential smothering of species. Other effects include gill clogging, reduction in light availability or feeding ability and increased acidification. It is largely agreed that effects increase with the volume of overburden deposited, and also duration. Particle size analysis of dredged sediments shows a high proportion of very fine particulate matter, suggesting that suspension and resuspension rates could result in widespread dispersal due to very slow settling rates combined with dynamic local oceanography. However, this will also assist in smaller effects on individual species, as dilution ratios and dispersal will be high. Likewise, the majority of sediment to be dredged will be similar to natural environments within the harbour and surrounds, and modelling shows seaward movement out of the harbour.

While the level of ecological effect on marine species are expected to be low according to e3s, further mitigation of potential adverse effects on marine species from suspended sediments has been recommended by e3s: Dredging should occur outside of little penguin breeding months (September to March), and outside of the flowering and most productive season for seagrass (*Zostera muelleri)* (December to March) as both species are most vulnerable during this period. These restriction also align with the predominant season when marine mammals have been found to utilise the harbour and nearby marine environment in Foveaux Strait. These mitigations ensure water clarity impacts on seabirds, sensitive marine species and habitats are assessed as low (minor).

5.5. Sediment Deposition

Sedimentation and sediment plumes have the potential to cause adverse effects to both rocky shore and soft-substrate marine species as reported by e3s.

During the proposed tidal release window (1 hour before to 4 hours after high water (ebb tide)), the sediment plume will be transported through the main channel entrance of Bluff Harbour and into Foveaux Strait.

Through sediment plume and depositional modelling OCS found that most of the generated sediment will drop rapidly to the seabed while the lighter fractions will be mobilised and readily resuspended via tidal currents and wave action.

The modelling by OCS shows the persistence of accumulated benthic deposition above 1.5 mm for 48 hours in only a few select areas around the harbour wharf, outside Berths 5 & 6 and east of the outer harbour rocky reefs but with very few depositional sites found within ecologically sensitive areas. Thicknesses above 3 mm for 48 hours are constrained to outside Berths 5 & 6 only. These depositional areas are likely due to localised eddies which retain sediment across tidal cycles, allowing material to fall to the seabed. Because of this, these small areas are anticipated to already exhibit the depositional characteristics of soft sediment environments.

e3s recently completed 2022 and 2023 monitoring surveys across Bluff Harbour within seagrass, rocky reef (mātaitai) and soft sediment habitats as part of the Kia Whakaū Capital Dredging activity which removed 99,120 m^3 of sediment from Bluff Harbour. Results of this monitoring showed no measurable effects which could be directly attributed to the dredging activity. Any variations found remained well within a state of natural variability (see Table 16, MEcIA). Overall, and based in part on these findings, e3s does not expect measurable effects near seagrass beds, the mātaitai or at all within Awarua Bay. High value habitats such as rocky reefs will be largely avoided, and water clarity should be rapidly restored after each 4.5 to 5 hour dredging cycle.

Faunal assemblages in the modelled depositional footprint (see Figure 17, MEcIA) are considered by e3s to be of moderate ecological value due to historic alterations to the benthic environment (e.g. port operations and existing dredge activities). Despite recent Kia Whakaū Capital Dredging activities, no observable or measurable effects have been noted at the community level through habitat monitoringMarine species within these areas should be highly tolerant of suspended sediment and sedimentation due to port-related activities, but primarily, due to natural coastal processes and background parameters found across Bluff Harbour.

e3s assess the level of ecological effect of sediment deposition as low (minor) due to the small volume and duration of the works, being comparable to a storm event or large wave event. To further reduce the level of ecological effect e3s recommend that dredging occurs during the winter months when natural turbidity levels are lower and where phytoplankton production is low so as to not create cumulative effects within the water column. This aligns with the recommendations set out in Section 5.4 in relation to water clarity effects.

5.6. Chemical Effects from Dredged Material Dispersal

Aquatic organisms may be directly or indirectly exposed to contaminants from proposed dredge spoil if disturbed or distributed, and it is possible they may experience a range of adverse effects. The chemical composition of dredge material primarily differed to the receiving environment in the heavy metal levels, with copper being the only contaminant to exceed GV-High thresholds (e.g. with *probable* effects). Overall, the chemical composition results likely reflect a long history of vessel traffic, shipping and maintenance within the harbour. Based on the extent of the depositional modelling, this sediment should primarily be deposited over an area outside sensitive habitats and within a highly dynamic part of the harbour mouth, as previously discussed. According to e3s the species within this part of the channel should be considered resilient to these effects due to the dynamic nature of this area and with sediment persistence estimated at days, the transient nature of elevated copper loadings should be low.

Measurable impacts to sensitive seagrass beds, rocky reef habitats and the mātaitai are not anticipated. Dilution will also significantly reduce the potential for any adverse chemical effects on individual species. Regardless, high ecological value species are found across the Bluff Harbour environment. To further mitigate the potential for contaminant effects on the receiving environment, e3s recommend that annual sediment monitoring be undertaken to continue assessing both source dredge material and potential accumulation within the receiving environment.

In consideration of the avoidance strategy of dredging on modelled tidal windows only (30 minutes before to 4 hours after high water (ebb tide)), the short duration of dredging, the small sediment volumes and the dispersal footprint, the magnitude of ecological effect is assessed by e3s as low (minor). The level of ecological is assessed as moderate as this accounts for the high ecological value attributed to species such as pāua and oysters found across Bluff Harbour.

5.7. Cumulative Effects

Maintenance dredging activity could potentially occur annually and thus cumulative effects were also considered by e3s. Based on the small dredge volumes proposed and modelled short sediment plume and deposition durations, e3s consider it is unlikely these transient influences will have cumulative effects.

The proposed sediment monitoring recommended by e3s aims to verify this assumption. This will include sediment sampling and analysis at the following locations:

- At the Syncrolift site;
- At the discharge point;
- At one sediment deposition area identified by the model; and
- One location within the Mātaitai.

5.8. Effects on Natural Character and Landscape Values

The assessment of effects of the proposed dredging activities on natural character and landscape values as well as visual effects draws on the assessment undertaken by Mike Moore Landscape Architect with respect to capital dredging campaign recently undertaken in Bluff Harbour.

Mr Moore assessed the effects of the capital dredging related activities (channel deepening, presence of dredges, the generation of water boils from blasting and sediment plumes generated during dredging and disposal of dredged sediment) on the natural character of Bluff Harbour and the Tiwai Point Open Coast as low. Mr Moore attributed this to:

- the highly modified environment of Bluff Harbour and its proximity to the work sites;
- the absence of any impacts on the shoreline or terrestrial environment;
- the short term and transient nature of the blasting and dredging activities;
- modifications by previous blasting and dredging operations;
- minimal impacts on tidal flows;
- the short duration of water boil effects; and,
- rapid dispersion of sediment plumes due to the nature of the local tidal currents and high energy wave climate beyond the harbour.

Mr Moore assessed adverse landscape character effects of the dredging activities in Bluff Harbour and disposal activities off the Tiwai Point Open Coast as very low to minimal respectively. Mr Moore attributes the low level of landscape character effect on:

- the capacity of the highly modified Bluff Harbour and wider Tiwai Point coastal environment setting to absorb change;
- the temporary nature of the effects associated with the dredging works, including temporary adverse of sediment plumes on water quality due to rapid dispersion;

Mr Moore determined the proposed dredging works to have no long-term visual effects owing to the transient nature of the works. He noted that the presence of dredge vessels, water boil effects and sediment plumes will not appear out of place, and nor are they inappropriate in the context of a working port environment.

Taking account of Mr Moore's assessment and the confined nature and duration of the proposed Syncrolift dredging activity, it is reasonable to assume that the effects of these proposed works on the natural character and landscape character of Bluff Harbour will be less than minor.

5.9. Effects on Marine Farms

Effects on the crayfish holding pots located in the upper harbour will be avoided by dredging and discharge of dredged sediment during outgoing ebb tides to ensure the mobilised sediments do not migrate towards any crayfish holding pots and instead move away from the discharge point and out of the harbour as sediment plume modelling indicates.

The effects of the proposed activity on marine farms in Bluff harbour is assessed as less than minor.

5.10. Noise Effects

Airborne dredging noise will be generated by the pontoon winch and from the suction dredge pump as described in Section 2.2. Owing to the dredging operation being performed beneath the Syncrolift and accounting for noise associated with port operations at Island Harbour it is considered unlikely that the operation will be audible to Bluff residents and other receivers beyond Island Harbour.

Underwater noise generated by the dredge cutter head is likely to act as a deterrent to fish and other mobile species residing in the vicinity of the Syncrolift, leading to the immediate area being avoided over the duration of the works.

5.11. Effects on Navigation and Recreational Values

The confined nature of the proposed dredging operation to beneath the Syncrolift and position of the discharge pipeline near to the seafloor avoids any potential for the dredging operation to hinder ship navigation and recreational craft movements.

The effects of the proposed activity on navigation and recreation values are assessed as negligible.

5.12. Effects of Climate Change

The effects of climate change on future operations of the Syncrolift notably a predicted increase in the frequency of winds from the westerly quarter and more frequent extreme weather events[1] are less than minor owing to relatively sheltered position of the Syncrolift on the lee side of Island Harbour.

5.13. Effects on Cultural Values

The cultural impact assessment (CIA) prepared by Te Ao Marama for the capital dredging project highlights the potential for dredging and other port activities to significantly affect mana whenua values, rights and interests, including effects on the spiritual value of water and effects on mauri. Te Ao Marama note that the physical modification of the seabed which creates sediment plumes increases turbidity which in turn can have adverse effects on water quality and mahinga kai species.

In the CIA Te Ao Marama refer to previous development activities, mainly reclamation projects that has already significantly affected Ngāi Tahu rights, values and interests. Te Ao Marama add that Ngāi Tahu values, rights and interests need to be respected when dealing with any activity that poses risks. These values and beliefs are central to Ngāi Tahu existence. Any impact upon one value will impact upon all values including and inevitably putting the health and wellbeing of humans at risk.

South Port have established a MOU with Te Rūnanga o Awarua that addresses the effects of port operations on cultural values, rights and interests. The MOU set out a range of outcomes:

- Awarua (Bluff Harbour) can be a port and provide for mahinga kai and tauranga waka, and that there are shared obligations to improve harbour health in terms of cultural use.
- South Port Ltd supports Te Rūnanga o Awarua in creating a pathway to enhance the harbour in terms of cultural use.
- Te Rūnanga o Awarua is included in the development of monitoring programmes and reporting.
- Te Rūnanga o Awarua and South Port Ltd work collaboratively to ensure any scientific monitoring requirements support the abundance of mahinga kai species and habitat.

The dredging of the seabed at the Syncrolift site and consequent sediment plumes generated will temporary diminish coastal water quality and potentially affect rocky reef habitats and mahinga kai species. However, the proposed timing of the works during ebb tides and over the winter months as recommended by e3s are considered effective measures in mitigating potential adverse effects on these taonga.

5.14. Summary of Effects

A summary of the effects of the proposed dredging project and the avoidance and mitigation measures South Port propose to undertake in response to the actual and potential effects of the proposal are set in Table 5-2.

[1] MfE, 2019.

Table 5-2: Summary of potential effects from Syncrolift dredging and spoil dispersal to Bluff Harbour.

Activity	Key Effects	Potential level of effect[1]	Rationale	Recommended avoidance & mitigation measures	Residual level of effect[1]
Syncrolift Dredging (Sediment removal at the site)	Disturbance and resuspension of soft sediments at the site can have physical & chemical effects on aquatic/avian species.	Minor	Benthic habitat at the site is primarily soft, fine sediments with low infaunal density & diversity. Mobile epifauna is minimal at the site and species considered common. Minimal volume and duration increases the dilution factor as well as the ability to control the material.	The use of a sediment curtain will contain resuspended material to the site and will exclude sensitive mobile species from the area.	Less than minor
	The removal of soft sediment benthic habitat from under the Syncrolift will entrain benthic flora and fauna in the process, with potential for species mortality.	Minor	Habitat is considered historically modified. Fauna present at the Syncrolift dredging site are considered resilient & common. No flora is attached to benthic substrate within the proposed dredging site.	None recommended.	Minor

			Any mobile species will depart the works area due to noise vibrations from the operational establishment.		
Effects of Spoil Dispersal to the Marine Receiving Environments	Reductions in water clarity can impact flora and fauna by reducing their ability to locate food and/or photosynthesize.	Minor	Dredging proposed to be restricted to the optimal slack and ebb tidal window (30 min/ 1 hr before to 4 hr after high water) from the P4 release location. Modelling shows that high value habitats such as seagrass beds, rocky reefs and the mātaitai should be avoided. Native flora & fauna with Threatened or At-Risk conservation status utilise the wider Bluff Harbour area, however seabirds & mobile species should be resilient to this level of effect as it is par with a natural event. These species can also actively avoid any areas of high suspended sediment. The low sediment volumes and short duration of dredging, along with tidal flows (and wave energy) should ensure water clarity is maintained to a high level of clarity through dilution and rapidly restored post dredging.	Works to occur outside of little penguin breeding months (September to March). Works to occur outside of the flowering and most productive season for seagrass (*Zostera muelleri*) (December to March).	Less than minor

	The physical effects from increased suspended sediments and sediment deposition could lead to a reduction in photosensitive benthic productivity and species smothering.	Minor	• Sedimentation and sediment plumes can cause adverse effects to both rocky shore and soft-substrate marine species. • PSA and oceanographic modelling suggests that fine material will be dispersed which will assist with dilution. • Deposition areas exceeding 3 mm for 48 hours are constrained to a previously modified area mid channel (outside Berth 5 & 6). • Flora and fauna within modelled affected areas are likely tolerant of acute impacts via storms and previous dredging. • Based on modelling results from tidally restricted dredge operations, highly sensitive habitats should be avoided.	None recommended.	Less than minor
	Chemical exposure: Aquatic organisms may be directly or indirectly exposed to sediment contaminants if disturbed or distributed, and it is possible they may experience a range of adverse effects.	More than minor	• Aquatic organisms may be directly or indirectly exposed to sediment contaminants if disturbed or distributed, and it is possible they may experience a range of adverse effects. • Species can be exposed to contaminants through both ingestion (directly or indirectly) and contact, with bioaccumulation and food- web effects possible. • Depositional environments show comparable levels of total organic carbon (TOC), tributylin (TBT), nutrient and polycyclic	Sediment sampling (via Van Veen or similar) to be undertaken at the following locations to monitor contaminant accumulation: ➢ At the Syncrolift site; ➢ At the discharge location; ➢ At one sediment deposition area identified by model; and, ➢ One location within the mātaitai. • Sediments should be analysed for PSA, heavy metals, total organic carbon, Polycyclic	Less than minor

			aromatic hydrocarbon (PAH) levels to dredged materials. • Syncrolift sediment samples show occasional exceedances of the adopted guideline values for arsenic, copper, nickel, zinc and tributyltin. • Elevated copper levels could have adverse impacts on both flora and fauna within the receiving environment. • Natural or pre-existing conditions should return rapidly post-works and any potential effects will be short-lived and comparable to natural disturbance events.	Aromatic Hydrocarbons (PAHs), and nutrients. • Monitoring to be completed at same time each year and results along with any volumes dredged within last 12 months should be provided to consenting authority (ES).	
Cumulative Effects from Annual Maintenance Dredging		More than minor	• Maximum of 14 days per year of dredge activity. • The maximum dredge volume required to be removed of 6,000 m^3 has taken 30 years to build up. • Dredge activity is tidally restricted to reduce dispersion and deposition to sensitive environments. • Modelling shows minimal deposition within the wider Bluff and Tiwai area after 48 hours.	Ongoing annual sediment monitoring recommended (as above) to provide verification cumulative effects are not being realised.	Less than minor

Effects on Natural Character and Landscape Values		Less than minor	Determined on the basis that the effects of the larger scale capital dredging campaign on the natural character and landscape character of Bluff Harbour were assessed by Landscape Architect Mike Moore as low and very low respectively.	None recommended	Less than minor
Effects on Marine Farms	Marine farms in the upper harbour could be potentially affected by sediment plumes in the absence of mitigation measures.	More than minor	Sediment plumes generated during dredging have the potential to migrate into the upper harbour on an incoming (flood) tide.	Works to occur 30 minutes / 1 hour before to 4 hours after high water (ebb tide) based on modelling of the sediment plume.	Less than minor
Noise Effects		Less than minor	Airborne dredging noise is unlikely to be audible in Bluff owing the works occurring beneath the Syncrolift and being situated on Island Harbour, a working port.	None recommended	Less than minor
Effects on Navigation and Recreation Values		Less than minor	The confined nature of the proposed dredging operation to beneath the Syncrolift and position of the discharge pipeline near to the seafloor will not hinder ship navigation and recreational craft movements.	None recommended	Less than minor

Effects of Climate Change		Less than minor	The effects of climate change are assessed as less than minor owing to relatively sheltered position of the Syncrolift on the lee side of Island Harbour.	None recommended	Less than minor
Effects on Cultural Values		More than minor	Dredging of the seabed and consequent sediment plumes represents an temporary adverse on coastal water quality and potentially rocky reef habitats and mahinga kai species.	The proposed timing of the dredging is to occur 30 minutes / 1 hour before to 4 hours after high water (ebb tide) based on modelling of the sediment plume. Works to occur outside the Little Penguin breeding months and seagrass flowering season.	Less than minor

1 – RMA Planning terminology.

6. Recommended Avoidance and Mitigation Measures

The following measures are recommended to avoid and/or mitigate adverse effects on the marine environment in Bluff Harbour and the harbour entrance:

1. Prior to commencement of any subtidal or surface operations, the Syncrolift 'site' shall be contained within a sediment barrier.
2. Dredging and spoil release should occur during the optimal tidal window of 30 minutes / 1 hour before to 4 hours after high water on an ebb tide to ensure sediment movement towards Foveaux Strait.
3. Soft sediment dredging shall occur between April and August, to avoid the Little Penguin breeding seasons and seagrass (*Zostera muelleri*) flowering/growth seasons (September to March).

7. Recommended Monitoring Measures

Annual sediment sampling is recommended by e3s to monitor any potential contaminant accumulation. This can be done via a Van Veen grab sampler at the following locations:

i. At the Syncrolift site;
ii. At the discharge location;
iii. At one sediment deposition area identified by the OCS model; and,
iv. One location within the Motupōhue mātaitai reserve.

Sediments should be analysed for PSA, heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. Monitoring should be completed at the same time each year and results, along with any volumes dredged within last 12 months, should be provided to consenting authority (ES).

8. Stakeholder Consultation

In accordance with the Marine and Coastal Area (Takutai Moana) Act 2011, South Port has advised the current applicant for customary title of the marine and coastal area of Murihiku, Te Rūnanga o Ngāi Tahu, represented by Te Ao Marama for Murihiku Papatipu Rūnanga of the application. South Port will advise Environment Southland of any responses received. A copy of the email sent to Te Ao Marama on 4 December 2023 seeking their views is provided in Appendix 3. A follow up email was sent to Te Ao Marama on 16 February 2024 seeking feedback as customary marine and coastal area title claimants.

South Port attended a hui with representatives from Te Ao Marama on 2 February 2024 to discuss the application. Further correspondence was conducted with Te Ao Marama thereafter in relation to the location of soft sediment monitoring sites. An initial set of draft conditions was circulated to Te Ao Marama on 16 February 2024 and then a further set of draft conditions on 29 February 2024 (Appendix 4) with the inclusion of a soft sediment monitoring site near Ocean Beach as requested by Te Ao Marama.

Written approval to the application will be sought from Te Ao Marama and the Department of Conservation in due course.

9. Alternative Sediment Discharge Locations

South Port investigated the option of disposal to land. However, this option was discounted as it would require dredging with an excavator which would not be possible due to the sediment being located under the Syncrolift platform. Furthermore, this method of dredging produces a liquid sediment which is very difficult to handle on land due to the high-water content and because it involves a small volume of sediment.

This initial investigation led South Port to commissioning a sediment modelling study and marine ecological investigations which determined that discharge of sediment to coastal waters is the most appropriate method. As previously discussed, this proposed discharge activity will be subject to mitigation measures such as the discharges being limited to specific tidal windows and restricting the dredging to the period April to September.

10. Statutory Assessment

10.1. New Zealand Coastal Policy Statement 2010

The New Zealand Coastal Policy Statement (NZCPS) is a national policy statement under the Resource Management Act 1991. The purpose of the NZCPS is to state policies that will achieve the purpose of the Act, in relation to the management of the coastal environment of New Zealand.

The NZCPS contains various objectives and policies that are relevant to the coastal environment affected by the proposal. Table 9-1 provides an assessment of the proposal against the relevant objectives and policies.

Table 9-1: Assessment of relevant provisions of the NZCPS

Provision	Commentary
Objective 1 To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by: • Maintaining or enhancing natural biological and physical processes in the coastal environment and recognising their dynamic, complex and interdependent nature; • Protecting representative or significant natural ecosystems and sites of biological importance and maintaining the diversity of New Zealand's indigenous coastal flora and fauna; and • maintaining coastal water quality, and enhancing it where it has deteriorated from what would otherwise be its natural condition, with significant adverse effects on ecology and habitat, because of discharges associated with human activity.	Ecologically sensitive rocky shorelines around the Motupōhue Mātaitai Reserve, Tiwai Point and tidal flats of the upper parts of Bluff Harbour and Awarua Bay will be protected from sedimentation effects by limiting the timing of dredging to outgoing ebb tides. The works will be undertaken within an modified area. Areas where sediment deposition is likely to occur as modelled are not representative of significant natural ecosystems. Mitigation measures are proposed to avoid potential adverse on effects on Little Penguins and seagrass beds. The integrity, form and function of the coastal environment will be maintained. The proposal is consistent with this objective.

Objective 2 To preserve the natural character of the coastal environment and protect natural features and landscape values through: • recognising the characteristics and qualities that contribute to natural character, natural features and landscape values and their location and distribution; identifying those areas where various forms of subdivision, use, and development would be inappropriate and protecting them from such activities; and encouraging restoration of the coastal environment.	The natural character, landscape and visual effects assessment undertaken by Mr Moore, Landscape Architect for the recent capital dredging campaign. Mr Moore has determined that the effects of these activities on the natural character of Bluff Harbour and the Tiwai Point Open Coast, including the seabed, will be low. The existing modified natural character, natural features and landscape values of the coastal environment of Bluff Harbour and the Tiwai Peninsula will be preserved according to Mr Moore. The proposal is consistent with this objective owing to the smaller scale of works proposed.
Objective 3 To take account of the principles of the Treaty of Waitangi, recognise the role of tangata whenua as kaitiaki and provide for tangata whenua involvement in management of the coastal environment by: • recognising the ongoing and enduring relationship of tangata whenua over their lands, rohe and resources; • promoting meaningful relationships and interactions between tangata whenua and persons exercising functions and powers under the Act; • incorporating mātauranga Māori into sustainable management practices; and • recognising and protecting characteristics of the coastal environment that are of special value to tangata whenua. Policy 2 In taking account of the principles of the Treaty of Waitangi (Te Tiri o Waitangi) and kaitiakitanga, in relation to the coastal environment: (a) recognise that tangata whenua have traditional and continuing cultural relationships withareas of the coastal environment, including places where they lived and fished for generations; …. (d) provide opportunities in appropriate circumstances for Māori involvement in decision making, for example when a consent application or notice of requirement is dealing with cultural localities or issues of cultural significance….	The role of Te Runanga o Awarua and relationship with Awarua (Bluff Harbour) is set out in the cultural impact assessment for the capital dredging campaign. South Port is committed to working with the Runanga improving the health of Awarua for cultural use, including mahinga kai resources and protection of tauranga waka. South Port proposed to limit the period of dredging to between April and August to protect the mahinga kai resources such as the seagrass beds and rocky reef habitats. The proposal is consistent with this objective and policy.

(e) take into account any relevant iwi resource management plan and any other relevant planning document recognised by the appropriate iwi authority or hapū and lodged wth council, to the extent that its content has a bearing on resource management issues in the region or district, … (f) provide for opportunities for tangata whenua to exercise kaitiakitanga over waters, forests, lands, and fisheries in the coastal environment through such measures as: (i) bringing cultural understanding to monitoring of natural resources; (ii) provide appropriate methods for the management, maintenance and protection of taonga of tangata whenua, (iii) having regard to regulations, rules or bylaws relating to ensuring sustainability of fisheries resources such as taiāpure, mahinga mātaitai or other no commercial Māori customary fishing; and …	
Objective 6 To enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use and development, recognising that: • the protection of the values of the coastal environment does not preclude use and development in appropriate places and forms, and within appropriate limits; • some uses and developments which depend upon the use of natural and physical resources in the coastal environment are important to the social, economic and cultural wellbeing of people and communities; • functionally some uses and developments can only be located on the coast or in the coastal marine area; • the protection of habitats of living marine resources contributes to the social, economic and cultural wellbeing of people and communities; Policy 6 Activities in the coastal environment (1) In relation to the coastal environment: (a) recognise that the provision of infrastructure, the supply and transport of energy including the generation and transmission of electricity, and the extraction of minerals are activities important to the social, economic and cultural well-being of people and communities;	The proposed maintenance dredging programme is an appropriate coastal development that will enhance the operation of the Syncrolift and vessel maintenance facility as well as South Port's operations overall. The mitigation measures proposed in the application are aimed at protecting marine habitats within Bluff Harbour and the inshore coastal waters beyond the harbour entrance. The proposal is consistent with this objective and policies.

... (2) Additionally, in relation to the coastal marine area: (a) recognise potential contributions to the social, economic and cultural wellbeing of people and communities from use and development of the coastal marine area, including the potential for renewable marine energy to contribute to meeting the energy needs of future generations; … (c) recognise that there are activities that have a functional need to be located in the coastal marine area, and provide for those activities in appropriate places;	
Policy 9 Ports Recognise that a sustainable national transport system requires an efficient national network of safe ports, servicing national and international shipping, with efficient connections with other transport modes, including by: (a) ensuring that development in the coastal environment does not adversely affect the efficient and safe operation of these ports, or their connections with other transport modes; and (b) considering where, how and when to provide in regional policy statements and in plans for the efficient and safe operation of these ports, the development of their capacity for shipping, and their connections with other transport modes.	
Policy 11 Indigenous Biodiversity To protect indigenous biological diversity in the coastal environment: (a) avoid adverse effects of activities on: (i) indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System lists; (ii) taxa that are listed by the International Union for Conservation of Nature and Natural Resources as threatened; (iii) indigenous ecosystems and vegetation types that are threatened in the coastal environment, or are naturally rare; (iv) habitats of indigenous species where the species are at the limit of their natural range, or are naturally rare; (v) areas containing nationally significant examples of indigenous community types; and (vi) areas set aside for full or partial protection of indigenous biological diversity under other legislation; and (b) avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on:	The marine effects assessment by e3s identifies nationally threatened taxa that permanently reside in Bluff Harbour or utilise the harbour on a seasonal basis. These include the nationally threatened Little penguin and the seagrass *Zostera muelleri*. The proposed timing of works between April and August are outside of the Little penguin breeding season and the productive flowering season for seagrass. The recommended timing of dredging to a specific tidal window, i.e. on outgoing ebb tides, as informed by sediment plume modelling avoid adverse effects of sedimentation on sensitive marine ecosystems such as sea grass beds associated with the upper harbour, Awarua Bay and rocky reef habitats of the Motupōhue Mātaitai Reserve. The proposal and in particular the proposed timing of the works are consistent with the outcomes anticipated by this policy.

(i) areas of predominately indigenous vegetation in the coastal environment; (ii) habitats on the coastal environment that are important during the vulnerable life stages of indigenous species; (iii) indigenous ecosystems and habitats that are only found in the coastal environment and are particularly vulnerable to modification, including estuaries, lagoons, coastal wetlands, dunelands, intertidal zones, rocky reef systems, eelgrass and saltmarsh; (iv) habitats of indigenous species in the coastal environment that are important for recreational, commercial, traditional or cultural purposes; (v) habitats, including areas and routes, important to migratory species; and (vi) ecological corridors, and areas important for linking or maintaining biological values identified under this policy.	
Policy 13 Preservation of natural character (1) To preserve the natural character of the coastal environment and protect it from inappropriate subdivision, use, and development: ... (b) avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on natural character in all other areas of the coastal environment;	The natural character, landscape and visual effects assessment undertaken by Mr Moore, Landscape Architect for the recent capital dredging campaign. Mr Moore has determined that the effects of these activities on the natural character of Bluff Harbour and the Tiwai Point Open Coast, including the seabed, will be low. The existing modified natural character, natural features and landscape values of the coastal environment of Bluff Harbour and the Tiwai Peninsula will be preserved according to Mr Moore. The proposal is consistent with this objective owing to the smaller scale of works proposed. The proposal is consistent with this policy.
Policy 23 Discharge of contaminants (1) In managing discharges to water in the coastal environment, have particular regard to: (a) the sensitivity of the receiving environment; (b) the nature of the contaminants to be discharged, the particular concentration of contaminants needed to achieve the required water quality in the receiving environment, and the risks if that concentration of contaminants is exceeded; and (c) the capacity of the receiving environment to assimilate the contaminants; and	Chemical analysis of the sediment proposed to be dredged by e3s show that the concentration of key contaminants including heavy metals and PAH are below the ANZG default guideline values under which biological effects are predicted. In terms of coastal water quality, the P & AL standards are assessed as being maintained outside a small mixing zone due

(d) avoid significant adverse effects on ecosystems and habitats after reasonable mixing; and (e) use the smallest mixing zone necessary to achieve the required water quality in the receiving environment; and (f) minimise adverse effects on the life supporting capacity of water within a mixing zone ... (5) In managing discharges from ports and other marine facilities: (a) require operators of ports and other marine facilities to take all practicable steps to avoid contamination of coastal waters, substrate, ecosystems and habitats that is more than minor; (b) require that the disturbance or relocation of contaminated seabed material, other than by the movement of vessels, and the dumping or storage of dredged material does not result in significant adverse effects on water quality or the seabed, substrate, ecosystems or habitats;	to the rapid rate of mixing by currents and wave action. The effects of isolated and short duration sedimentation events on benthic fauna has been assessed by e3s as low. This is due to: • The similarity of the physical characteristics of the dredged sediment to the sediment occurring in the receiving environment; • Sediment plume modelling indicates that tidally restricted discharge operations will avoid highly sensitive habitats; and • The greatest degree of sediment deposition (3 mm for 48 hours) will be constrained to outside of Berths 5 and 6, Island Harbour. The proposal is consistent with this policy.

Overall, the small scale and short duration of the dredging project annually and the proposed avoidance and mitigation and monitoring measures are considered to achieve the objectives of the NZCPS and meet the requirements of the relevant policies. Key summary points are:

- The project will enhance the efficiency of the Ports operation;
- Bluff harbour does not exhibit high levels of natural character. Effects on natural character are assessed as low; and
- The adverse effects on the marine environment have been assessed as temporary and less than minor to minor in scale based on the implementation of avoidance and mitigation measures as recommended by e3s on behalf of South Port.

10.2. Southland Regional Policy Statement 2017

The Southland Regional Policy Statement (RPS) guides resource management policy and practice in Southland. It provides a framework on which to base decisions regarding the management of the region's natural and physical resources, including the coastal marine area.

Table 10-2: Assessment of relevant provisions of the RPS

Provision	Assessment
Objective COAST.2 – Activities in the coastal marine area Infrastructure, ports, energy projects, aquaculture, mineral extraction activities, subdivision, use and development in the coastal environment are provided for and able to expand, where appropriate, while managing the adverse effects of those activities.	The proposed maintenance dredging programme is an appropriate coastal development that will enhance the operation of the Syncrolift and vessel maintenance facility as well as Port operations overall. Potential adverse effects on the coastal environment will be addressed through

	avoidance and mitigation measures recommended in the application. The proposal is consistent with this objective.
Objective COAST.3 – Coastal water quality and ecosystems Coastal water quality and ecosystems are maintained or enhanced.	Chemical analysis of the sediment proposed to be dredged by e3s show that the concentration of key contaminants including heavy metals and PAH are below the ANZG default guideline values under which biological effects are predicted. In terms of coastal water quality, the P & AL standards are assessed as being maintained outside a small mixing zone due to the rapid rate of mixing by tidal currents and wave action. The effects of isolated and short duration sedimentation events on benthic fauna has been assessed by e3s as low. This is due to: • the rapid dispersion of sediment due to tidal flows and wave action; • The similarity of the physical characteristics of the dredged sediment to the sediment occurring in the receiving environment; • Sediment plume modelling indicates that tidally restricted discharge operations will avoid highly sensitive habitats; and • The greatest degree of sediment deposition (3 mm for 48 hours) will be constrained to outside of Berths 5 and 6, Island Harbour. The proposal is consistent with this objective.
Objective COAST.4 – Natural Character The natural character of the coastal environment is restored, rehabilitated or preserved.	The natural character, landscape and visual effects assessment undertaken by Mr Moore, Landscape Architect for the recent capital dredging campaign. Mr Moore has determined that the effects of these activities on the natural character of Bluff Harbour and the Tiwai Point Open Coast, including the seabed, will be low. The existing modified natural character, natural features and landscape values of the coastal environment of Bluff Harbour and the Tiwai Peninsula will be preserved according to Mr Moore. The proposal is consistent with this objective owing to the smaller scale of works proposed.

Policy COAST.2 – Management of activities in the coastal environment Ensure adequate measures or methods are utilised within the coastal environment when making provision for subdivision, use and development to: (a) protect indigenous biodiversity, historic heritage, natural character, and natural features and landscape values; (b) maintain or enhance amenity, social, intrinsic, ecological and cultural values, landscapes of cultural significance to tangata whenua and coastal dune systems; (c) maintain or enhance public access; and (d) avoid or mitigate the impacts of natural hazards, including predicted sea level rise and climate change.	Potential adverse effects on areas of significant ecological and cultural values will be avoided by restricting the dredging to ebb tides to protect senstive receiving environments in the upper parts of Bluff Harbour, Awarua Bay, harbour entrance and the Motupōhue Mātaitai. South Port is committed to working with Te Runanga o Awarua in improving the mahinga kai values in Bluff Harbour through a recently signed MOU. This applies to all port related projects. The proposal is consistent with this policy.
Policy COAST.4 – Infrastructure, port, aquaculture, mineral extraction and energy projects Recognise and make provision for nationally significant, regionally significant or critical infrastructure that has a functional, operational or technical need to be located within the coastal environment, and appropriate port, aquaculture, mineral extraction activities and energy projects that must be located within the coastal environment.	The proposed maintenance dredging programme is an appropriate coastal development that will enhance the operation of the Syncrolift and vessel maintenance facility as well as Port operations overall. The proposal is consistent with this policy.

Policy COAST.5 – Management of effects on coastal water quality and ecosystems Avoid, remedy or mitigate adverse effects of land-based and marine activities on coastal water quality and its ecosystems. **Policy BIO.3 – Protect coastal indigenous biodiversity** Protect indigenous biodiversity from adverse effects in the coastal environment as set out in Policy 11 of the New Zealand Coastal Policy Statement 2010.	Chemical analysis of the sediment proposed to be dredged by e3s show that the concentration of key contaminants including heavy metals and PAH are below the ANZG default guideline values under which biological effects are predicted. In terms of coastal water quality, the P & AL standards are assessed as being maintained outside a small mixing zone due to the rapid rate of mixing by tidal currents and wave action. The effects of isolated and short duration sedimentation events on benthic fauna has been assessed by e3s as low. This is due to: • the rapid dispersion of sediment due to tidal flows and wave action; • The similarity of the physical characteristics of the dredged sediment to the sediment occurring in the receiving environment; • Sediment plume modelling indicates that tidally restricted discharge operations will avoid highly sensitive habitats; and • The greatest degree of sediment deposition (3 mm for 48 hours) will be constrained to outside of Berths 5 and 6, Island Harbour. The proposal is consistent with this objective and policy

The application and the recommended avoidance and mitigation measures meet the objectives and policies of the RPS.

10.3. Regional Coast Plan for Southland 2013

The purpose of the Regional Coastal Plan (RCP) is to assist Environment Southland, in conjunction with the Minister of Conservation, to achieve the purpose of the Resource Management Act 1991 in relation to the coastal marine area of the Southland region.

Table 10-3: Assessment of relevant provisions of the RCP

Provision	Assessment
Objective 5.1.1 – Preserve natural character To preserve the natural character of the coastal marine area.	The natural character, landscape and visual effects assessment undertaken by Mr Moore, Landscape Architect for the recent capital dredging campaign Mr Moore has determined that the effects of these activities on the natural character of Bluff Harbour and the Tiwai Point Open Coast, including the seabed, will be low. The existing modified natural character, natural features and landscape values of the coastal

	environment of Bluff Harbour and the Tiwai Peninsula will be preserved according to Mr Moore. The proposal is consistent with this objective owing to the smaller scale of works proposed.
Objective 5.3.1 – Protection of amenity values To ensure the use and development of the resource of the coastal marine area will not have significant adverse effects on amenity values, nor on the safety of the public, nor on the enjoyment of the coast by the public. **Policy 5.3.1 – Amenity Values** Protect amenity values of the coastal marine area. **Policy 5.3.15 – Amenity Values** Protect amenity values of the coastal environment from the adverse effects of artificial noise in the coastal marine area. **Objective 5.3.7 – Noise levels** To ensure that the effects of noise in the coastal marine area do not adversely affect people's health and well-being, natural character and amenity values.	The dredging operation will be performed beneath the Syncrolift on Island Harbour which is a noisy environment owing to port operations. It is considered unlikely that the operation will be audible to Bluff residents and other receivers beyond Island Harbour. The proposal is consistent with these objectives and policies.

Objective 7.2.2.1 – Maintenance of coastal water quality To maintain the quality of coastal waters in those areas where ambient water quality is suitable for: a. contact recreation; b. the growth of shellfish, the human consumption of which is not limited by pathogenic or chemical contamination; c. the health and vitality of aquatic ecosystems; and d. a fishery, including aquaculture, the produce of which is not limited for human consumption by pathogenic or chemical contamination: **Policy 7.2.2.3 – Water Quality Standards in areas not in Natural State** Manage the coastal waters of Southland's coastal marine area which are not in their natural state (classified as NS) for the purposes of People and Aquatic Life (P & AL). **Policy 7.2.2.4 – Managing Waters for Cultural Purposes** Manage areas of water in the coastal marine area having regard to those characteristics which have a direct bearing upon cultural or spiritual values.	Chemical analysis of the sediment proposed to be dredged by e3s show that the concentration of key contaminants including heavy metals and PAH are below the ANZG default guideline values under which biological effects are predicted. In terms of coastal water quality, the P & AL standards are assessed as being maintained outside a small mixing zone due to the rapid rate of mixing by tidal currents and wave action. The effects of isolated and short duration sedimentation events on benthic fauna has been assessed by e3s as low. This is due to: • the rapid dispersion of sediment due to tidal flows and wave action; • The similarity of the physical characteristics of the dredged sediment to the sediment occurring in the receiving environment; • Sediment plume modelling indicates that tidally restricted discharge operations will avoid highly sensitive habitats; and • The greatest degree of sediment deposition (3 mm for 48 hours) will be constrained to outside of Berths 5 and 6, Island Harbour. The proposal is consistent with this objective and policies.
Policy 7.2.3.1 – Size of Zone of Reasonable Mixing Minimise the size of the area where the relevant water classification standards are breached. **Policy 7.2.3.2 – Determining the size of zones of reasonable mixing** The area of any zone of reasonable mixing from any outfall or discharge activity shall be determined on a case by case basis.	The proposed timing of the dredging on an ebb tide is informed from sediment plume modelling by OCS. This will assist in the dispersion of the sediment and in minimising the zone of reasonable mixing. The proposal is consistent with these policies.
Objective 10.1.1 – Disturbance to the seabed or foreshore To avoid, remedy, or mitigate the adverse effects of disturbance to the seabed or foreshore.	The confined area affected by the proposed maintenance dredging operation and the short duration of the works in any given year coupled with the avoidance and mitigation measures

Policy 10.1.3 – Drilling, tunnelling, excavation, dredging and drainage activities Avoid, remedy or mitigate the impact of drilling, tunnelling, excavation, dredging and drainage activities on the environment in which they are undertaken.	recommended in the application is consistent with this objective and policy.
Objective 10.1.2 – Maintain safe and efficient navigation To maintain safe and efficient navigation in the coastal marine area.	The confined nature of the proposed dredging operation to beneath the Syncrolift and position of the discharge pipeline near to the seafloor avoids any potential for the dredging operation to hinder ship navigation and recreational craft movements. The proposal is consistent with this objective.
Policy 10.1.1 - Dredging and excavation Provide for dredging and excavation to remove deposited silt and other material, where the rate of natural deposition has been exceeded, and that deposition adversely effects the continuance of current uses and activities.	This policy aligns with the purpose of the application to remove accumulated sediment that is constraining the operation of the Syncrolift. The proposal is consistent with this policy.
Policy 10.2.3 – Avoid, remedy or mitigate the disposal of contaminants in the coastal marine area Avoid, wherever practicable, remedy or mitigate the adverse effects of the disposal or deposition of contaminants and materials containing contaminants in the coastal marine area.	Chemical analysis of the sediment proposed to be dredged by e3s show that the concentration of key contaminants including heavy metals and PAH are below the ANZG default guideline values under which biological effects are predicted. The proposal is consistent with this policy.

The application which includes recommended avoidance and mitigation measures and ongoing monitoring requirements, is considered to achieve the objectives of the RCP and meet the requirements of the relevant policies.

10.4. Te Tangi a Tauira – The Cry of the People

Te Tangi a Tauira is the Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan. It was officially endorsed by Te Rūnanga o Awarua, Te Rūnanga o Oraka/Aparima, Te Rūnaka o Waihōpai and Te Rūnanga o Hokonui in Janaury 2008.

The purpose of this Iwi Management Plan (the Plan) is to consolidate Ngāi Tahu ki Murihiku values, knowledge and perspectives on natural resource and environmental management issues within the Southland environment. It is an expression of kaitiakitanga. While the Plan is first and foremost a planning document to assist Ngāi Tahu ki Murihiku in carrying out kaitaki roles and responsibilities, it also recognises the role of communities in achieving good environmental outcomes and healthy environments, and thus is designed to assist others in understanding tangata whenua values and policy.

The purpose of Te Tangi a Tauira is to:

- describe the values underpinning the relationship between Ngāi Tahu ki Murihiku and the natural environment;
- identify the primary issues associated with natural resource and environmental management in the takiwā, from the perspective of Ngāi Tahu ki Murihiku;
- articulate Ngāi Tahu ki Murihiku policies and management guidelines for natural resource and environmental management, wāhi tapu and wāhi taonga.

Section 3.6 – Te Ākau Tai Tonga (Southland's Coastal Environment) sets out General Policy for Southland's Coastal Environment and a series of specific policies arranged by subject matter. Policies relating to Coastal Water Quality and Coastal Ecosystems are relevant to the application by South Port seeking to undertake drilling, blasting, dredging and disposal activities in Bluff Harbour and offshore of Tiwai Peninsula.

General policies acknowledge that the impacts of mismanagement affect the cultural health of the coastal environment and seek to:

- respect, protect and enhance coastal areas of importance where possible; and
- protect and enhance kaimoana and kaimataitai for future generations.

Issues identified in relation to coastal water quality and coastal ecosystems that are relevant to this application by South Port include:

- impacts on kaimoana, kaimataitai (sea food) and mahinga kai;
- impacts on cultural use of estuaries and the ocean;
- impacts on the ocean as a result of sediment loading;
- protection of intrinsic values of ecosystems; and
- maintaining healthy kaimoana.

In response to these issues, the following policies seek protection and enhancement of the coastal environment:

- Encourage protection and enhancement of the mauri of coastal waters, to ensure the ability to support cultural and customary usage.
- Avoid the use of coastal waters and the ocean as a receiving environment for the direct discharge of contaminants.
- Have active involvement in promoting the understanding of ecosystem interactions within the coastal environment and the impacts that changes to water quality and levels of deposition and disturbance may have on each organism and their subsequent role in maintaining ecosystem health.
- Avoid changes to coastal landscapes and biodiversity which have detrimental impacts on Ngāi Tahu ki Murihiku relationships and associations with coastal land, water, wāhi tapu and wāhi taonga areas.
- Promote the importance of the health of kaimoana in coastal waters.
- Protect coastal environments in which marine birds nest and feed, particularly tītī populations.
- Avoid compromising marine bird habitats as a result of inappropriate coastal land use, subdivision or development.

South Port commissioned Te Ao Marama to undertake a CIA of the recent capital dredging campaign that addresses these issues and policies. The assessment acknowledges the importance of shared obligations between South Port and Te Rūnanga o Awarua in creating a pathway to enhancing the harbour health for cultural use and emphasises the importance of working collaboratively with South Port.

The recommendations set out in the CIA are adopted for this project.

10.5. Resource Management Act 1991

10.5.1. Part 2 – Purpose and Principles

The assessment of the relevant policy documents described in sections 9.1 – 9.4 above (required by section 104 of the RMA) is subject to Part 2 of the RMA, which sets out the purpose and principles. Section 5 of the RMA defines its purpose. Section 6 sets out matters of national importance, section 7 describes 'other' matters and section 8 requires those exercising functions and powers under the RMA to take into account the principles of the Treaty of Waitangi. Table 9-4 provides an assessment of the dredging related activities that require resource consent against the requirements of Part 2 of the RMA.

Table 9-4: RMA Part 2 Assessment

Provision	Assessment
Section 5	
In this Act, sustainable management means managing the use, development and protection of natural and physical resources in a way or at a rate that allows people and communities to provide for their social, economic and cultural wellbeing and for their health and safety, while...	The proposal including the avoidance and mitigation measures recommended by e3s on behalf of South Port is in accordance with the purpose of the Act as it represents sustainable management of natural resources of the coastal environment. The proposal will allow communities of Southland to better provide for their social, economic and cultural wellbeing, through a more efficient operation of a Syncrolift facility which is an integral part of the vessel maintenance facility.
Section 5(2)(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations	The natural resources associated with the coastal marine area, including mahinga kai resources will be sustained for future generations through the implementation of the recommended avoidance and mitigation measures . The project will enhance the performance of the Syncrolift allowing the needs of future generations to be met.
Section 5(2)(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems	The life supporting capacity of the coastal waters and coastal ecosystems will be safeguarded through the implementation of avoidance and mitigation measures as recommended in the application.
Section 5(2)(c)	

Avoiding, remedying or mitigating any adverse effects of activities on the environment	The proposal includes a suite of avoidance and mitigation measures. These include timing of the dredging operation to avoid the breeding season of Little Penguin and the seagrass flowering season and employment of a sediment curtain during dredging.
Section 6(a) The preservation of the natural character of the coastal environment (including the coastal marine area) ...and the protection of [it] from inappropriate subdivision, use and development	The natural character assessment that forms part of the resource consent application for the capital dredging campaign and adopted for this application concludes that the effects of the dredging activities on the natural character of the entrance and port area of Bluff Harbour will be low (minor).
Section 6e and sections 7(a) & 7(aa) The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga.	Section 6(e) matters and section 7(a), (aa) matters concerns recognising and providing for the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga, the role of as kaitiaki (section 7(a)) and the ethic of stewardship (section 7(aa)). South Port's recognition of the special relationship of Te Rūnanga o Awarua as kaitiaki of Awarua (Bluff Harbour) is reinforced through a commitment to a shared obligation to enhance the harbour health for cultural use as underscored in the CIA.
Section 7(b) The efficient use and development of natural and physical resources	South Port represents a significant physical resource for the Southland region. The proposed dredging operation will enable the Syncrolift and vessel maintenance facility at Island Harbour to operate more efficiently.
Section 7(d) Intrinsic values of ecosystems	The assessment of marine environmental effects that forms part of the application details the intrinsic values of the marine ecosystems in Bluff Harbour that are part of the receiving environment. These values combined with analysis of the physical characteristics of the

	sediment at the Syncrolift site and sediment plume modelling have been essential in informing measures to avoid and mitigate adverse effects on affected marine ecosystems.
Section 8 In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).	Section 8 require the principles of the Treaty of Waitangi to be considered with respect to the application. These are partnership, participation and protection. South Port has a long-standing relationship with Te Rūnanga o Awarua. South Port has developed a MOU with the Rūnanga and Te Ao Marama representatives along with the commissioning of a CIA for the capital dredging campaign. The assessment is relevant to this application. South Port and the Runanga are jointly committed to protecting of natural (mahinga kai) resources of the harbour.

Overall, the proposed maintenance dredging project will achieve the purpose of the RMA and is consistent with the principles outlined in section 6-8 of the RMA.

10.5.2. Section 105

Section 105 of the RMA states that if an application is for a discharge permit to do something that would contravene section 15 of the Act, the consent authority must have regard to:

(a) the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and
(b) the applicant's reasons for the proposed choice; and
(c) any possible alternative methods of discharge, including discharge into any other receiving environment.

The nature of the discharge and the sensitivity of the receiving environment are described in detail in the Assessment of Marine Environment, including recommendations to avoid and mitigate potential adverse effects of a temporary decline in water clarity and sediment deposition on sensitive receiving environments.

No alternative site for the disposal of dredged sediment exists owing to the operational and safety issues that will arise if the discharge point was located further into the harbour.

10.5.3. Section 107

Section 107 of the RMA states that a consent authority shall not grant a discharge permit for something that would contravene section 15 of the RMA if, after reasonable mixing, it is likely to give rise to any of a series of identified effects in s107(1)(c) – (g) unless it is satisfied:

(a) that exceptional circumstances justify the granting of the permit; or
(b) that the discharge is of a temporary nature; or
(c) that the discharge is associated with necessary maintenance work

and that it is consistent with the purpose of this Act to do so.

While the proposed dredging operation will give rise to the production of suspended material in the water column and a change in the colour and visual clarity of the receiving waters, these effects will be of a transitory and temporary nature. Furthermore the proposed maintenance dredging operation is a necessary maintenance operation that will ensure the Syncrolift can operate efficiently.

There is therefore no restriction on Environment Southland granting the consent under section 107(2)(b) of the RMA.

11. Conclusions

South Port is applying for a coastal permit for maintenance dredging for a term of 25 years.

The Syncrolift dredging operations will allow for improved use of South Port's shiplift and the ability to safely accommodate vessels for maintenance. The Syncrolift is an important piece of infrastructure for large South Island vessels, which require clean hulls for sensitive marine environments (e.g. Fiordland) and for fuel efficiency. However, coastal dredging operations are known to put additional pressures on often stressed marine ecosystems. Impact management and mitigation is therefore vital to maintain important habitats and ecosystem processes in and adjacent to these often highly modified marine environments.

Based on prior research conducted by e3s and South Port, along with supporting scientific publications, the dredge site and receiving environment has been characterised and assessed for adverse effects from the proposed works. In light of coastal port dredging operations nation-wide, the annual volumes and duration considered here (6,000 m^3 & 2-3 week annual duration) are minor in comparison. Recently completed, the South Port Capital Dredging project consisted of a dredged sediment volume of 120,000 m^3 and rock volume of 40,000 m^3 over the Bluff Harbour main channel. Preliminary monitoring results suggest that even at these relatively large volumes, measurable effects on sensitive marine habitats are less than minor for this area. This is largely due to the dynamic nature of Bluff Harbour and Foveaux Strait. Throughout the Capital Dredging project and in addition to the Syncrolift dredging proposal, South Port remains focused on the goal of ensuring impacts from works are as low as possible.

Sediment distribution to the Bluff Harbour main channel (near Berth 8 at the discharge location) has been modelled and mapped against habitats and nearby high value environments such as inner harbour environs, rocky reefs, seagrass beds and the mātaitai. Sediment plumes from fine sediment mobilisation were shown to be short lived due to the relatively small volume being removed and the expected timeframe. To further control depositional vectors and reduce impacts to high value inner-harbour habitats, optimal disposal locations and windows have been derived. Spoil dispersal shall be restricted to slack and outgoing tides from 30 minutes / 1 hour before to 4 hours after high water and any site works should be contained with a sediment curtain. In addition, works should occur outside of vulnerable little penguin breeding months (September to March), and outside of the flowering and most productive season for seagrass (*Zostera muelleri)* (December to March). Due to the potential for dredge sediments to introduce elevated heavy metals concentrations to the receiving environment, annual sediment sampling (monitoring) at four locations has been proposed. Sediment monitoring should include testing for PSA, heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. Monitoring should be completed at the same time each year and results along with any volumes dredged within last 12 months should be provided to consenting authority (ES).

Overall, this assessment finds that the proposed maintenance dredging operation has the potential to further modify the receiving environment. e3s has recommended effects management measures which can avoid and mitigate potential ecological impacts, ensuring effects are reduced to an acceptably low or minor level.

The activity has been assessed against the relevant statutory requirements and found to achieve the relevant objectives and is consistent with the policy framework.

There is no regulatory barrier to the application being granted.

Draft conditions of consent are attached at Appendix 4.

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Appendices

Appendix 1: Assessment of Marine Environmental Effects

South Port Syncrolift Maintenance Dredging
Assessment of Marine Environmental Effects

e3 Scientific
Raranga toru taiao
Te Ao, Te Wai, Te Moana

South Port NZ Ltd

December 2023

Arrow Lane Arrowtown 9302
www.e3scientific.co.nz

South Port Syncrolift Maintenance Dredging

Assessment of Marine Environmental Effects

Document Status

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COVER PHOTO: Courtesy of South Port - https://southport.co.nz/marine-services#Syncrolift

Executive Summary

South Port New Zealand Limited (South Port) operate a vessel maintenance facility on the northeast side of Island Harbour (251 Foreshore Road) in Bluff Harbour. At the facility, a shiplift and transfer system (Syncrolift) is used to take vessels out of the water and move them to dry dock sheds for inspection, repairs, blasting or painting. Since the facility became operational in 1993, sediment has built up under the Syncrolift platform, preventing the platform from being fully lowered into the water to its' initial depth of 7.5 m C.D. South Port are proposing to remove the material from underneath the structure so that the Syncrolift meets operational requirements at the port. Based on initial assessments made in 2022, an approximate maximum total of 6,000 m^3 of sediment is to be removed initially, with annual maintenance dredging of the same volume proposed.

South Port have proposed to use a venturi suction dredge to remove the sediment from a floating and movable dredging plant. This method of dredging transfers material from under the platform via temporary pipeline and will discharge the sediment to the water column and receiving environment approximately 320 - 400 m away from the Syncrolift platform (near Berth 8 in the main harbour channel). At the discharge site, the sediment mixture will be released near to the seabed into the water column on an ebb tide, to promote transport towards Foveaux Strait and minimise deposition in the local receiving environment. The proposed discharge location will be located in ~7 - 8 m of water depth near the seafloor. Dredge working time is estimated at a maximum of two weeks per year. This allows for works to occur during ebb tidal windows.

This marine assessment of effects report includes a collation of previously conducted data for the Bluff Harbour region as part of previous dredging and monitoring projects. These include both the Capital Dredging Project (2021 -2023) as well as previous Syncrolift dredge trial assessments. Much of this data has been collected by either e3Scientific or South Port and has been supported by a desktop collation of existing scientific literature and other supporting ecological reports.

The proposed receiving environment of Bluff Harbour and the Tiwai Peninsula encompasses a range of high energy and ecologically important marine habitats and species. These include rocky reefs, seagrass beds, fringing intertidal coastlines and dynamic subtidal environs associated with the harbour mouth and estuary. The high rate and volume of tidal flushing likely maintains the high water quality.

Rocky reef habitats contribute to habitat complexity and provides abundant interstices for small invertebrates, fish, and algal species. These reefs and fringing coastal habitats support seabird and penguin feeding grounds. Marine mammals and shark species utilise these dynamic habitats in pursuit of fish and prey. The inner harbour and Awarua Bay support At Risk – Declining seagrass, sponge, and intertidal sand flat habitats supporting a range of species throughout their lifecycle. Wading and shore birds, as well as sharks, utilise the soft sediment intertidal and subtidal areas as feeding habitats during the summer months. Ecologically important species identified within Bluff Harbour include Threatened and At-Risk birds, sharks and marine mammals. During a 12 month acoustic monitoring programme in Bluff Harbour (in 2021/2022), Hector's dolphins (Threatened – Nationally Vulnerable) and Southern right whales (At-Risk - Recovering) were infrequently recorded from within the vicinity at 0.01 and <0.01% over the 12 months, respectively. 59 bird species were identified in the area with a threat category of At-Risk, Naturally Uncommon or above. The Threatened - Nationally Endangered white shark is known to feed within Foveaux Strait during summer but has not been identified as using Bluff Harbour. Other rocky reef species found were generally common and resilient including cushion stars, sea tulips, sponges, topshells, brittle stars, wandering anemones, kina, pāua and coralline algae. No unique, threatened or rare soft sediment fauna were identified.

Biologically, proposed dredge removal areas were characterised by common and resilient flora and fauna. No Threatened or At-Risk marine invertebrate species were identified, and Shannon Diversity Index values were consistently low, ranging from 0.3 to 2.1. No flora is attached to benthic substrate within the propose dredging sites, and it is expected that any mobile species will depart the works area due to noise vibrations from the pre-dredging set-up. A sediment barrier has been recommended during dredge operations to both contain sediment plumes locally, but also to assist with isolating the area from any high value mobile species that might utilise the larger Bluff Harbour area.

The sediment characteristics of the proposed Syncrolift dredge material include a high proportion of silt/clay (~40%) and very fine sand (~32%), representative of a depositional area. Sediment chemistry results found that ANZG (2018) GV-High and CCME (1999) PEL (*probable* effect guideline levels) were exceeded occasionally across samples for copper and tributyltin. ANZG (2018) DGV and CCME (1999) TEL (*possible* effect guideline levels) were exceeded occasionally for arsenic, nickel and zinc. This area is predominantly utilised by large international vessels and all results are most likely attributable to vessel maintenance work. Nutrient, total organic carbon (TOC) and polycyclic aromatic hydrocarbons (PAH) sampling tests were below ANZG (2018) DGV guidelines for the protection of aquatic species, across all sites. Within the proposed deposition areas (main channel), only tributyltin was found to occasionally exceed DGV thresholds, with one site (Berth 8a) exceeding GV-High thresholds in 2019 and 2021.

Sediment plume modelling of the proposed dredging dispersal activities was conducted by Oceanum Calypso Science. This modelling assessed both the persistence and depositional footprint across Bluff Harbour and Foveaux Strait. The objective of the modelling included the identification of optimal discharge locations and tidal release timing for minimal impacts to sensitive environmental habitats. Testing revealed an optimal release scenario from the P3 location (400 metres from the Syncrolift, mid channel; -8 m depth) from 1 hour before to 4 hours after high water (ebb tide). Because of shipping movement constraints, an optional secondary location was identified at the P4 location, 320 m from the Syncrolift in -7 m water depth. At this alternate location, the optimal dredge window is 30 minutes before to 4 hours after high water (ebb tide) to reduce sediment re-accumulating within the Syncrolift site.

Model results show decreasing total suspended solids (TSS) and sediment deposition moving southeast, or away from the disposal point, gradually wrapping around Bluff point on the western side of the harbour entrance. Once on the east side of Bluff point, open water dispersion occurs.

The persistence of settled material on the seabed showed a patchy network of accumulation areas within the general plume TSS footprint, with elevated deposition along Island Harbour and Berths 1 – 4. TSS concentrations above 2.5 mg/L were shown to persist for up to 24h near the Harbour entrance and southeast of the dispersal point. Concentrations greater than 5.0 mg/L did not persist more than one tidal cycle (12h). Exceedances of 50 mg/L were found to occur for only three hours over the total working time, with a very small proportion anticipated to overlay a section of mapped rocky reef within the main channel entrance.

Overall, during this tidal release window, the dredge spoil will be transported within the main channel entrance of Bluff Harbour and into Foveaux Strait, temporarily altering water quality, but with very few depositional sites found within ecologically sensitive areas. Based on this, measurable effects are not expected near seagrass beds, the mātaitai or at all within Awarua Bay. High value habitats such as rocky reefs will be largely avoided, and water clarity should be rapidly restored after each 4.5 to 5 hour dredging cycle.

Reductions in water clarity could impact flora and fauna by reducing their ability to locate food and/or photosynthesize. Modelled TSS concentrations were compared to 'background levels' from long-term water quality monitoring within Bluff Harbour. Background TSS within the harbour was shown to range from 11.4 to 1.3 mg/L, with downstream mixing-zone monitoring results from Capital Dredging operations only exhibiting a range from 3.88 to 6.22 mg/L with an average of 4.41 mg/L. This data suggests that even under high-volume, longer term dredging operations such as the Capital Dredging project, only slight turbidity increases are observed within the mixing zone. Sediment pluming is therefore expected to be of limited ecological effect relative to background observations, and exceedingly short-lived.

The primary areas affected by reduced water clarity such as the harbour Swing Basin and Channel (entrance area) are considered highly dynamic regions. These areas are subject to storm and wave events with constricted tidal forcing pushing event-driven land-based sediments from the estuary through this area. Because of this, species utilising these areas will be accustomed to elevated suspended sediments, for similar short duration events. Based on the small footprint, mobiles species should be able to temporarily avoid areas of high suspended sediment over the short durations and these animals should have sufficient capacity to avoid or tolerate these areas.

While effects on marine species are expected to be low, further mitigation of potential adverse effects on marine species from suspended sediments has been proposed. It is recommended that soft sediment dredging occur outside of little penguin breeding months (September to March), and outside of the flowering and most productive season for seagrass (*Zostera muelleri)* (December to March) as both species are most vulnerable during this period. These times also effectively avoid the predominant season marine mammals have been found to utilise the harbour and nearby marine environment. These mitigations ensure water clarity impacts have a low overall effect on seabirds, sensitive marine species and habitats.

Potential physical effects on receiving habitats and species includes reductions in photosensitive benthic productivity and the potential smothering of species. Other effects include gill clogging, reduction in light availability or feeding ability and increased acidification. It is largely agreed that effects increase with the volume of overburden deposited, and also duration. Particle size analysis of dredged sediments shows a high proportion of very fine particulate matter, suggesting that suspension and resuspension rates could result in widespread dispersal due to very slow settling rates combined with dynamic local oceanography. However, this will also assist in smaller effects on individual species, as dilution ratios and dispersal will be high. Likewise, the majority of sediment to be dredged will be similar to natural environments within the harbour and surrounds, and modelling suggests seaward movement out of the harbour.

Modelling shows the persistence of accumulated benthic deposition above 1.5 mm for 48 hours in only a few select areas around the harbour wharf, outside Berths 5 & 6 and east of the outer harbour rocky reefs. Thicknesses above 3 mm for 48 hours are constrained to outside Berths 5 & 6 only. These depositional areas are likely due to localised eddies which retain sediment across tidal cycles, allowing material to fall to the seabed. Because of this, these small areas are anticipated to already exhibit the depositional characteristics of soft sediment environments.

Faunal assemblages in the modelled depositional footprint (see Figure 17) are considered of Moderate ecological value, being already modified due to historic alterations to the benthic environment (e.g. port operations and existing dredge activities). Despite historic activities, no observable or measurable effects have been noted to date at the community level, despite ongoing monitoring by e3s. Marine species within these areas should be highly tolerant of suspended sediment and sedimentation due to port-related activities, but primarily, due to natural coastal processes and background parameters found across Bluff Harbour.

Aquatic organisms may be directly or indirectly exposed to contaminants from proposed dredge spoil if disturbed or distributed, and it is possible they may experience a range of adverse effects. The chemical composition of dredge material primarily differed to the receiving environment in the heavy metal levels, with copper being the only contaminant to exceed GV-High thresholds (e.g. with *probable* effects). Overall, the chemical composition results likely reflect a long history of vessel traffic, shipping and maintenance within the harbour. Based on the extent of the depositional modelling, this sediment should primarily be deposited over an area outside sensitive habitats and within a highly dynamic part of the harbour mouth. The species within this part of the channel should be considered resilient due to the dynamic nature of this area and with sediment persistence estimated at days, the transient nature of elevated copper loadings should be low.

Measurable impacts to sensitive seagrass beds, rocky reef habitats and the mātaitai are not anticipated. Dilution will also significantly reduce the potential for any adverse chemical effects on individual species. Regardless, high ecological value species are found across the Bluff Harbour environment. To further mitigate the potential for contaminant effects on the receiving environment, it is suggested that annual sediment monitoring be undertaken to continue assessing both source dredge material and potential accumulation within the receiving environment. Considering the effects avoidance strategy of dredging on modelled tidal windows only, previously proposed mitigations and recommendations, and in light of the short duration, small sediment volumes and relative contribution of contaminants over the dispersal footprint, any residual chemical effects from spoil discharge should be considered low.

As the maintenance dredge activity could potentially occur annually, cumulative effects were also considered. However, based on the small dredge volumes proposed and modelled short durations, it is unlikely these transient influences will have cumulative effects. The proposed sediment monitoring across the receiving environment aims to verify this assumption.

Overall, this assessment finds that the proposed dredging and disposal operations have the potential to further modify the receiving environment. However, e3s has recommended management measures which can avoid and mitigate potential ecological impacts, ensuring effects are reduced to an acceptably low level. These proposed actions include the following:

1. Prior to commencement of any subtidal or surface operations, the Syncrolift 'site' should be contained within a sediment barrier.
2. Dredging and spoil release should occur during the optimal tidal windows of 30 minutes (from the P4 location) to 1 hour (from the P3 location) before to 4 hours after high water on an ebb tide to ensure sediment movement towards Foveaux Strait.

3. Sediment dispersal in the main channel should occur from the P3 location, with an alternate P4 location used for shipping conflicts. Dispersal should be used in conjunction with the optimal tidal windows noted above.
4. Soft sediment dredging should occur during the winter months outside of the most vulnerable avifaunal breeding seasons and seagrass (*Zostera muelleri*) flowering/growth seasons (September to March).
5. Annual sediment sampling is recommended to monitor any potential contaminant accumulation. This can be done via a Van Veen grab sampler at the following locations:
    a. At the Syncrolift site;
    b. At the disposal locations utilised (i.e. P3 & P4 locations);
    c. At one sediment deposition area identified by the model; and,
    d. One location within the mātaitai.

    Sediments should be analysed for PSA, heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. Monitoring should be completed at the same time each year and results, along with any volumes dredged within last 12 months, should be provided to consenting authority (ES).

In conjunction with the above findings and proposed mitigations, it is considered that all possible measures have been taken to avoid, mitigate or manage any potential adverse impacts on the marine environment from the proposed works.

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1 Introduction

1.1 Overview

South Port New Zealand Limited (South Port) operate a vessel maintenance facility on the northeast side of Island Harbour (251 Foreshore Road) in Bluff Harbour (Figure 1). At the facility, a shiplift and transfer system (Syncrolift) is used to take vessels out of the water and move them to dry dock sheds for inspection, repairs, blasting or painting. Since the facility was constructed in 1993, sediment has built up under the Syncrolift platform, preventing the platform from being fully lowered into the water. South Port are proposing to remove the material from underneath the structure so that the Syncrolift meets operational requirements at the port.

Due to the limited access under the platform where the sediment build up has occurred (Figure 2), South Port have proposed to use a venturi suction dredge to remove the sediment. This method of dredging transfers material from under the platform via temporary pipeline and will discharge the sediment to the water column and receiving environment approximately 400 m away from the Syncrolift platform (near Berth 8 in the main harbour channel). Based on initial assessments made in 2022, an approximate maximum total of 6,000 m^3 of sediment is to be removed initially, with annual maintenance dredging of the same volume proposed.

A specific sediment removal technique was trialled in 2022 but was deemed unsuccessful due to the type of venturi suction dredge methods being utilised in the soft sediment environment. Apart from the dredge suction technology being used, the overall dredging methodology of sediment removal, transport and discharge remains similar, although the discharge location will be further from the Syncrolift than originally discussed. As such, South Port have developed the overall dredging methods and volumes but seek to retain the ability to modify the specific equipment used at the dredge head to achieve the project goal.

Figure 1: Syncrolift site location on South Ports' Island Harbour within Bluff Harbour, NZ.

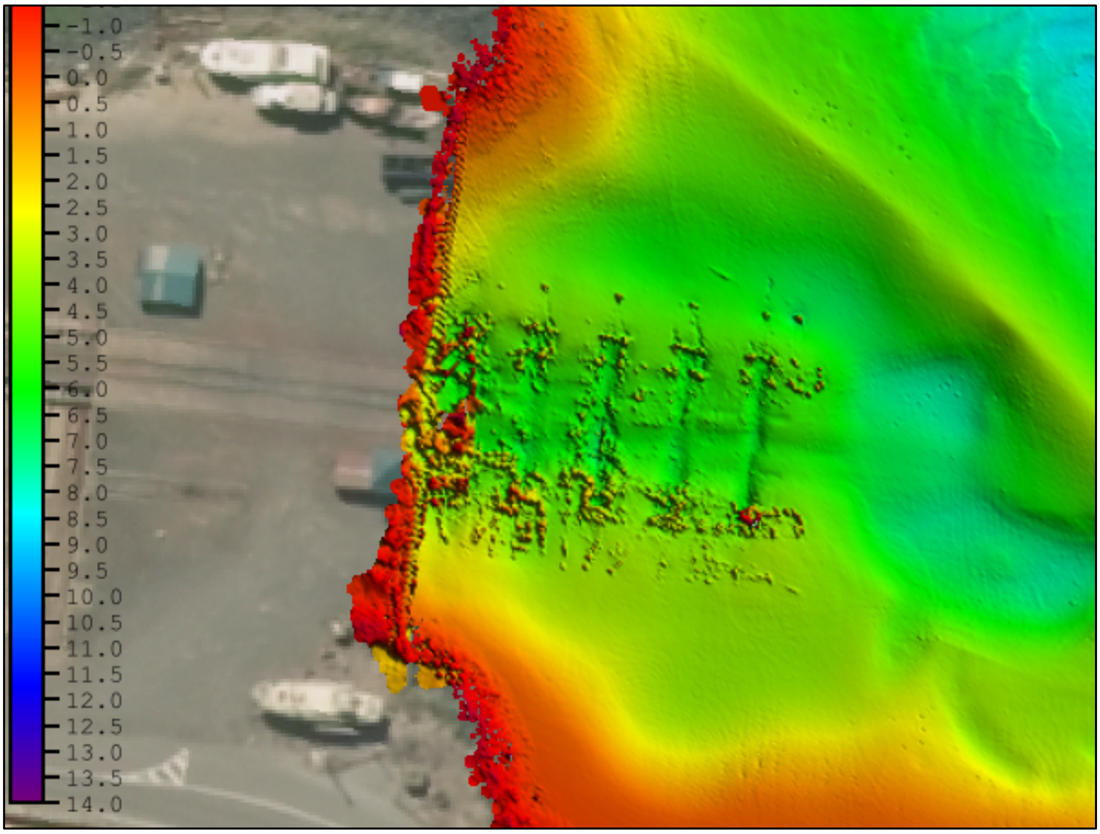

Figure 2: Bathymetry beneath the Syncrolift (Beardmore & Miller, 2022).

1.2 Scope of Works

e3Scientific Limited (e3s) has been contracted to provide a Marine Ecological Impact Assessment (MEcIA) for the proposed Syncrolift dredging activities. This assessment includes specific site investigations for the dredge area including benthic habitat and sediment analysis, as well as a collation of data and comprehensive desktop assessment for ecological values in the area. More specifically this report is structured as follows:

- Section 2: Environmental context and site descriptions.
- Section 3: Description of the proposed dredging and deposition methodology.
- Section 4: Assessment methodology, site investigations and desktop review.
- Section 5: Results and descriptions of the marine habitats and values present within the Syncrolift site and Bluff Harbour entrance.
- Section 6: Assessment of marine environmental effects.
- Section 7: Recommendations for avoidance and mitigation; conclusions.

1.3 Limitations

The findings of this report are based on the Scope of Work outlined above. e3Scientific Limited (e3s) performed the services in a manner consistent with the normal level of care and expertise exercised by members of the environmental science profession. No warranties, expressed or implied, are made. Subject to the Scope of Work, e3s's assessment is limited strictly to assessing the effects of the proposed Syncrolift dredging and dredge spoil deposition on the marine environment.

The results of this assessment are based upon site inspections conducted by e3s personnel and information provided in reports. All conclusions and recommendations are the professional opinions of e3s personnel involved with the project, subject to the qualifications made above. While normal assessments of data reliability have been made, e3s assumes no responsibility or liability for errors in any data obtained from regulatory agencies, statements from sources outside e3s, or developments resulting from situations outside the scope of this project.

2 Site Description and Environmental Context

2.1 Site Description

Bluff Harbour and Awarua Bay are two parts of a single harbour system on Southland's south coast. Bluff Harbour itself consists of a large, predominantly subtidal, inlet of 1,656 hectares (ha), and Awarua Bay is an intertidal lagoon system, approximately 605 ha in area (Robertson, *et al*., 2004). The harbour system is connected to the open ocean by a narrow (500 m) harbour entrance between Tiwai Point and Bluff Township (Heath, 1976). Bluff Harbour is sheltered to some extent from the prevailing westerly winds by a narrow but hilly peninsula, terminating to the southwest in the dominant Motupōhue/Bluff Hill. To the north and east the landscape is generally flat and is dominated by the swampy Awarua Plain and the large Tiwai Peninsula.

The harbour waters, and those of the associated Awarua Bay lagoon system, are tidal and strong currents are generated within the port zone and at the harbour entrance. Some rocky reef habitat occurs near the harbour entrance at Tiwai Point and on the Bluff Township side of the entrance and remains exposed due to the strong tidal currents eroding soft sediments at this location. South Port itself is located on a reclaimed section of land joined to the mainland by a bridge, aptly named Island Harbour, near the Bluff Harbour entrance.

The location of the Syncrolift can be seen in Figure 1 on the northeastern side of Island Harbour. The sediment disposal site is located roughly 400 m east of the Syncrolift in the main channel zone near Berth 8. This region of Island Harbour is fundamentally industrial, with boulder seawalls and vertical sheet pile wharves extending to the seafloor. The proposed disposal site mid channel is characterised by a soft-sediment benthic environment with large tidal flows operating in both directions but an otherwise semi-sheltered harbour environment.

Figure 3 shows the location of other management areas and Environment Southland compiled information in the coastal marine area in the context of the dredge area and disposal location.

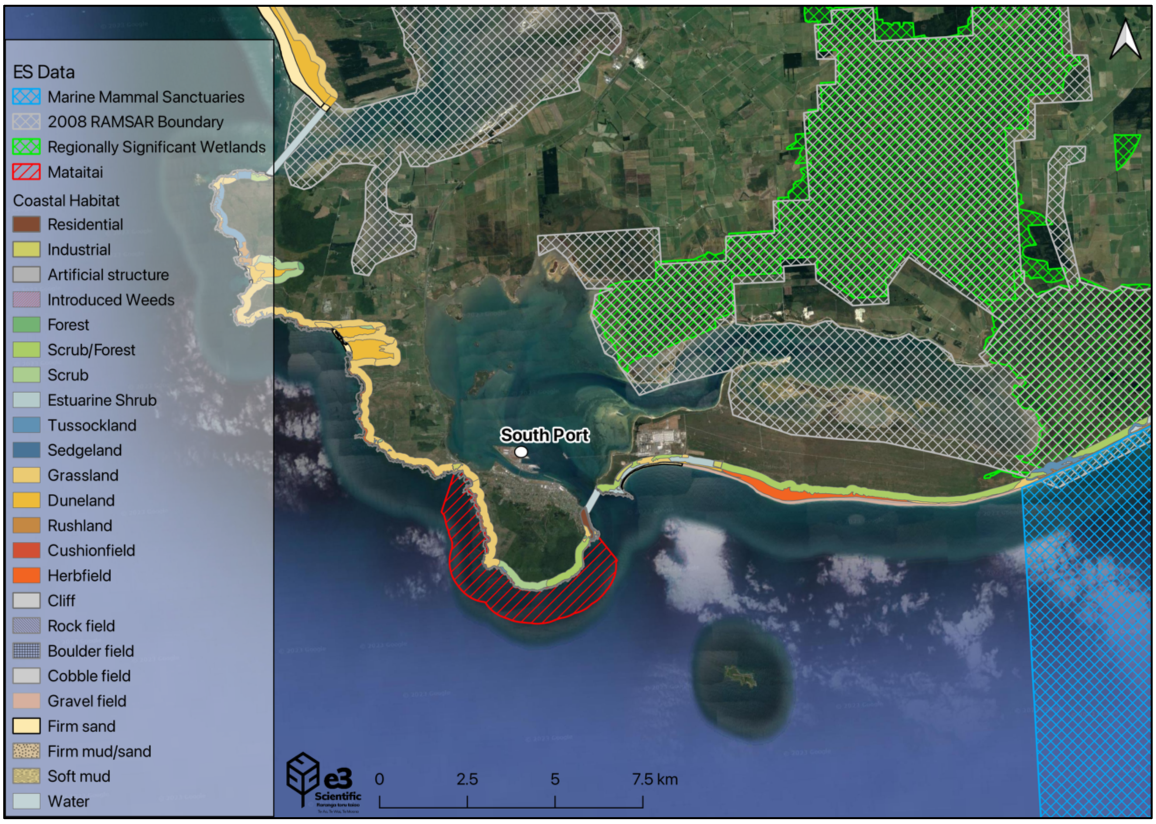

Figure 3: South Port and nearby Mātaitai reserves, marine mammal sanctuaries and Awarua Wetland Ramsar site (from Environment Southlands' (ES) Beacon https://maps.es.govt.nz/index.aspx?app=coastline-habitat&ext=1224990,4822529,1279375,4853104).

2.2 Bluff and Foveaux Strait Weather Characteristics

Bluff and Foveaux Strait experiences some seasonal variation in monthly rainfall with the most rain on average occurring between December and January (100 mm average total accumulation) and the least rain on average occurring in July and August (58 mm average total accumulation). The windiest time of year is from the end of August to start of December (i.e. over the spring months) with average wind speeds of more than 20 km/hr and predominant wind direction from the west throughout the year (NASA, 2021). During the winter months easterlies and northerlies are more common than in any other months.

2.3 Physical Environment

Bluff Harbour is within the Southern Coastal Biogeographic region which is particularly noted for high tidal flow areas within Foveaux Strait (Ministry of Fisheries & Department of Conservation, 2008).

2.3.1 Bluff Harbour

The Bluff Harbour entrance system comprises a large ebb-tidal delta which is fed with fine grained sands and silts derived from within the harbour and from net sediment transport from west to east through Foveaux Strait (Morris, 1984). It is a well flushed harbour dominated by firm sand and gravel with little mud present (Figure 4) (Robertson, *et al.*, 2004). Circulation in the vicinity of the harbour is primarily tide driven. The ebb-tidal delta is flanked under Motupōhue/Bluff Hill, and to the north along the beaches of Tiwai Peninsula, by marked channel systems which carry high velocity tidal streams. Moderate to high natural sand transport rates occur in both these channels. The outer edge of the delta is steep faced and subject to very strong current shear in a net easterly mean circulation (Morris, 1984).

Within the western harbour, including the port area, the sediments are derived, probably at low net rates, from tidal flow into the harbour and from reworking of coarser sediments in the eastern portion of the harbour basin. Sands transported into the harbour are circulated around both margins of the Island Harbour. The eastern margin of the entrance adjacent to the Tiwai Wharf is also a zone of siltation (Robertson, *et al.*, 2004).

The Bluff Harbour entrance channel comprises bedrock basalt along the northern and southern margins and coarse sand substrate predominating in the middle of the channel (Stevens & Clarke, 2004). Fragmented boulders within the northern margins of the shipping channel are a minor indication of capital dredging drilling and blasting as opposed to the naturally occurring bedrock.

Water temperature in the outer harbour (i.e. near Island Harbour) ranges from 9° Celsius (C) in the winter months to 19°C in the summer months. There is very limited water quality data within Bluff Harbour, however it is generally believed to have good water quality within the outer harbour which is utilised for recreational fishing and boating purposes. The inner harbour and Awarua Bay is subject to adjacent land-use and often has high silt loadings from farmland run-off after high rainfall events.

Figure 4: Substrate types present within Bluff Harbour (from Stevens & Clarke, 2004).

2.3.2 Foveaux Strait/Tiwai Peninsula

Foveaux Strait, is identified as having the strongest tidal flow in any coastal water around mainland NZ with a mean speed of 0.08 m/sec and volume transport of 70,000 m^3/sec (Heath, 1973). The entire 32 km of the strait is a shallow body of water less than 30 m in depth and coupled with the strong wind-driven constricted flow and Subantarctic weather patterns can be a dangerous body of water. River deltas to the west produce a large volume of sediment and sand to the strait. This material is transported east, past Motupōhue/Bluff Hill, where it is moved past the delta-front to join sand exiting the Bluff Harbour channel before being moved through the basin formed west of Dog's Tongue Reef (Morris, 1984). Wave break is significant along the outer margin of the delta, particularly during storms. In conjunction with strong tidal currents, the wave-induced turbulence results in very high sediment transport rates in this area.

Water temperatures are more consistent in Foveaux Strait as they are dominated by oceanic systems and range from an average of 11°C from June to October and 14°C from January to April (NASA, 2021).

2.4 Biological Environment

Bluff Harbour contains estuarine vegetation dominated by seagrass and macroalgal beds in the inner harbour (Robertson *et al*., 2004). Nearer to the harbour entrance, red macroalgae beds dominate on the soft sediment habitats, with few epifaunal species present such as turret shells (*Maoricolpus roseus*) and hermit crabs (*Pagurus* spp.). Storm-generated waves and strong tidal currents shape the sandy bottom into ripples and ridges in shallow subtidal sandy habitats in the inner harbour. Some rocky reef habitat occurs near the harbour entrance at Tiwai Point and on the Bluff Township side of the entrance (including Argyle Beach).

Species common to the southern area of New Zealand are present including algae, shellfish, echinoderms, and fish. Pāua, green lipped mussels and kina predominate where rock substrate is present, while the main fish species are moki, butterfish and blue cod. These invertebrate and fish species are valued by recreational fisherman. The South Port berths and the nearby fisherman's wharf are productive and diverse habitats with triplefins, spotties, octopus, seahorses, rock lobsters, bryozoans, hydroids, ascidians, sponges and the green algae, *Caulerpa brownii*, present (e3Scientific Ltd, 2019). The invasive brown algae *Undaria pinnatifida* is prevalent through much of the harbour, particularly on man-made structures such as wharves and berths.

2.4.1.1 Sharks

Shark species such as the broadnose sevengill (*Notorhynchus cepedianus;* Not Threatened[i]), white pointer (*Carcharodon carcharias;* Threatened – Nationally Endangered), spiny dogfish (*Squalus acanthias;* Not Threatened), school (*Galeorhinus galeus*; Not Threatened) and oceanic blue (*Prionace glauca;* Not Threatened) will utilise Bluff Harbour and Foveaux Strait at certain times of the year in varying frequencies.

[i] All shark Threat Classifications are from (Duffy, *et al*., 2016).

2.4.1.2 Seabirds

A total of 155 bird species are identified as utilising the area surrounding the Bluff Harbour marine environs. Of these, 59 species have a conservation status of more than At Risk identified by Robsertson, *et al*. (2016) and cover eight main categories of birds; waterfowl, penguins, albatross, petrels/ shearwaters and allies, cormorants/shags, shorebirds, herons, gulls and terns (Stephenson, 2021). More specifically, species that are commonly seen in the Bluff environs include black-backed gulls (*Larus dominicanus*; Not Threatened), red-billed gulls (*Larus novaehollandiae*; At Risk - Declining), black-billed gulls (*Larus bulleri*; Threatened – Critical), white-fronted terns (*Sterna striata*; At Risk – Declining), variable oystercatchers (*Haematopus unicolor*; At Risk – Recovering), black shags (*Phalacrocorax carbo*; At Risk – Naturally Uncommon), Foveaux shag (*Leucocarbo stewarti;* Threatened – Vulnerable), albatross/mollymawk species (*Thalassarche* spp.), sooty shearwaters (*Puffinus griseus*; At Risk – Declining), little penguin (*Eudyptula minor*; At Risk – Declining) and yellow-eyed penguins (*Megadyptes antipodes*; Threatened – Nationally Endangered).

2.4.1.3 Marine Mammals

The greater Southland and Foveaux Strait region is an important area for a large number of New Zealand's whale, dolphin and seal species. At least six marine mammal species are year-round residents and/or seasonal visitors, with several baleen whale species migrating to and through Foveaux Strait each winter/spring, and more offshore species wandering into shallow regions over warmer months (Childerhouse, 2021). Seal species are commonly observed along the foreshore near Bluff Township, Stirling Point and within the Motupōhue mātaitai, with prominent seal colonies on the Tītī Islands and Bench Island near Stewart Island.

3 Description of Proposed Activity

The proposed dredging is considered an overdue maintenance activity for South Port's Syncrolift operations. Since the Syncrolift became operational in 1993, sediment has accumulated under the platform, preventing the platform from being fully lowered into the water to its' initial depth of 7.5 m C.D. The proposed maintenance dredging is required to allow for the full range of the Syncrolift system and for this target depth of 7.5 m C.D. to be maintained.

In Figure 2, both Syncrolift piles and accumulated sediment can be seen in and around the structure. The proposed activity will use a venturi suction dredge to remove the built-up material, where it will be transported via pipeline to a discharge location approximately 400 m away near Berth 8 in the main harbour channel (Figure 5). At the discharge site, the sediment mixture will be released near to the seabed into the water column on an ebb tide, to promote transport towards Foveaux Strait and minimise deposition in the local receiving environment. The proposed discharge location will be located in ~8 m of water depth and near the seafloor. An alternate discharge location has been identified due to potential shipping (vessel) constraints ~320 m away in the main channel, in ~7 m water depth. Based on initial assessments made in 2022, a maximum volume of 6,000 m^3 of sediment is to be removed annually. Discharge rates are estimated at 800 to 1,000 m^3/hr for the mixed slurry (water and solids) and 150 to 250 m^3/hr for total solids within, however these are theoretical and may change slightly based on finalised dredging methodologies. Based on this estimated dredging capacity, and dredge setup/movement, approximate total dredging time to remove the maximum volume of 6,000 m^3 during optimal tidal windows is estimated at a maximum of two weeks annually.

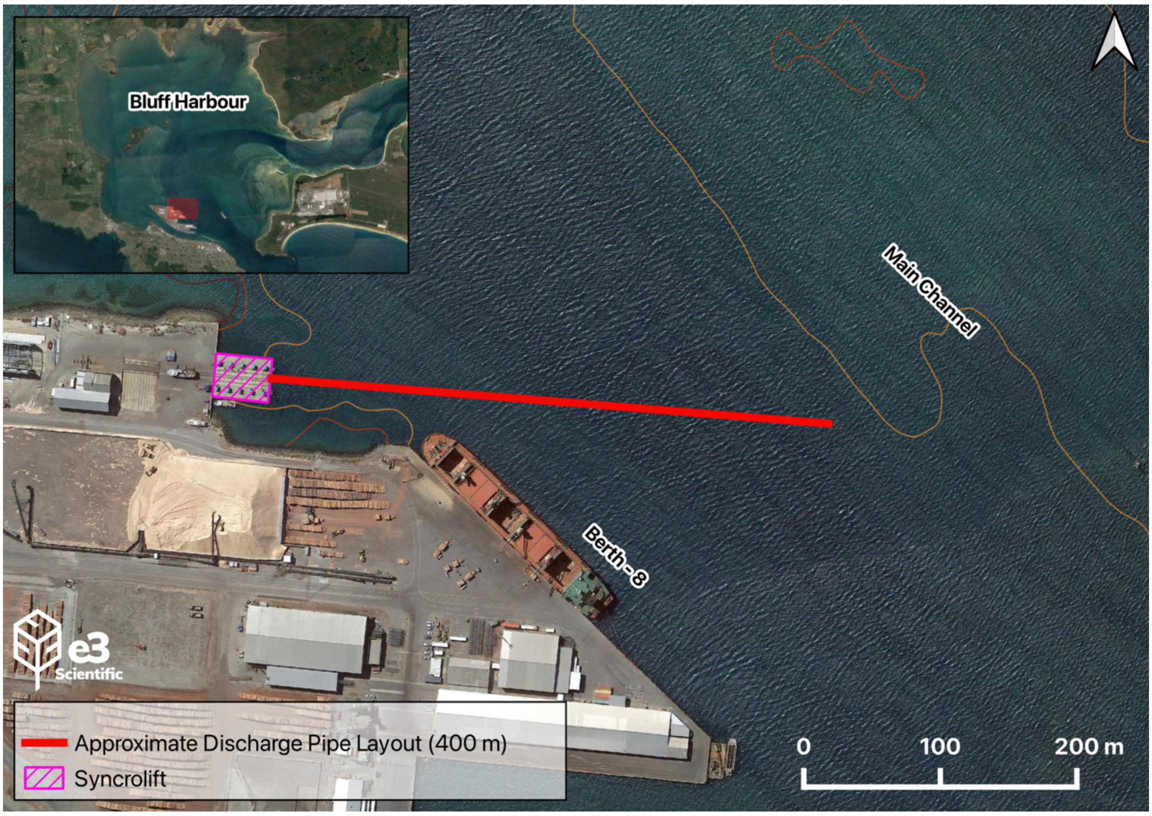

Figure 5: Syncrolift dredge site and approximate discharge pipe layout (400 m pipe).

3.1 Dredging Methodology

The suction dredging methodology beneath the Syncrolift involves the use of a floating and movable dredging pontoon, which houses a winched dredging unit (Figure 6A & 6B). This pontoon is anchored laterally to the adjacent Syncrolift piles during operation, allowing movement in all directions (Figure 6C). The suction dredging methodology beneath the Syncrolift involves an engine-driven dredge pump. The suction created by this pump is sufficient to dislodge a mixture of seabed materials and water through the cutter head and suction pipe, which will be pushed to the discharge location via the pipe.

In 2022, a technique was trialled using a cutter head on a venturi suction dredge from a floating pontoon (see Beardmore & Miller, 2022). The test was deemed unsuccessful due to diver operations and water jets being used in the soft sediment environment. Because of this, South Port has specified the overall dredging plan, with the ability to modify the exact type of equipment being used on (or at) the dredge head. Overall, there are only a few types of small dredging machines for this application, and all types should maintain a similar effect on benthic and water quality values while in operation. Because of this, no other equipment-specific effects are expected.

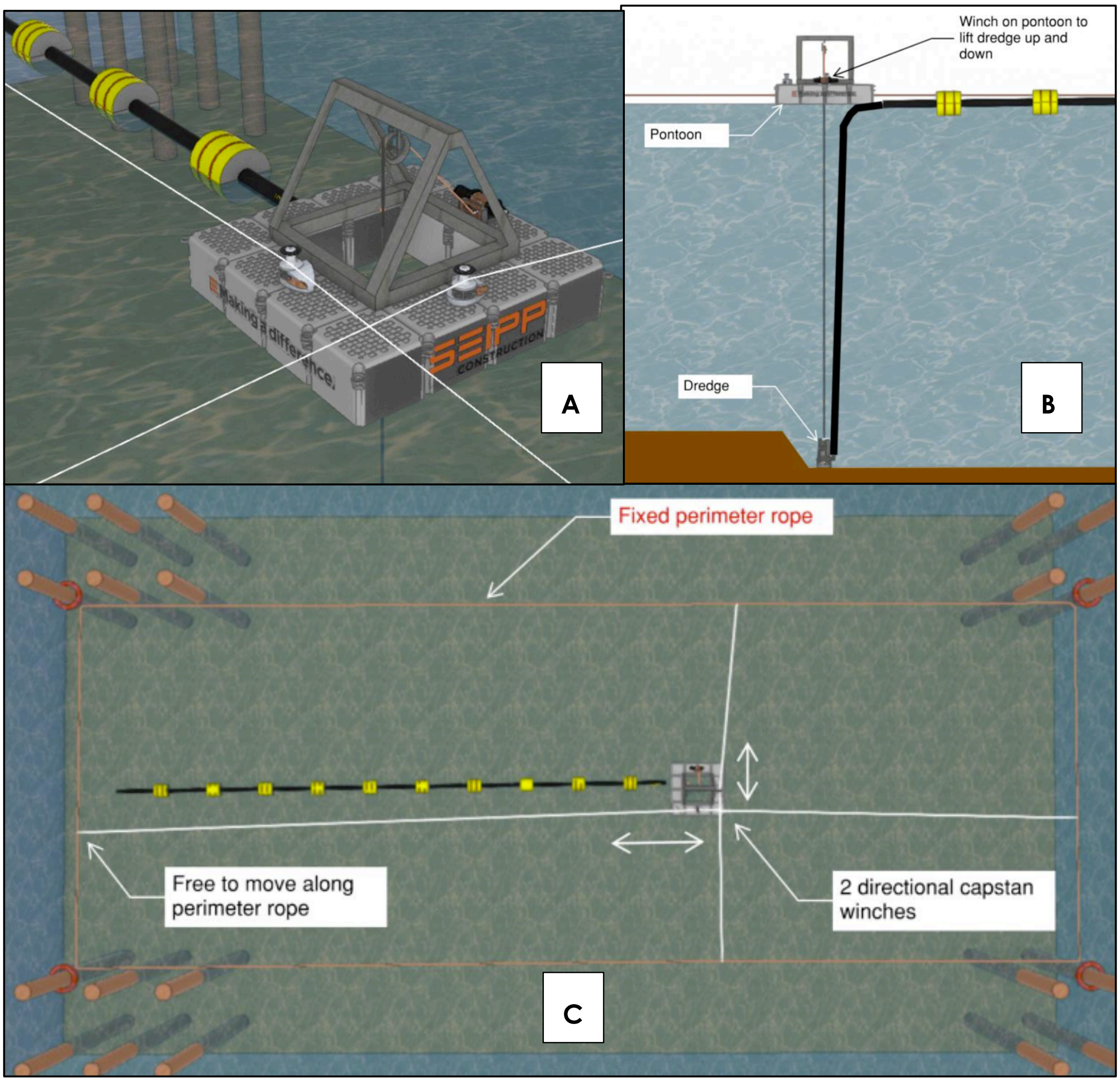

Figure 6: A) Example dredging pontoon, B) vertical suction head profile, and C) plan-view lateral movement configuration.

3.2 Disposal Activities

Sediment slurry (water and benthic material) from the Syncrolift suction dredging operation will be transported via a pipe to a location approximately 400 m east of the Syncrolift to the approximate location of 1242819 E, 4829903 N (NZTM), in a water depth of approximately -8 m water depth (see Figure 5). The slurry will exit the pipeline through a diffuser at the pipe end, where it will join the outgoing tidal water column near the seafloor. The total volume of material to be transported is estimated at a maximum of 6,000 m^3 with pumping rates[ii] estimated at between 150 – 250 m^3/hour or 750 - 1250 m^3 per tidal cycle[iii].

While most of the sediment will drop rapidly to the seabed, the lighter fractions will be mobilised and readily resuspended via tidal currents and wave action. Because of this, the lighter fractions of the total dredging volume of 6,000 m^3 are anticipated to be mobilised and distributed over the following days, with onshore/offshore movement by wave action, alongshore by currents and by wave induced littoral drift inside the surf zone. Therefore, it is unlikely that a significant depth change is observed at any location from sediment deposition.

[ii] These are theoretical and may change slightly based on finalised dredging methodologies.

[iii] Based on a 5-hour tidal window option.

4 Assessment Methodology

The methodology for the assessment of ecological values and effects is based on a desktop study, previously undertaken reporting for the area and site investigations completed by e3s and South Port. Site visits primarily aimed to characterise the sediment proposed for removal, and desktop research aimed to collate previous investigations and pertinent information to better understand receiving environments and potential impacts/effects.

4.1 Desktop Collation of Information

Over the last 6 years, e3s has completed a number of subtidal investigations around South Port, the wider Bluff Harbour, Motupohue mātaitai and Tiwai Peninsula across multiple projects. The projects have included detailed collection of existing information as well as site-specific environmental monitoring. The main studies which have been utilised within this report are briefly described below:

- Between 2017 and present day, e3s has completed an annual seabed and wharf assessment collecting sediment cores and epibiota photos of existing benthic/mobile communities around Island Harbour and the wider Bluff Harbour. An annual sediment assessment is also completed assessing port locations and the consented dredge spoil discharge location near the Tiwai Peninsula.
- In 2020 e3s was commissioned to complete a MEcIA for the South Port Capital Dredging Project (Miller & Davis, 2021) along with subsequent environmental monitoring pre and post activity (ongoing). Cumulatively these studies have collated existing available information, have conducted oceanographic modelling, mapped habitats and have provided site-specific characterisations of flora and fauna in soft sediment habitats and rocky reefs throughout the main channel of Bluff Harbour.
- In 2022 e3s assisted South Port with a resource consent application for a dredging trial underneath the Syncrolift, which aimed to characterise sediment characteristics in and around the platform (Beardmore & Miller, 2022). This report also discussed potential adverse effects of the discharge on the receiving environment (contained within a sediment curtain).

- In 2022 and 2023 e3s has completed repetitive seagrass and mātaitai rocky reef assessments (including sediment and epibiota characterisations) as part of the monitoring programme for the Capital Dredging Project.

Other pertinent reports and online literature are cited within. In aggregation, this collation of literature has informed the marine ecological values and habitats.

4.2 Benthic Sampling

4.2.1 Syncrolift Dredge Material

An investigation was conducted in 2021 and 2022 by e3s to characterise the physical and chemical composition of sediment to be dredged under and around the Syncrolift platform (see Beardmore & Miller, 2022). Nine core samples were collected from under the Syncrolift, and 16 core samples collected from the nearby environment. In December 2021, 8 of the receiving environment samples were collected at a distance of 2.5 m from the edge of the platform. In February 2022, a further 8 samples were collected between 20 and 25 m from the platform. All samples were tested for particle size (PSA), heavy metals, tributyltin, nutrients and total organic carbon.

Following the unsuccessful trial dredging effort, further sediment samples were collected by South Port on 26 June 2023. These samples were collected from directly underneath the Syncrolift, and were tested for PSA, heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. Aggregated sample locations are shown in Figure 7. Additional South Port sediment samples collected in June 2023 were 'composite' samples and are described below in Table 1.

Figure 7: Sampling plan for the initial Syncrolift dredge testing of sediments (Beardmore & Miller, 2022), and the latest South Port sediment sampling in June 2023.

Table 1: South Port composite sample descriptions (provided by South Port). Composition points link with Figure 7 (South Port Samples for June 2023).

Sample	Description
1 - Syncro	1 - Syncro: composition of materials from points 1, 2 and 3, on the seabed surface (<200 mm)
2 - Syncro	2 - Syncro: composition of materials from points 4, 5 and 6, on the seabed surface (<200 mm)
3 - Syncro	3 - Syncro: composition of materials from points 7, 8 and 9, on the seabed surface (<200 mm)
4 - Syncro	4 - Syncro: composition of materials from points 7, 8 and 9, with depth between 800 mm and 1000 mm
5 - Syncro	5 - Syncro: composition of materials from points 4, 5 and 6, with depth between 800 mm and 1000 mm
6 - Syncro	6 - Syncro: composition of materials from points 1, 2 and 3, with a depth between 800 mm and 1000 mm

During the first round of sampling (December 2021), samples from the receiving environment were collected using a van Veen grab operated from the vessel Takitimu III. At each location, a grab sample of 200 mm of surficial sediment was retrieved. Samples from under the Syncrolift and from the receiving environment during the second round of sampling were collected by divers on SCUBA using

80 mm diameter cores. These cores were driven 200 mm into the sediment, capped and brought to the surface. South Port samples collected in 2023 were also completed on SCUBA using similar methods.

All samples were homogenised at the surface and a subsample of the core was transferred to a 200 mL glass jar as supplied by Analytica Laboratories. All samples were labelled in a clear and durable manner, detailing sample name, project number, time and date of collection. Samples were transferred to the laboratory using signed chain of custody procedures and all sediment samples were couriered to Analytica Laboratories[iv] within a day of collection. Analytica conduct internal QA/QC in accordance with IANZ requirements. Following the receipt of laboratory data, a detailed review of the data was performed to determine its accuracy and validity. All laboratory data were checked for analytical and typographical errors. For a full description of methods and results, see Beardmore & Miller (2022) and Miller & Doheny (2023).

4.2.2 Receiving Environment

4.2.2.1 Soft Sediments Chemical & Physical Characteristics

As part of a Discharge Agreement between South Port and Environment Southland (ES), marine sediment sampling for contaminants and particle size has been ongoing since 2014 within berth sites and the inner harbour (see Appendix A). Sediment cores were taken on SCUBA every 12 months near the berths and a harbour control site (Figure 8). As part of this sampling, four sediment cores and a further 4 replicate cores (of an 80 mm diameter) are collected within a 10 m^2 area at Berths 3A, 5 and 8, and Harbour Control sites. Further to this sediment samples have been collected within the Swinging Basin (SB zone) adjacent to Island Harbour as part of the Capital Dredging project.

To obtain the sediment, a corer is manually driven into the sediments to a depth of 150 mm, capped in situ, and returned to the vessel. On board, each core is examined to qualitatively determine sediment texture, colour, and odour. The presence/absence of apparent redox potential discontinuity (aRPD) and hydrogen sulphide odour are used as qualitative indicators of enriched conditions. Photographs are taken of each core to document the relative degree of enrichment to provide a long-term record.

[iv] Analytica have IANZ accreditation for the analysis of heavy metals, organic carbon, and organic tin.

For analysis, the surface layer (i.e. the top five centimetres) of each set of four cores is composited into pre-labelled, sterilised, sample jars. The laboratory analytical suite determined for the sediment samples was specified by South Ports' existing Discharge Agreement monitoring conditions. Consequently, the following laboratory analytical suite was completed for these samples:

- Particle size analysis (PSA) (percent gravel, sand and silt / clay);
- Total Organic Carbon (TOC);
- Phosphorus (P);
- Heavy metals: arsenic (Ar), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), zinc (Zn);
- Tributyltin (Tbt); and,
- Polycyclic Aromatic Hydrocarbons (PAHs).

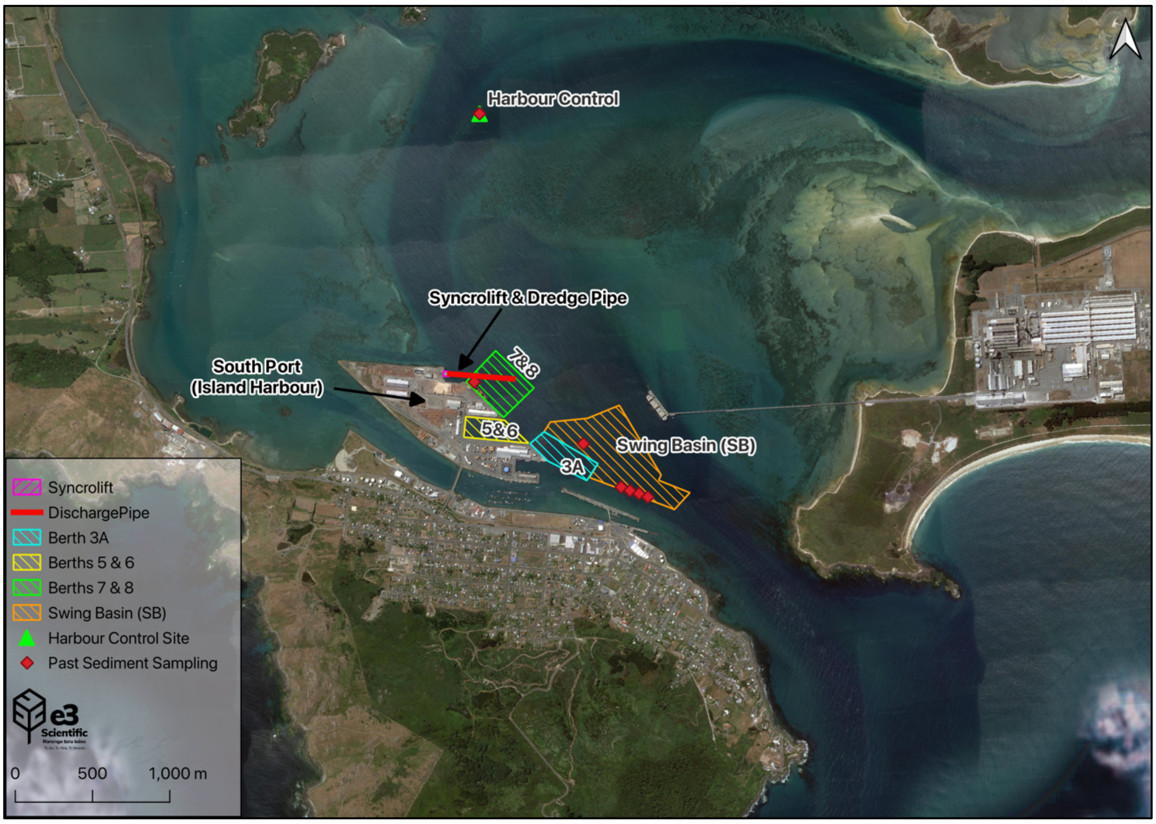

Figure 8: Past sediment sampling sites.

4.2.2.2 Soft Sediments Infauna

Benthic infauna assessments have been also conducted within berth sites and the inner harbour (Figure 9; see Appendix A).

All infaunal sampling was completed via cores on SCUBA and sites were located using fixed landmarks from previous surveys, or a portable global positioning system (GPS). Each infaunal core has a 100 mm internal diameter and was driven approximately 150 mm into the sediment, capped in situ and returned to the surface whereby the contents were sieved through a 0.5 mm mesh. The residual was emptied into a clearly labelled plastic container, preserved with 70% ethanol and couriered to NIWA for processing. Identifications were made to the lowest practicable taxonomic level. Infauna count data were analysed to determine individual species density (abundance), species richness (diversity) and standardised indices of community diversity and evenness for each sample (Table 2). The full methods and results of this sampling are provided in Appendix A.

Figure 9: Past benthic infauna assessment sites within the receiving environment relative to berth layout.

Table 2: Descriptions of infaunal indices.

Index	Equation	Description
Abundance (N)	Sum (n)	Total number of individuals in a sample.
Species Richness (S)	Count (taxa)	Total number of species in a sample.
Evenness (J')	$J' = H/\ln(S)$	Pielou's evenness. A measure of how evenly the individuals are distributed among the different species. Values range from 0 to 1; 0 indicates

		uneven distribution and 1 indicates an even distribution.
Diversity (H')	$H' = -SUM(Pi * \ln(Pi))$	Shannon-Weiner diversity index (H'). A diversity index that describes, in a single number, the different types and amounts of animals present in a sample. The index ranges from 0 for samples with a single species to high values for samples containing many species.

4.2.3 Sediment Quality Guidelines

Sediment quality guidelines were adopted from both the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) and the Canadian Council of Ministers of the Environment (1999). Both guidelines were used to assess potential risk to aquatic organisms where available. These guidelines present default guideline values or threshold effect levels with 'possible' effects (DGV or TEL) and upper guideline values or 'probable' effect levels (GV-High or PEL). The ANZG (2018) default guideline values for heavy metals were "*primarily adapted from the effects range low (ERL) and effects range median (ERM) values of Long et al. (1995)*." The CCME has published documents for select elements and more broadly states that "*guidelines are numerical concentrations or narrative statements intended to protect all forms of freshwater and marine (including estuarine) aquatic life during all aspects of their aquatic life cycles for an indefinite period of exposure to substances associated with bed sediments*." As noted, the two threshold levels under which biological effects are predicted include the lower threshold which indicates a *possible* biological effect, while the upper threshold indicates a *probable* biological effect. These trigger values are conservative criteria for sediment quality that should ensure environmental values are protected. The intent of these threshold values is to act as a trigger value for more intensive assessments if they are exceeded. For a more detailed account of sediment collection and analysis methods, sites and results please see Appendix A.

4.3 Oceanographic Modelling and Water Quality

4.3.1.1 Currents Modelling

Sediment plume modelling of the proposed dredging activities was conducted by Oceanum Calypso Science (Zyngfogel & McComb, 2023). This report assesses the suspended solids persistence and depositional footprint from potential plume dispersal across Bluff Harbour and Foveaux Strait. The objective of the modelling included the identification of optimal discharge locations and tidal release timing for minimal impacts to sensitive environmental habitats. Assumptions for the model exercise include a release elevation of 0.5 m above the seafloor (at varied locations), tidally driven plume trajectories (e.g., no wave/wind influence), intake plumes are excluded and ambient (existing) turbidity of the water column (varies from ~1 to 10 mg/L) is not considered in the suspended sediment concentrations. In addition, the model utilises a maximum scenario of 6,000 m^3 total solids with pumping rates between 150 – 250 m^3/hr.

To model how the sediment will behave in the water column, information on the characteristics of the dredge sediments were utilised. Sediment samples were collected from the upper 1 m of material underneath the Syncrolift (see Section 4.2.1 and Table 1) and the median size and proportion (%) was calculated for five distinct classes: Clay, Fine Silt, Medium Silt, Fine Sand, and Medium Sand. Sediment particle size distributions (PSA) were utilised to derive modelled settling velocities with deposition on the seabed modelled at 50 m resolutions (in mm of settled material on the seabed). For Total Suspended Solids (TSS) within the water column, a depth-averaged concentration (mg/L) was calculated per timestep.

Detailed model parameters for the Oceantracker particle simulator can be found within the modelling report (Zyngfogel & McComb, 2023).

4.3.1.2 Water Quality

Water quality information at the site or within the anticipated receiving environment was not specifically assessed as part of this study but has been previously collected across Bluff Harbour as part of the South Port Capital Dredging project. Water clarity and by association, light availability, represents the primary factor influencing seagrass growth and productivity, which in turn has been identified as being the most sensitive ecological receptor within Bluff Harbour (Robertson, *et al*., 2004; Stevens & Clarke, 2004; NIWA, 2013).

Three months of water quality sampling between May and August 2016 were undertaken by Southern Waterways on behalf of ES at the town wharf near South Port (see Miller & Davis, 2021). Water clarity was also assessed using a secchi disc at eight locations within the harbour in April 2021 (Figure). This historical data can be viewed alongside more recent turbidity monitoring conducted by South Port as part of the Capital Dredging project for dredge plume mixing zones. This monitoring aimed to gather data from across Bluff harbour at designated control and treatments sites (active dredging or disposal sites). This monitoring specifically tested for Nephelometric Turbidity units (NTU), optical dissolved oxygen, pH and temperature.

Unfortunately the latest sampling by South Port did not test for suspended solids (TSS in mg/L) which would allow for direct comparison to the latest dispersal modelling. To address this, NTU (turbidity; depth-averaged) has been converted to TSS (mg/L) using *in-situ* data collected during a similar environmental impact dredging assessment off NW Australia (MScience, 2011). Figure 11 shows the relationship and conversion factor (y = 2.1368 + 1.1166(x)) which has been applied. The report concludes that a "*strong relationship between turbidity and TSS provides the basis for conversion of turbidity into TSS across a range of water quality conditions and supports the use of turbidity monitoring as an indicator of changes in both TSS and light attenuation*."

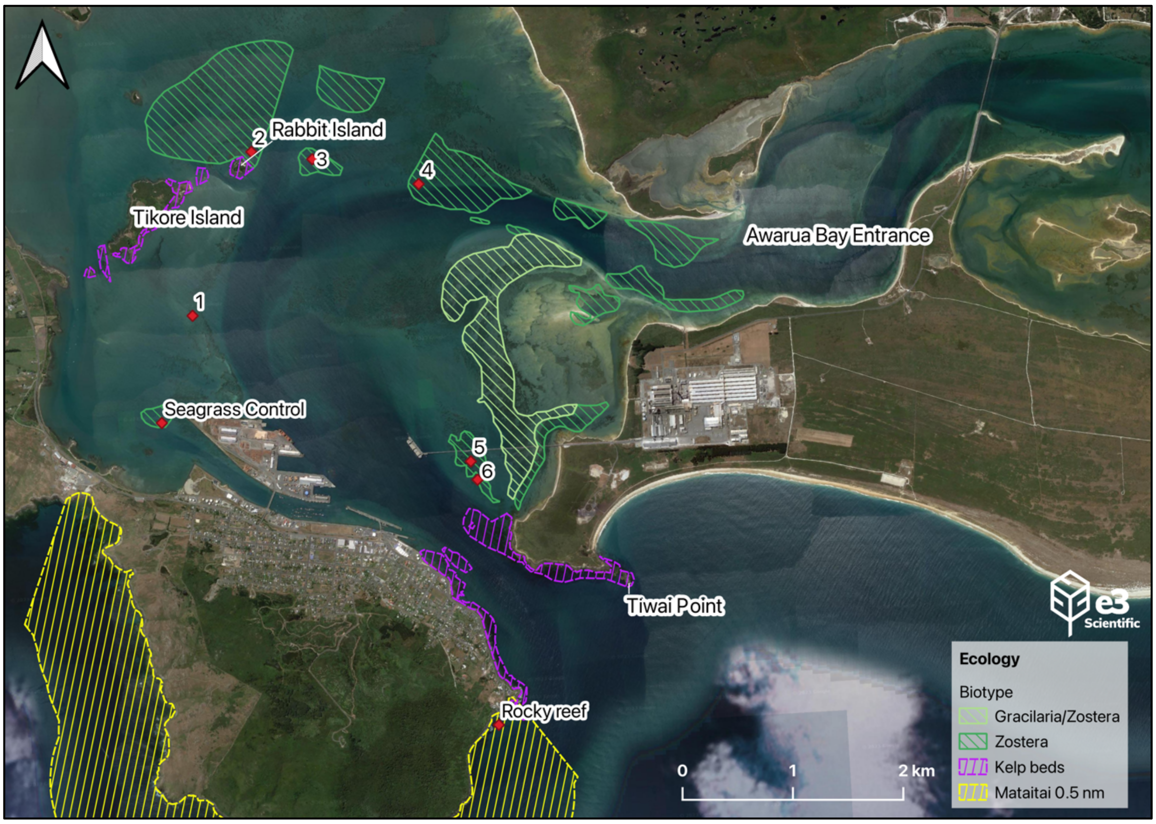

Figure 10: Water clarity sites assessed in April 2021 by secchi disc.

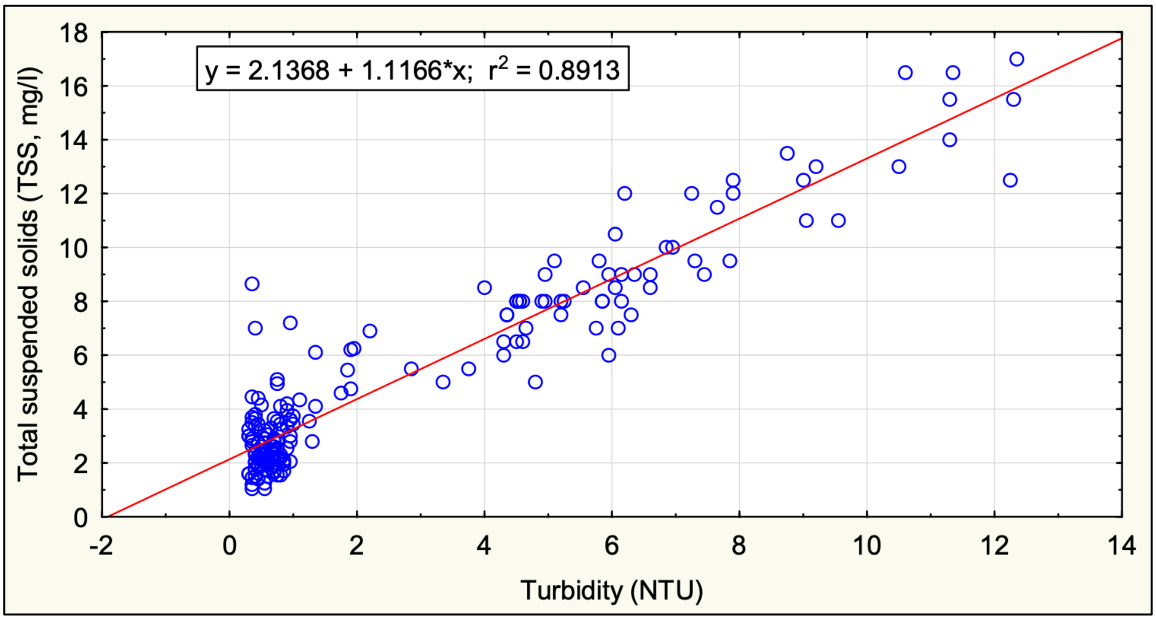

Figure 11: Depth-averaged turbidity (NTU) relationship to TSS (mg/L) (MScience, 2011).

4.4 Ecological Impact Assessment Methodology

4.4.1 Ecological Value

Under the EIANZ guidelines (Roper-Lindsay et al. 2018) ecological value is assigned based on the following assessment criteria:

- Representativeness
- Rarity and Distinctiveness
- Diversity and Pattern
- Ecological Context

Some of these assessment criteria are difficult to utilise within the marine environment as they rely on a range of information to support the assessment i.e. Assignment of a Representativeness value is supported by the Ecological District Framework and/or the Land Environments of New Zealand (LENZ) classification. Similar frameworks have not been established for the marine environment; however, the principles remain valid with respect to variability in physical environmental attributes driving biodiversity. Sites recognised as important in the marine environment include Marine Reserves, Mātaitai Reserves, Marine Mammal Sanctuaries and Important Bird Areas (IBA's) among others. Without a framework to support an assessment of representativeness we consider the reserves, sanctuaries and IBAs will contain ecological attributes that are highly representative of these marine environments.

More easily incorporated into the EIANZ criteria are rarity, diversity and ecological context in the marine environment which can be utilised to support an assessment of ecological value.

Rarity
The New Zealand Threat Classification System (NZTCS) is used to assess the threat status of marine mammals, seabirds and shorebirds, sharks, rays and chimaeras, marine invertebrates and macroalgae. The NZ Coastal Policy Statement also requires adverse effect to be avoided on taxa that are listed by the International Union for Conservation of Nature (IUCN) and Natural Resources as threatened. This impact assessment has utilised the NZTCS and IUCN reports to inform an assessment of rarity.

Diversity
Studies into the biodiversity present within marine habitats in Bluff Harbour and Tiwai Peninsula/Foveaux Strait are provided in Section 2 and a summary of ecological values present is provided in Section 5. This information is utilised to assign ecological value in the vicinity of the proposed landing infrastructure.

Ecological Context
Ecological context describes an ecosystems role in ecosystem function. Examples may include:

- marine habitat may provide an important food source for seabirds.
- marine habitat may play an important part in the lifecycle of a species e.g. nursery habitat for fish species.

For the purpose of this assessment marine habitats that support threatened species, are biologically diverse, provide an important food source or play a critical role in the lifecycle for a species are considered to have a high ecological value.

In addition to ecological values, some habitats are also important for recreational fishers such as rocky shores. These sites have also been assigned a high recreational value.

4.4.2 Assigning Magnitude of Effect

The EIANZ guidelines provide criteria for assigning the extent of the effects on the ecological values within the area that may be disturbed by the activity. This assessment adopts the criteria for describing magnitude of effect and is provided in Table 3 below.

Table 3: Criteria for describing magnitude of effect (Roper-Lindsay, *et. al.*, 2018)

Magnitude	Description
Very High	Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature.
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

4.4.3 Assigning Level of Effect

The level of ecological effect is based on combining the ecological value of a marine environment that may be impacted by the proposed activities and the magnitude of the effect. Table 4 is adapted from the EIANZ guidelines to provide a level of effect matrix. For the purpose of this assessment, where the level of effect is moderate or above, a management response is generally required to ensure potential environmental effects are avoided or mitigated appropriately.

Table 4: Criteria for describing level of effect.

		Ecological Value		
		High	**Moderate**	**Low**
Magnitude	**Very High**	Very High	High	Low
	High	High	Moderate	Low
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Low
	Negligible	Low	Low	Low
	Positive	Net Gain	Net Gain	Net Gain

4.4.4 Residual Impact

The residual impact is the final impact level assigned to the proposed activity and potential effects once proposed avoidance, mitigation or remediation options have been applied. To realign the primarily freshwater and terrestrial EcIA effects assessment method (Roper-Lindsay, *et al.*, 2018) with a marine environment effects assessment, a Low residual impact is synonymous with 'Less than minor'.

5 Results

5.1 Syncrolift Sediments (Dredge sediments)

Sediments underneath the Syncrolift and within the nearby area (<25 m away; see Figure 7) were assessed for both organic and contaminant composition as well as particle size.

5.1.1 Physical Characteristics

Overall, the distribution of particle sizes was similar in sediments from beneath the Syncrolift and from the nearby surrounding area. Samples were dominated by silt, clay and very fine sand, with samples further away from the Syncrolift generally containing a slightly lower proportion of silt and clay. Particle size distributions for each sample are found in Figure 12, with average percentages for each class, across all samples, found in Table 5.

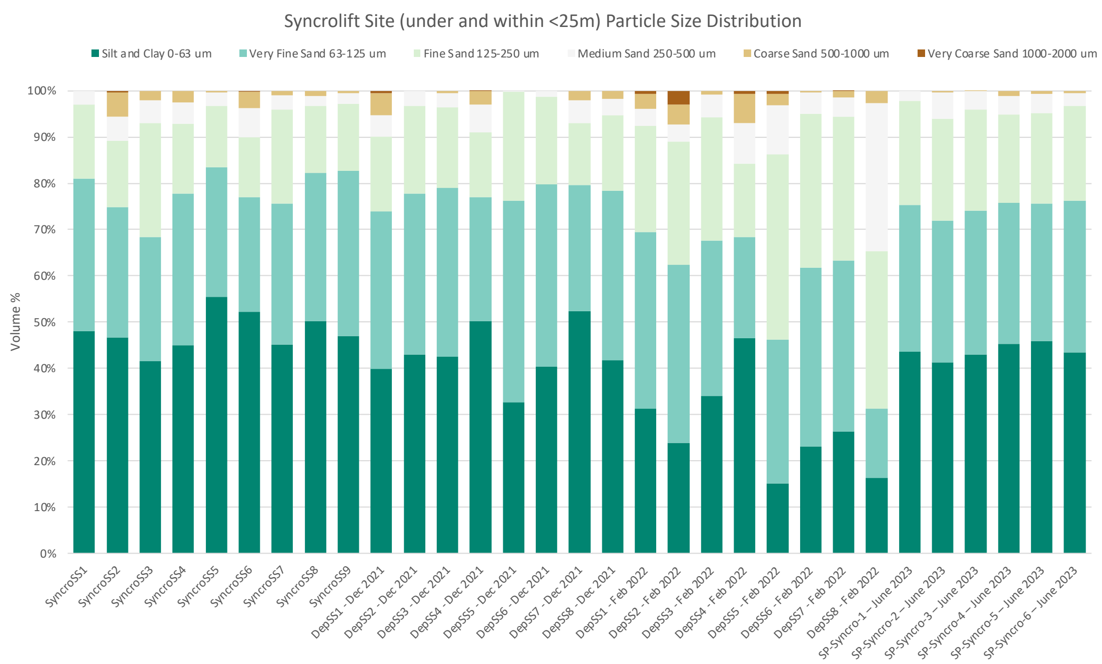

Figure 12: Particle size distribution for all collected samples within <25 m of the Syncrolift site.

Table 5: Average particle size composition across all samples.

	Silt and Clay (0-63 um)	Very Fine Sand (63-125 um)	Fine Sand (125-250 um)	Medium Sand (250-500 um)	Coarse Sand (500-1000 um)	Very Coarse Sand (1000-2000 um)
Average % Across all Samples	40.45%	31.93%	20.66%	5.05%	1.72%	0.2%

5.1.2 Chemical Composition

5.1.2.1 Total Organic Carbon (TOC)

Total organic carbon (TOC) is a measure of the carbon contained within sediment organic matter. For marine surface sediments average TOC is approximately 2% along coastal margins (Seiter *et al.,* 2004). TOC levels tend to correlate with factors causing ecological stress (stressors can include low dissolved oxygen, high ammonia and sulphide, and/or chemical contamination of sediments). Increasing organic carbon content aids the apportioning of both metals and organics to sediment particles. Generally, benthic species and biomass decrease as TOC levels become high (i.e., above 3.5 g/100 g) due to the stronger binding of contaminants to TOC (Hyland *et al.,* 2005). Therefore, TOC can provide a non-specific indicator of benthic species stress. Hyland et al. (2005) also found an intermediate risk of potential effects on benthic species could occur between 1.0 g/100g and 3.5 g/100g. TOC concentrations found across samples ranged between 0.24 and 2.1, maintaining consistency with a 2% 'average' coastal guideline.

5.1.2.2 Heavy Metal and Tributyltin Results

Table 6 and Table 7 provide the heavy metals and total organic carbon (TOC), tributyltin (Tbt) and triphenyltin results, respectively.

Analytical results for heavy metals included arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn). Copper consistently exceeded the ANZG (2018) DGV and CCME (1999) threshold guidelines across most samples with samples nearby or underneath the Syncrolift showing elevated values for all but one site. Arsenic was occasionally found at levels above CCME (1999) threshold (TEL) limits, again in locations closer to the Syncrolift. Results for both nickel and zinc showed occasional ANZG (2018) DGV and CCME (1999) exceedances across sampling years/groups. Overall, deposition samples from 2022 were farther away from the Syncrolift platform and showed decreased heavy metal concentrations.

The purpose of measuring for Tributyltin (Tbt) is to monitor for possible inputs of antifoul paint from vessels. All detected Tbt levels were normalised to 1% organic carbon (mg/kg dry weight, 1% OC) as the concentrations of Tbt (as an organotin compound) in the organic fraction of sediment is more relevant than dry weight concentrations with regards to assessing adverse ecological and biological effects (see Table 7). Tbt results showed occasional DGV and GV-High exceedances across both Syncrolift and Deposition location samples. Tbt was not tested for in the June 2023 samples; however, it would be expected that similar levels of Tbt are present within these samples.

Table 6: Heavy metal results arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn) (mg/kg).

Sample ID	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
SyncroSS1	5.4	0.082	17.6	**24.7**	7.54	<0.025	14	47.7
SyncroSS2	4.9	0.087	19.6	**31.7**	4.9	<0.025	15.2	50.6
SyncroSS3	6	0.14	18.6	**292**	6.15	<0.025	18.2	**171**
SyncroSS4	6.1	0.11	18.3	**207**	6.38	<0.025	15.8	115
SyncroSS5	5.2	0.079	19.2	**60.8**	5.17	<0.025	15.4	60.1
SyncroSS6	5.5	0.14	20.9	**37.3**	5	<0.025	15.5	55.3
SyncroSS7	6.7	0.077	19.5	**47.7**	5.52	<0.025	14.9	62.3
SyncroSS8	5.7	0.068	18	**64.6**	5.01	<0.025	13.5	94.1
SyncroSS9	**7.4**	0.13	18.8	**756**	7.91	<0.025	**33.9**	**315**
DepSS1 – Dec 2021	5.7	0.17	17.6	**36.3**	4	<0.025	17.7	**278**
DepSS2 – Dec 2021	5.5	0.17	28.3	**27.9**	4.1	<0.025	**21.4**	59.5
DepSS3 – Dec 2021	4.9	0.12	17.1	17.2	3.9	<0.025	12.7	39.8
DepSS4 – Dec 2021	4.8	0.11	20.2	**24.7**	4.9	<0.025	14.5	47.6
DepSS5 – Dec 2021	5.3	0.11	14.3	18	2.9	<0.025	9.97	33.4
DepSS6 – Dec 2021	6.2	0.12	18.7	**35.7**	4.1	<0.025	12.9	47.4
DepSS7 – Dec 2021	5.9	0.1	21.8	**53.4**	5.18	<0.025	15.6	112
DepSS8 – Dec 2021	7	0.13	18.4	**533**	9.42	<0.025	**22.4**	**293**
DepSS1 – Feb 2022	3.6	0.12	16.7	**23.6**	3.8	<0.025	17.9	41.9
DepSS2 – Feb 2022	3.2	0.11	12	12.1	2.6	<0.025	15.6	29.9
DepSS3 – Feb 2022	3.8	0.15	15	14.7	3.4	<0.025	12.4	33.8
DepSS4 – Feb 2022	4.3	0.16	15.8	13.5	4.4	0.036	12.1	34.3
DepSS5 – Feb 2022	4.2	0.069	11	14.8	4.1	<0.025	8.2	23.3
DepSS6 – Feb 2022	4.8	0.077	12.9	14.5	2.8	<0.025	10	29.9
DepSS7 – Feb 2022	5.8	0.12	14.2	16.4	3.2	<0.025	11.7	30.7
DepSS8 – Feb 2022	5.5	0.027	12.8	5.1	2	<0.025	8.52	17.7
Syncro-1 – June 2023	**8.4**	0.11	22.4	**118**	8.71	NA	17.9	**303**
Syncro-2 – June 2023	**16.4**	0.1	23.5	**96.3**	15.1	NA	12.7	114
Syncro-3 – June 2023	8	0.1	17	**30.7**	4	NA	12.5	53.2
Syncro-4 – June 2023	**7.9**	0.12	18.8	**259**	4.9	NA	14.6	**146**
Syncro-5 – June 2023	6.6	0.069	19.2	**695**	5.96	NA	13.9	**326**
Syncro-6 – June 2023	5.6	0.064	17.3	**28.5**	3.8	NA	12.3	48.8
Maximum	16.4	0.17	28.3	756	15.1	0.036	33.9	326
Minimum	3.2	0.027	11	5.1	2	0.036	8.2	17.7

Mean	6.01	0.11	17.92	116.46	5.19	0.04	14.96	100.46
Standard deviation	2.29	0.03	3.55	196.71	2.53	NA	4.79	97.43
ANZ (2018) DGV	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**
ANZ (2018) GV-High	**70**	**10**	**370**	**270**	**220**	**1**	**52**	**410**
CCME (1999) TEL*	**7.24**	**0.7**	**52.3**	**18.7**	**30.2**	**0.13**	**-**	**124**
TEL Incidence % (CCME, 1999)	**3**	**6**	**4**	**9**	**6**	**8**	**-**	**4**
CCME (1999) PEL*	**41.6**	**4.2**	**160**	**108**	**112**	**0.7**	**-**	**271**
PEL Incidence % (CCME, 1999)	**47**	**71**	**53**	**56**	**58**	**37**	**-**	**65**

Bold denotes exceedance of the DGV, **Red** denotes exceedance of the GV-High, **Blue** denotes exceedance of CCME (2001) TEL.
< denotes value less than the laboratory limit of reporting, NA denotes samples not analysed.
TEL – Threshold Effect Level; PEL – Probable Effect Level

Table 7: Normalised tributyl tin and total organic carbon results

Sample ID	Total Organic Carbon (g/100g dry wt)	Tri-butyltin (mg/kg dry weight, 1% OC)	Tri-phenyltin (mg/kg)
SyncroSS1	1.1	0.0020	<0.0009
SyncroSS2	1.6	0.0018	<0.0006
SyncroSS3	1.8	**0.1167**	<0.0006
SyncroSS4	1.3	**0.0238**	<0.0008
SyncroSS5	1.2	0.0058	<0.0008
SyncroSS6	1.7	**0.0106**	<0.0006
SyncroSS7	1.2	**0.1167**	<0.0008
SyncroSS8	0.93	0.0046	<0.0011
DepSS1 – Dec 2021	1.5	0.0043	<0.0007
DepSS2 – Dec 2021	1.3	0.0018	<0.0008
DepSS3 – Dec 2021	1.1	0.0012	<0.0009
DepSS4 – Dec 2021	1.5	0.0019	<0.0007
DepSS5 – Dec 2021	1.1	<0.0009	<0.0009
DepSS6 – Dec 2021	0.94	**0.0117**	<0.0011
DepSS7 – Dec 2021	2.1	0.0024	<0.0005
DepSS8 – Dec 2021	1.4	**1.5714**	<0.0007
DepSS1 – Feb 2022	1.4	0.0068	<0.0007
DepSS2 – Feb 2022	1	**0.0230**	<0.0010
DepSS3 – Feb 2022	1	<0.0010	<0.0010
DepSS4 – Feb 2022	1.8	<0.0006	<0.0006
DepSS5 – Feb 2022	0.84	0.0039	<0.0012
DepSS6 – Feb 2022	1.1	0.0027	<0.0009
DepSS7 – Feb 2022	1	0.0016	<0.0010
DepSS8 – Feb 2022	0.24	<0.0042	<0.0042
SP-Syncro-1 – June 2023	0.71	NA	NA
SP-Syncro-2 – June 2023	0.9	NA	NA
SP-Syncro-3 – June 2023	0.66	NA	NA
SP-Syncro-4 – June 2023	0.89	NA	NA
SP-Syncro-5 – June 2023	0.6	NA	NA
SP-Syncro-6 – June 2023	0.48	NA	NA
Minimum	0.24	0.0012	0
Maximum	2.1	1.5714	0
Mean	1.15	0.095735	NA
Standard Deviation	0.42	0.34903947	NA
ANZ (2018) DGV	**-**	**0.009**	**-**

ANZ (2018) GV-High	-	0.070	-

Bold denotes exceedance of the DGV, Red denotes exceedance of the GV-High
< denotes value less than the laboratory limit of reporting, NA denotes samples not analysed/acquired,
'-' indicates no guideline value available.

5.1.2.3 Nutrient and PAH Results

Table 8 and Table 9 provide the nutrient sampling and Polycyclic Aromatic Hydrocarbon (PAHs) results respectively.

Nutrients were only tested in the June 2023 samples, with nitrate (NO_3N), nitrite (NO_2N), and orthophosphate (PO_4P) all found below detection limits. Ammonia (NH_3N) is produced in sediments during decomposition of organic matter. Ammonia was found across samples at low to non-detectable levels, with no guidance on threshold limits in the marine environment available.

All detected PAH values were normalised to 1% organic carbon (mg/kg dry weight, 1% OC) as the concentration of PAHs in the organic fraction of sediment is more relevant than dry weight concentrations with regards to assessing adverse ecological and biological effects (see Table 9). Changes to the ANZECC 2000 guideline values for toxicants in sediments in 2018 included a shift away from guideline values for each PAH. The guideline values have since been changed to a total PAH concentration limit. Total PAH concentrations were only tested in the June 2023 samples, with all samples exhibiting low concentrations relative to DGV thresholds.

Table 8: South Port sediment nutrient sampling (mg/kg dry wt).

Sample ID	Nitrate-N	Nitrite-N	Orthophosphate-P	Ammonia-N
SP-Syncro-1-June 2023	<2.60	<1.0	<2.00	5.61
SP-Syncro-2-June 2023	<2.60	<1.0	<2.00	7.22
SP-Syncro-3-June 2023	<2.50	<1.0	<2.00	9.62
SP-Syncro-4-June 2023	<2.50	<1.0	<2.00	11.6
SP-Syncro-5-June 2023	<2.50	<1.0	<2.00	6.73
SP-Syncro-6-June 2023	<2.40	<1.0	<2.00	<5.00
DGV	-	-	-	-
DV - High	-	-	-	-

< denotes value less than the laboratory limit of reporting

Table 9: South Port sediment Polycyclic Aromatic Hydrocarbons (PAHs) sediment analysis results (mg/kg dry weight, 1% OC).

Analyte*	Syncro-1 June 2023	Syncro-2 June 2023	Syncro-3 June 2023	Syncro-4 June 2023	Syncro-5 June 2023	Syncro-6 June 2023	ANZG (2018)	
							DGV	GV-H
Acenaphthene	0.001	0.003	0.010	0.064	0.008	0.004	-	-
Acenaphthylene	0.002	0.001	0.001	0.002	0.001	0.001	-	-
Anthracene	0.003	0.004	0.005	0.016	0.004	0.005	-	-
Benz[a]anthracene	0.014	0.023	0.032	0.064	0.027	0.031	-	-
Benzo[a]pyrene	0.014	0.026	0.029	0.051	0.028	0.033	-	-
Benzo[b]&[j] fluoranthene	0.032	0.042	0.058	0.085	0.060	0.056	-	-
Benzo[g,h,i]perylene	0.013	0.016	0.020	0.030	0.022	0.023	-	-
Benzo[k]fluoranthene	0.009	0.012	0.017	0.029	0.016	0.017	-	-
Chrysene	0.020	0.024	0.029	0.057	0.027	0.025	-	-
Dibenz(a,h)anthracene	0.003	0.004	0.006	0.010	0.006	0.007	-	-
Fluoranthene	0.025	0.041	0.048	0.135	0.047	0.050	-	-
Fluorene	0.002	0.005	0.005	0.026	0.006	0.003	-	-
Indeno(1,2,3-cd)pyrene	0.012	0.019	0.026	0.038	0.025	0.027	-	-
Naphthalene	0.011	0.004	0.002	0.002	0.002	0.002	-	-
Phenanthrene	0.009	0.020	0.027	0.045	0.020	0.016	-	-
Pyrene	0.023	0.034	0.035	0.109	0.040	0.050	-	-
TOTAL PAHs (mg/kg of total PAHs (1% OC))	0.191	0.278	0.349	0.764	0.338	0.350	**10**	**50**

* Excluded analytes: 1-Methylnaphthalene, 2-Methylnaphthalene, Benzo[a]pyrene TEQ (LOR), Benzo[a]pyrene TEQ (Zero).
Bold denotes exceedance of the DGV, **Red** denotes exceedance of the GV-High,
Blue cells denote below laboratory detection limits, '-' indicates no guideline value available.

5.1.3 Biological Composition

While no specific infaunal analysis of dredge material was conducted under the Syncrolift, extensive sampling across adjacent (similar) berth and channel sites has informed potential values for the proposed dredging area. For a comprehensive synthesis of infaunal sampling results, please refer to Section 5.4.1 below, or Appendix A.

Overall, no Threatened or At Risk[v] marine invertebrate species have been identified through previous sampling efforts among adjacent South Port berths. Berth sites appear to have similar or greater infaunal diversity and densities than nearby 'natural' environments (such as the Swinging basin and Harbour Control).

[v] In accordance with NZ Threat Classifications from Freeman, *et al.*, (2013).

This may be attributable to slight enrichment being present in the berth sites (i.e. Berth 8a) which could allow for a 'fertilisation' effect within infauna communities. That being said, strong tidal currents and erosion/frequent suspension of soft sediments may also be a factor at control and channel sites.

5.2 Receiving Environment Sediment Characteristics

Based on prior studies (Appendix A; Miller & Davis, 2021), a collated synthesis of general sediment characteristics for South Port Berth areas and the main channel receiving environment are provided (see Figure 8 for site map). The following section provides the mean data from these last seven years of surveys. This information can inform the relative nature of the benthic receiving environment, in relation to the proposed deposition/dispersal of Syncrolift dredge material.

5.2.1 Physical Characteristics

Figure 13 provides the mean of approximately seven years of sediment particle size composition in the receiving environment. Silt/clay (≤ 63 µm) fraction is highest in Berths 5 & 6 where tidal currents are minimal. The Swinging Basin zone was found to be primarily sands (≤ 2 mm) with minimal silt/clays (4.68%) which is largely representative of a natural harbour environment with high tidal flow evident. Berths 7 & 8 and 3A had similar particle size composition with approximately 20:80 silt to sand ratio at both sites and Berth 8a had approximately 16% silt proportion. The Harbour Control Sites' location in the inner Bluff Harbour allows for greater accumulation of fine silts than would be typically found in areas subject to greater tidal flow such as the Swinging Basin. Gravel (≤ 5 mm) was found to be scarce across all sites ranging from 0.96% within Berth 3A to 0.11% in Berths 7 & 8. No gravel fraction was found in the Swinging Basin site.

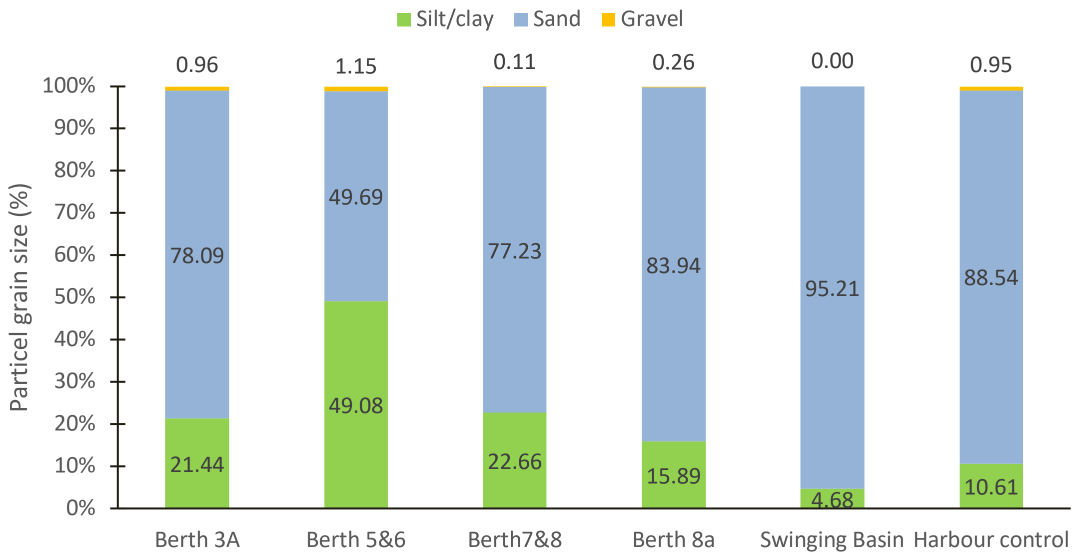

Figure 13: 2014 to 2021 averaged particle size composition data for South Port Berths, Swinging Basin and Harbour Control Sites. Silt/clay is ≤ 63 µm, sand is ≤ 2 mm, and gravel is ≤ 5 mm. Sediment data represents 0.2 m surface layer.

5.2.2 Chemical Composition

Sediment samples within South Port berths and a nearby harbour control site have been annually analysed for contaminants since 2014. Samples are tested for heavy metals, total organic carbon (TOC), phosphorus, tributyltin (Tbt) and polycyclic aromatic hydrocarbons (PAH). A full sediment summary report is provided in Appendix A and is summarised here.

Sediment was also analysed for total organic carbon (TOC) and phosphorus (P) concentrations (Table 10). Neither of these analytes have associated DGV guidelines however TOC levels tend to correlate with factors causing ecological stress. Generally, benthic species and biomass decrease as TOC levels become high (i.e. above 3.5 g/100 g) due to the stronger binding of contaminants to TOC (Hyland, *et al*., 2005). TOC concentrations were well below the ecological stressor level of 3.5 g/100 g at all sites with means ranging from 0.09 g/100 g at the Swinging Basin to 0.78 g/100 g at Berths 5 & 6. Berths 5 & 6 have the highest historic concentrations with the maximum TOC level found to be 1.096 g/100g in 2014 (Appendix A; Figure 5). Phosphorus levels were higher in the berth sites than the Swinging Basin and Harbour Control Sites (Table 10). Berths 7 & 8 have shown increasing phosphorus concentrations over time as the seabed erodes at this site (Appendix A; Table 6) alluding to legacy phosphates from historic land use in this area as opposed to benthic accumulation from port-based activities.

Table 10: 2014 to 2021 mean total organic carbon (TOC) and phosphorus sediment results for South Port Berth, Swinging Basin and Harbour Control sites.

	Berth 3A	Berths 5&6	Berths 7&8	Berth 8a	Swinging Basin	Harbour Control
TOC (g/100 g)	0.23	0.78	0.48	0.36	0.09	0.19
Phosphorus (mg/kg)	708	1,346	4,285	2,683	358	347

All heavy metal concentrations for Bluff Harbour sediment samples collected between 2014 and 2021 have been found in concentrations less than the ANZG (2018) DGV threshold (Appendix A; Figure 14). Heavy metal concentrations are fairly consistent over the seven years within the berths although some variability in cadmium and zinc concentrations have been noted, however, no overall trend is apparent. Berths 5 & 6 show consistently higher contaminant concentrations which is likely due to the lack of tidal current velocities at this site (Figure 14). The Swinging Basin and Berth 3A sites are comparable to the Harbour Control Site with regards to heavy metal contaminant concentrations.

Polycyclic aromatic hydrocarbon (PAH) concentrations have remained below ANZG (2018) DGV guidelines since monitoring began in 2014 (Miller & Davis, 2021).

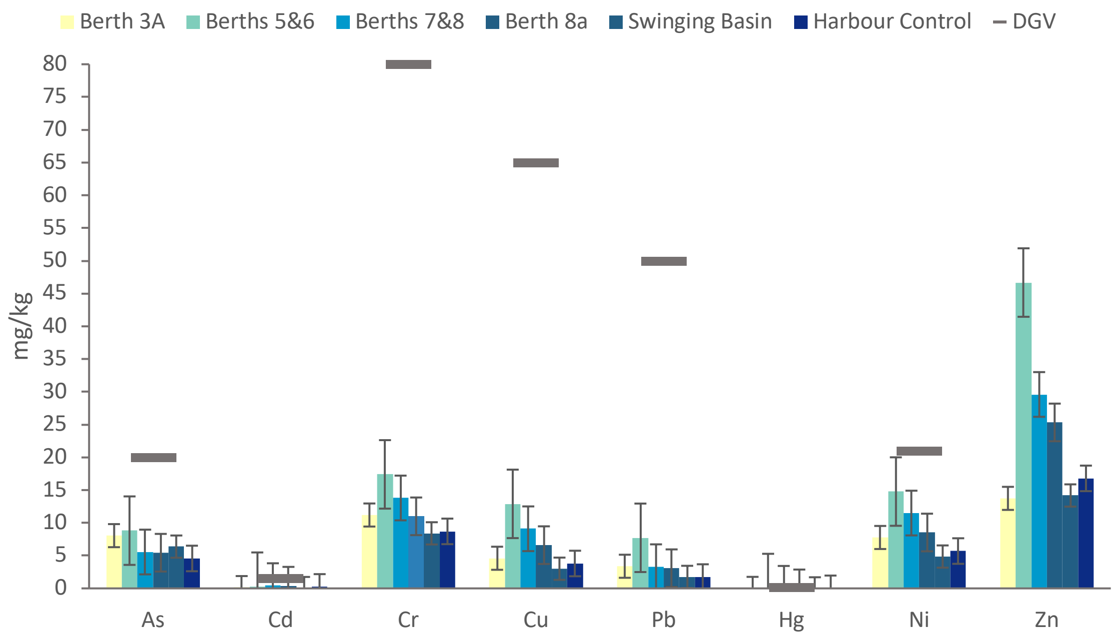

Figure 14: 2014 to 2021 averaged heavy metal sediment results for South Port Berth, Swinging Basin and Harbour Control Sites (As: arsenic; Cd: cadmium; Cr: chromium; Pb: lead; Hg: mercury; Ni: nickel; Zn: zinc). Zn DGV value is 200 mg/kg.

Tributyltin (Tbt) is tested for annually within the South Port berths where inputs of antifoul paint from vessels are possible. All detected Tbt levels were normalised to 1% organic carbon (mg/kg OC) as the concentrations of Tbt (as an organotin compound) in the organic fraction of sediment is more relevant than dry weight concentrations with regards to assessing adverse ecological and biological effects. Table 11 shows that Tbt levels have exceeded the ANZG (2018) DGV threshold levels on six occasions since 2014 and exceed the GV-High threshold on two occasions, predominantly at Berth 8a, which is situated 20 m directly out from Berth 8 (Figure 8; Zone A8). All exceedances, with the exception of 2019, have not been consistent across replicate and duplicate samples, suggesting these levels are most likely attributable to discrete particles of antifoul paint. In 2019 and 2021, two samples at Berth 8a exceeded the GV-High threshold with 0.082 and 0.129 mg/kg OC (average of 0.567 mg/kg OC), indicating that these elevated levels may have been ambient and could be attributable to discrete particles of antifoul paint coupled with low levels of TOC. These samples also add to the elevated normalised Tbt levels. Berth 3A, Swinging Basin, Disposal and Disposal Control sites were tested for Tbt in 2021 and all results were reported below the laboratory limit of detection of 0.001 mg/kg (Appendix A).

Table 11: Tributyltin (Tbt) results (mg/kg OC). N.B. Only sites that had Tbt present within a sample are included in the table.

Year	Berths 5&6			Berths 7&8			Berth 8a			ANZG (2018)	
	SS1	SS2a	SS2b	SS1	SS2a	SS2b	SS1	SS2a	SS2b	DGV	GV-High
2014	0.004	**0.020**	0.004	0.004	0.004	0.006	0.004	0.004	0.004	**0.009**	**0.07**
2015	0.004	0.004	0.004	0.004	0.004	0.004	0.004	**0.0167**[1]	0.004		
2017	0.004	0.007	0.008	0.004	0.008[1]	0.004	0.004	**0.011**[1]	**0.058**[1]		
2018	0.004	0.006	0.008	0.004	**0.0125**[1]	0.0079[1]	0.004	0.004	0.004		
2019	0.001	0.001	0.001	0.001	0.001	0.001	**0.038**[1]	0.003[1]	**0.129**[1]		
2021	0.001	0.001	0.001	0.001	0.002	0.002	0.001	**0.082**	0.002		

[1] Samples had very low levels of TOC (≤0.3 g/100g).

* Red font indicates exceedance of DGV threshold. Red square indicates exceedance of GV-High threshold. Blue shading refers to laboratory limit of reporting.

5.3 Currents and Water Quality

5.3.1 Currents

Studies completed by Morris (1984) established that based on the tidal prism and cross-sectional area the harbour entrance was 'erosional'. This indicates that the entrance is self-scouring and high sediment transport rates could occur through it, both into and out of the harbour basin (OCEL, 2021). Raw data from an Acoustic Doppler Current Profiler (ADCP) by Ross Vennell and Chris Old of the Department of Marine Science, University of Otago in 1998 showed flows of up to 6 knots (3 m/sec) were observed at the surface in the harbour entrance. Peak flows near the bottom in the entrance channel were 4 knots (2 m/sec).

The Coastal Processes Assessment completed by OCEL (2021) describes the tidal currents within the Bluff Harbour. These are summarised as follows; the tidal currents are strongest in the constricted entrance throat and in the channel sweeping past the Tiwai Wharf. The strong tidal flow through this constricted harbour entrance throat generates a tidal vortex reverse flow in the swinging basin as the harbour widens out because of the concentration of the flow along past the Tiwai Wharf. Slack water in the entrance channel is typically less than 1 hour and can be only 15 minutes during the low slack tide. The current speeds drop off with distance from the entrance.

The natural channel curves around to line up with the narrow entrance to Awarua Bay. The distance, the flow path length, from the harbour entrance to the entrance to Awarua Bay is of the order of 12 km. The tidal excursion distance, (i.e., the distance a particle carried through the entrance on an incoming tide before the tide turns and the particle is swept back out) is likely less than the 12 km distance to the entrance to Awarua Bay. For incoming seawater to reach Awarua Bay to affect a tidal exchange would take several tidal cycles.

5.3.1.1 Plume Modelling

The full results for the Oceanum Calypso Science report can be found in Zyngfogel & McComb (2023) and are summarised below.

Simulation plume modelling results from the P2 and P3 position (Figure 15) on an ebb tide were considered for two optimal disposal windows (1 h before to 4 h after high water, and 2 h before to 4 h after high water). Preliminary testing revealed that these scenarios represent the least accumulation of sediments within the harbour as the ebb tide is utilised to transport material outside the harbour towards Foveaux Strait.

Both disposal windows and locations scenarios show decreasing TSS and sediment deposition moving southeast, or away from the disposal point, gradually wrapping around Bluff point on the western side of the harbour entrance.

Generally, the plume hugs the western channel as it follows the coast and the Bluff point contour (see Figure 16). Once on the east side of Bluff point, open water dispersion occurs. The report notes that "*areas characterized by extended persistence are ear the Harbour entrance where concentration above 2.5 mg/L can persist for up to 24h. Concentration greater than 5.0 mg/L does not persist more than one tidal cycle (12h*)." The disposal window from 1 hour before to 4 hours after high water was determined to be the optimal scenario for sediment movement out of the harbour.

The persistence of settled material on the seabed shows a patchy network of accumulation areas within the general plume TSS footprint. Sediment deposition thicknesses above 1.5 mm and 3.0 mm are shown in Figure 17 for the P2 and P3 release locations. Figure 17 also shows the contours outlining durations above 48 hours, noted with red outline. These appear to be along the berth pockets and southern wharf/jetty, where it is noted that the areas with the "*highest persistent deposition is predicted to occur along Island Harbour, especially near berth 1-4*".

A 'worst case' depositional footprint was modelled with sediment resuspension at the seabed removed (e.g., once the sediment reaches the seabed it stays there). Model results for this scenario (from a P3 release location from 1 h before to 4 h after high water) can be seen in Figure 18, with a deposition footprint at the end of dredging extending southeast within the main channel with green and red contours highlighting 2 and 4 mm accumulation respectively. There is no evidence of deposition noted within the Syncrolift, berth pockets or sensitive habitats of the harbour.

Based on sensitivity testing across all 48 model scenarios, the report notes the preferable discharge scenario is a release from the P3 station (400 m into the main channel), 1 hour prior to high water and concluding 4 hours after high water. The report notes that the exact P3 location could potentially disrupt shipping movements due to the proximity to the channel. Consequently, an alternative 'P4' site has been proposed 100 m to the north, in -7 meters of water depth and 320 meters from the Syncrolift (Figure 19). The currents at this site are similar to the original P3 site, but to minimize the risk of sediment spreading back towards the Syncrolift, the working window start time should be adjusted to 30 minutes before high water (not 1 hour).

Figure 15: Modelled P2 and P3 dispersal locations conducted by Oceanum Calypso Science (Zyngfogel & McComb, 2023).

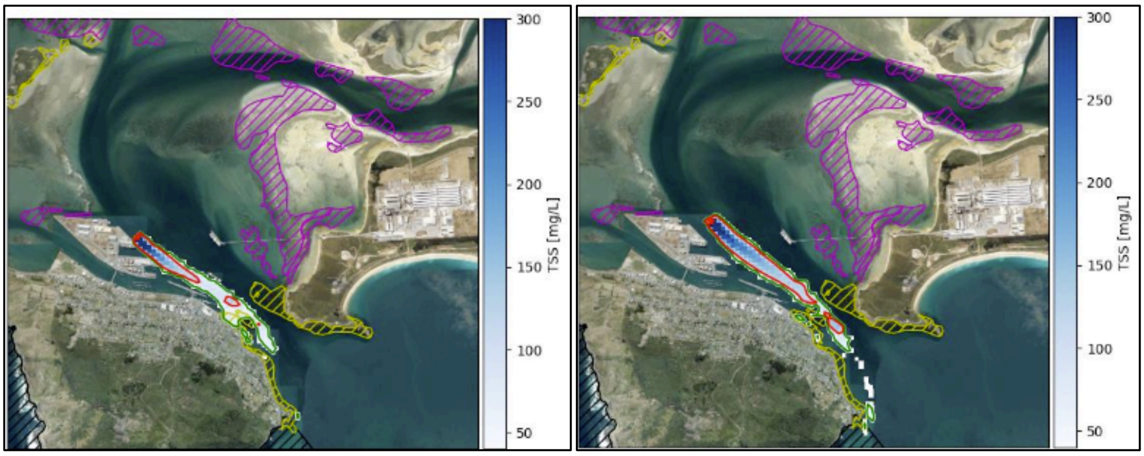

Figure 16: 90th percentile depth-averaged suspended sediment concentration during a release from site P2 (left) and P3 (right) over a spring tide cycle from 1 hour before to 4 hours after high water. The green and red contours highlight 50 and 100 mg/L respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. TSS were masked below 30 mg/L (from Zyngfogel & McComb, 2023).

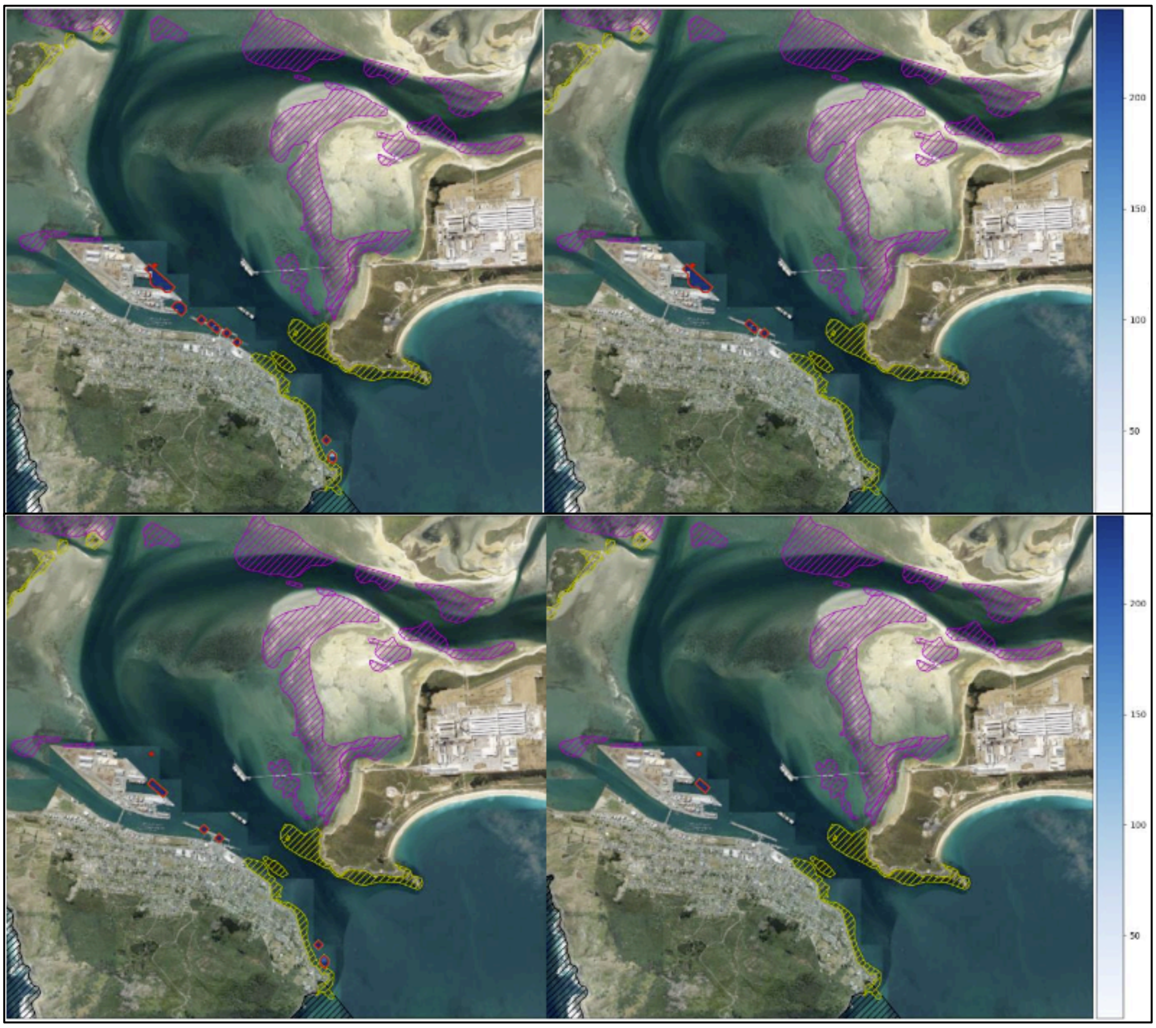

Figure 17: Maximum amount of time (in hours) the sediment deposition thickness is above 1.5 (left column) and 3.0 mm (right column) for a release from location P2 (top row) and P3 (bottom row) over a spring tide cycle from 1 h before to 4 h after high water. Red contours highlight 48 h persistence time. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12 h were masked (from Zyngfogel & McComb, 2023).

Figure 18: Worst-case sediment footprint (from a P3 release location over a spring tide cycle from 1 h before to 4 h after high water) with seabed resuspension excluded. The green and red contours highlight 2 and 4 mm respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Deposition thickness of less than 1mm were masked (from Zyngfogel & McComb, 2023).

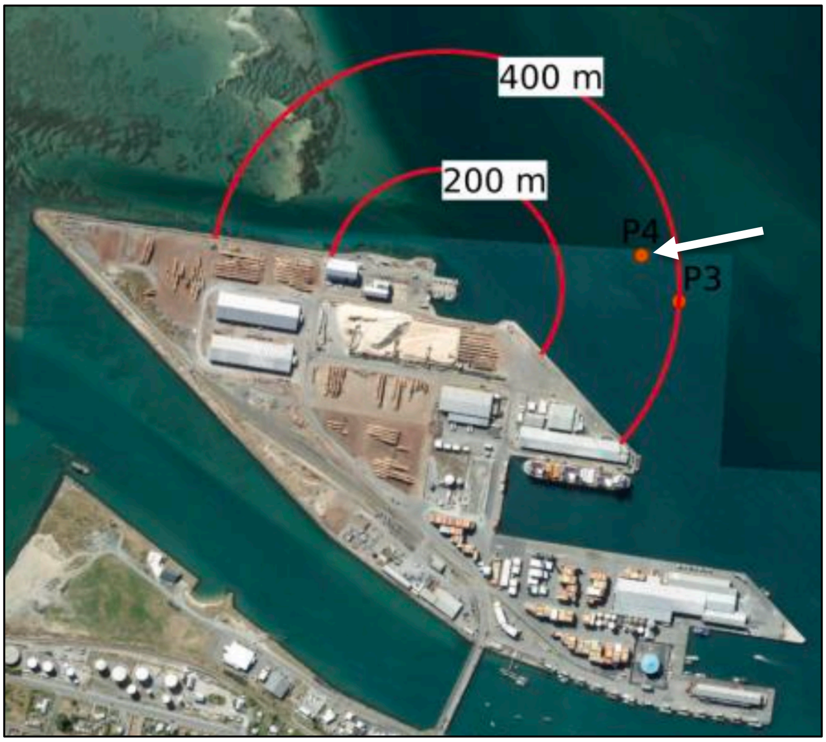

Figure 19: Updated site location at the P4 site.

5.3.2 Water Quality

Results from the three months of water quality sampling at the town wharf (by Southern Waterways on behalf of ES) found that the mean water temperature during this time was 9.3°C, mean turbidity was 1.7 NTU, mean dissolved oxygen was 9.23 mg/L, and mean total suspended solids was 3.92 mg/L, with a range between 11.4 and 1.3 mg/L (Table 12).

The e3s secchi disk water clarity results (from Miller & Davis, 2021) found that a range between 2 and 2.5 m of water clarity was observed at all sites during this survey (see Figure 10 for site layout).

The latest turbidity monitoring conducted by South Port as part of the Capital Dredging project is presented in Table 13 & Figure 20. As noted in Section 4.3, NTU was converted to TSS (mg/L) for reference and comparison to dispersal model results. TSS results at control sites range from 3.88 to 5.98 with an average of 4.41 (mg/L).

In general, water quality in Bluff Harbour will be affected by a range of anthropogenic inputs, port activities and adjacent historic and current land use. High velocity tidal movements and no significant riverine inputs into the harbour and a 2 m variance of water exchange with the open ocean will maintain a relatively high standard of water quality (Miller & Davis, 2021).

Table 12: Discrete water quality results from Bluff Harbour at Town Wharf (sourced from ES).

Date sampled	Temp (°C)	pH	Suspended solids (Total) (mg/L)	Dissolved oxygen (mg/L)	Turbidity (NTU)
31-May-2016	10.90	8.00	3.80	7.98	1.05
10-Jun-2016	10.80	7.90	11.40	9.00	1.20
17-Jun-2016	-	8.00	4.00	8.76	1.63
24-Jun-2016	12.60	8.00	2.70	8.60	1.11
01-Jul-2016	-	7.90	3.20	9.40	1.20
07-Jul-2016	-	8.00	2.60	9.23	1.43
18-Jul-2016	7.90	8.00	2.70	9.46	1.74
25-Jul-2016	7.80	7.90	5.50	9.40	4.40
02-Aug-2016	7.00	8.20	3.90	9.81	3.40
08-Aug-2016	8.00	8.00	3.80	9.75	1.35
17-Aug-2016	8.90	8.10	2.50	9.55	1.32

23-Aug-2016	9.70	8.10	1.30	9.72	0.81
31-Aug-2016	9.50	8.20	3.60	9.39	1.46

Table 13: South Port Capital Dredge monitoring data from May and June, 2023.

Site	Date	Average Turbidity (NTU)	Average TSS (NTU converted to mg/L)	Average of ODO % Saturation	Average of pH*	Average of Temp °C
Disposal site - U/S - control	7/06/23	1.83	4.18	102.32	8.08	12.11
	15/05/23	1.63	3.96	102.24	**18.85**	13.35
	17/05/23	2.17	4.56	102.29	8.10	13.08
	18/05/23	1.83	4.18	103.05	8.11	12.86
	22/05/23	1.91	4.27	99.90	8.11	12.71
	24/05/23	2.13	4.51	100.81	8.09	12.68
	25/05/23	1.56	3.88	101.52	8.08	12.62
Disposal site - D/S - treatment	7/06/23	2.42	4.84	101.94	8.08	11.88
	15/05/23	1.62	3.95	101.76	**18.85**	13.38
	17/05/23	2.62	5.06	102.25	8.08	13.09
	18/05/23	2.55	4.98	102.77	8.10	12.84
	22/05/23	1.65	3.98	99.91	8.11	12.76
	24/05/23	2.10	4.48	101.11	8.09	12.75
	25/05/23	1.58	3.90	101.72	8.07	12.61
Dredging Area - D/S - Treatment	6/06/23	3.65	6.22	101.65	8.06	11.76
	15/05/23	2.33	4.74	105.37	**18.87**	12.88
	17/05/23	2.06	4.44	102.42	8.06	13.06
	18/05/23	2.23	4.63	102.15	8.08	12.76
	20/05/23	3.08	5.58	100.15	8.093	12.626
	21/05/23	2.27	4.67	100.06	8.09	11.97
	22/05/23	1.86	4.21	98.64	8.09	10.91
	24/05/23	2.92	5.39	100.70	8.07	11.81
	25/05/23	2.07	4.45	100.95	8.06	12.16
Dredging Area - U/S - Control	6/06/23	2.55	4.98	101.98	8.08	12.36
	15/05/23	2.02	4.39	103.48	**18.85**	13.40
	17/05/23	2.06	4.44	102.34	7.90	13.15
	18/05/23	1.93	4.29	102.55	8.03	13.01
	20/05/23	1.76	4.10	100.54	8.086	13.017
	21/05/23	1.66	3.99	100.15	8.10	12.96
	22/05/23	1.96	4.32	99.17	8.07	11.39
	24/05/23	3.44	5.98	100.20	8.05	10.64
	25/05/23	2.21	4.60	101.40	8.06	11.19

***Bold pH readings in error.**

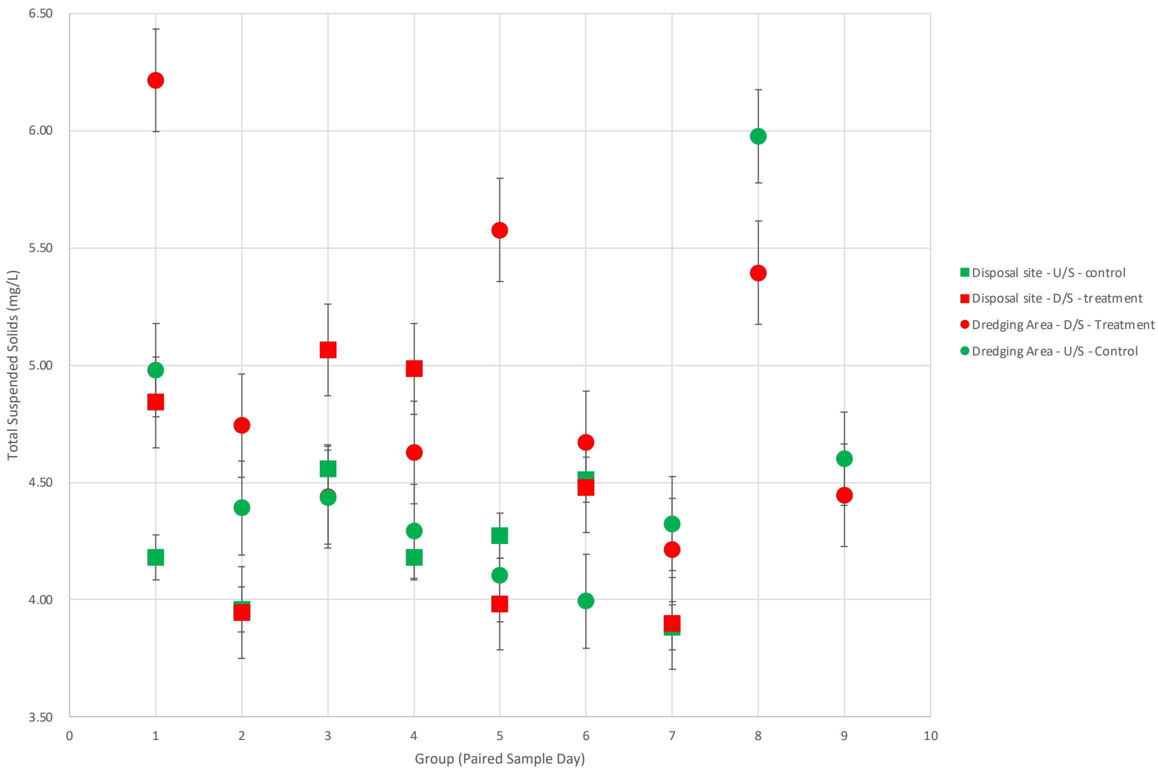

Figure 20: South Port average turbidity monitoring data across disposal site and dredge sites at treatment and control locations.

5.4 Receiving Environment - Marine Habitats and Ecological Values

Marine habitats, species and ecological values were collated from desktop research and previously conducted studies within Bluff Harbour by e3s. A summary of the primary collated literature used here can be found in Section 4.1.

5.4.1 Soft Sediment Infauna and Epifauna

No specific infauna or epifauna sampling within the dredge spoil receiving environment was conducted as part of this study; however, no Threatened or At Risk[vi] marine invertebrate species have been identified through previous sampling efforts. Based on prior studies, a collated synthesis for the general site area and receiving environment are provided (see Figure 8 for site map – for detailed results see Appendix A).

[vi] in accordance with NZ Threat Classifications from Freeman, *et al.*, (2013).

5.4.1.1 Berth Areas

Berth 8a exhibited the highest abundance and taxa richness of all the sites with a mean of 104 individuals (*S.E.* = *26.5*), 12 taxa and a high infaunal density of 13,248 individuals/m^2. Polychaetes were the most numerous at this site with high numbers of individuals in the Spionidae, Oweniidae and Capitellidae families. *Ampelisca* spp. amphipods and the razor mussel *Solemya parkinsonii* were also found in moderate numbers. This site was found to have the largest abundance of bivalves and gastropods within the harbour. Tidal velocity is lower at this location than the other harbour sites, with the exception of Berths 5 & 6.

5.4.1.2 Main Channel & Harbour Control Areas

Infauna in the Swinging Basin and main channel was found to be dominated by deposit feeders such as polychaetes and roundworms in a study completed by Cawthron in 2004 (Stevens & Clarke, 2004). Infaunal communities in these sites exhibited the lowest diversity (average of 3 taxa) and densities (732 individuals/m^2) of all sites, with predominantly only Capitellidae polychaetes found in numbers greater than one per sample. This site exhibits high tidal flow and is regularly disturbed by natural processes such as storm events.

Berth 3A is a non-dredged, relatively unmodified site in the outer harbour with low total diversity and density and a community dominated by Capitellidae polychaetes. This area experiences moderate to high tidal flow.

The Harbour Control site exhibited moderate infaunal densities with 3,854 individuals/m^2 and had a range of polychaetes in moderate numbers. The only bivalve found at the Harbour Control was the southern tuatua, *Paphies donacina*, which is likely due to its burrowing ability as this site experiences high tidal flow.

5.4.1.3 Epifauna

The South Port berths and Swinging Basin are predominantly characterised by turret shells (*Maoricolpus roseus)*, hermit crabs (*Pagurus* spp.), and foliose red algae (Figure 21). A 200 m epifauna dredge tow at the southern end of the Swinging Basin found a mixture of green, red and brown algae, hermit crabs (*Pagurus* spp.), masking crabs (*Notomithrax peronii*), chitons, sea stars (*Coscinasterias muricata* & *Patiriella sp*), and ascidians. No bivalves or gastropods were present (Figure 22). Sand flounder (*Rhombosolea plebeian)*, and blue cod, (*Parapercis colias),* are also present within this area and were observed during diving surveys carried out in January 2020 and 2021. Little to no epifauna has been observed in the vicinity of the inner berths (e.g., Berths 5 & 6) during annual seabed and wharf monitoring carried out by e3s (e3Scientific Ltd, 2019) nor during dive surveys in 2021 (Miller & Davis, 2021). As this is a highly disturbed soft sediment habitat, these epifaunal species are not considered to be sensitive to physical disturbance activities.

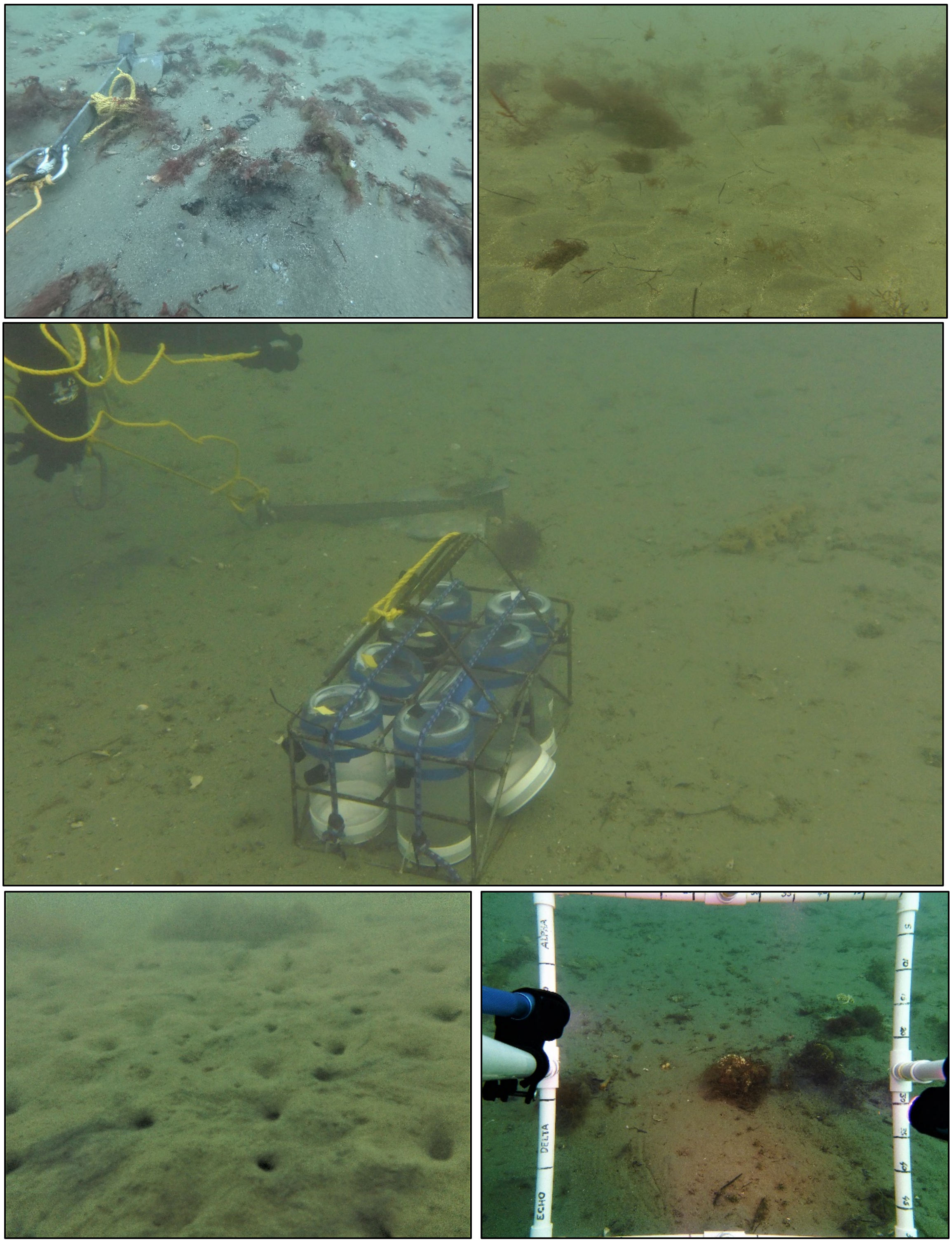

Figure 21: Top left-Berth 3A; Top right-Swinging Basin; Middle-Berth 8a; Bottom left-Berths 5&6; and Bottom right-Berths 7&8 (Miller & Davis, 2021).

Figure 22: Swinging Basin 200 m epifaunal trawl contents (Miller & Davis, 2021).

5.4.2 Soft Sediment Habitats

Soft sediment benthic habitats within the inner harbour and Awarua Bay include the At Risk – Declining[vii] seagrass (*Zostera muelleri*), sponges, and productive intertidal sand flats utilised by avifauna (Figure 23). Seagrass habitats are predominantly estuarine and near-shore in New Zealand which means that seagrass is particularly vulnerable and sensitive to anthropogenic disturbance, such as sedimentation, associated with catchment land-use activities and coastal development. Loss of seagrass habitat can mean loss of estuarine and coastal ecosystem productivity, which can reduce species diversity and consequently changes in community structure and ecosystem functioning (Turner & Schwarz, 2006).

Within Bluff Harbour the seagrass beds are primarily located in water depths of 0 – 4 m CD depth and in areas of high tidal flow. This distribution is likely due to seagrass' high photosynthetic requirement which is a primary factor influencing growth and productivity (Duarte, 1991). Seagrass is particularly vulnerable to changes in light availability and fine silt sedimentation during their flowering and reproductive periods (Turner & Schwarz, 2006). Ismail (2001) recorded flowering shoots in December and March in Otago Harbour, which roughly aligns with findings from a comprehensive study completed by Ramage & Schiel (1998, 1999)

[vii] Conservation status from de Lange, *et al*. (2017).

which described flowering and reproductive patterns for seagrass on the Kaikoura Peninsula. Although seagrass beds in Bluff Harbour have not been well studied, based on intertidal and subtidal habitats in NZ, it can be inferred that the flowering and reproductive period in Bluff Harbour is shorter than northern NZ counterparts and would occur roughly between December and March (Miller & Davis, 2021).

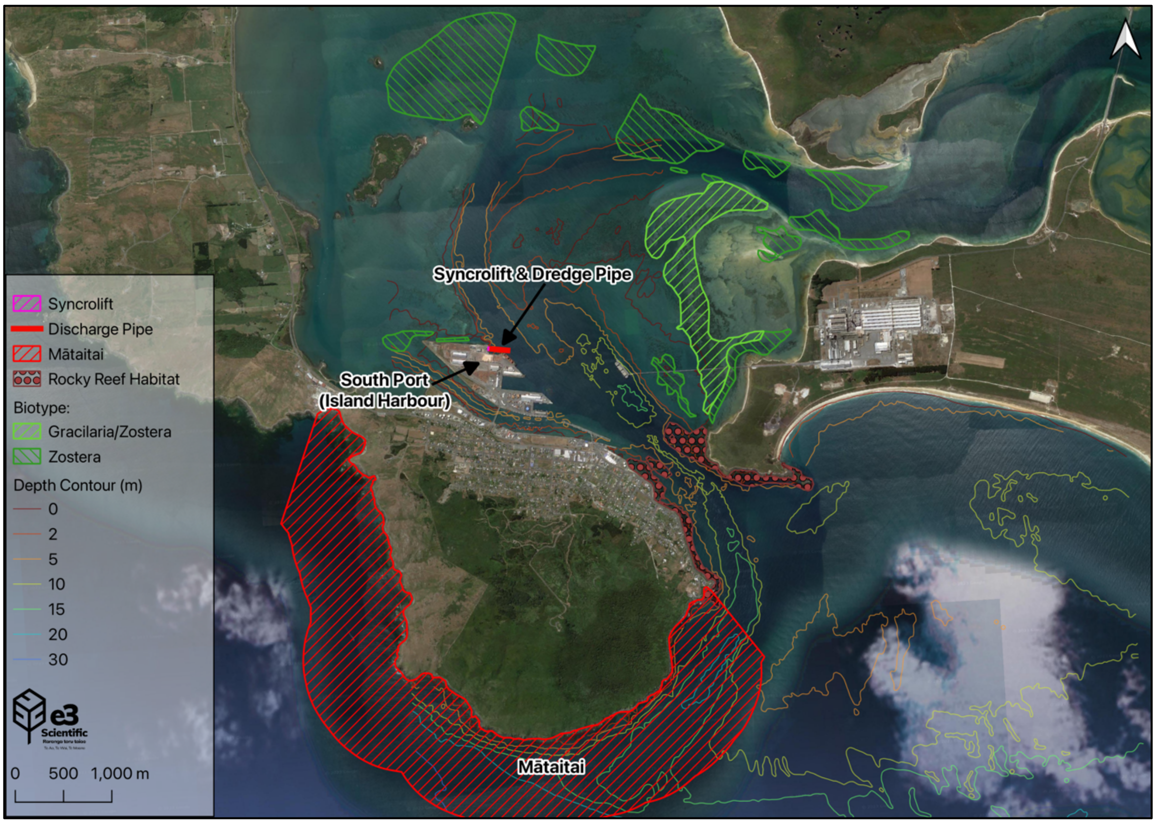

Figure 23: Syncrolift dredge operations in relation to seagrass beds, rocky reefs and Motupōhue Mātaitai.

5.4.3 Rocky Reef Habitats

A rock high-energy habitat is present in the middle of the main entrance to Bluff Harbour at a depth of 6 – 8 m and along the eastern and western margins of the shoreline (Figure 23).

The habitat mid-channel is characterised by areas of clean gravel/cobble intermittently dispersed between areas of bedrock. Algal coverage across the area varies from high densities where bedrock is present, to no coverage in gravel/cobble substrate (Figure 24). Dense algae beds on the relatively flat bedrock present in the channel consist of a mixed assemblage of predominantly soft algae dominated by *Caulerpa brownii*, but also containing several smaller foliose brown and red algae and sea tulips (*Pyura* spp.) (Stevens & Clarke, 2004). The bedrock itself supports a variety of common rocky habitat species including cushion stars, sea tulips, sponges, topshells, brittle stars, wandering anemones, kina, pāua and coralline algae. Several species of fish are known to be present including greenbone (*Odax pullus*; Least Concern[viii]), blue cod (*Parapercis colias*; Least Concern), wrasse (*Labridae* spp.), and red moki (*Cheilodactylus spectabilis*) (Stevens & Clarke, 2004).

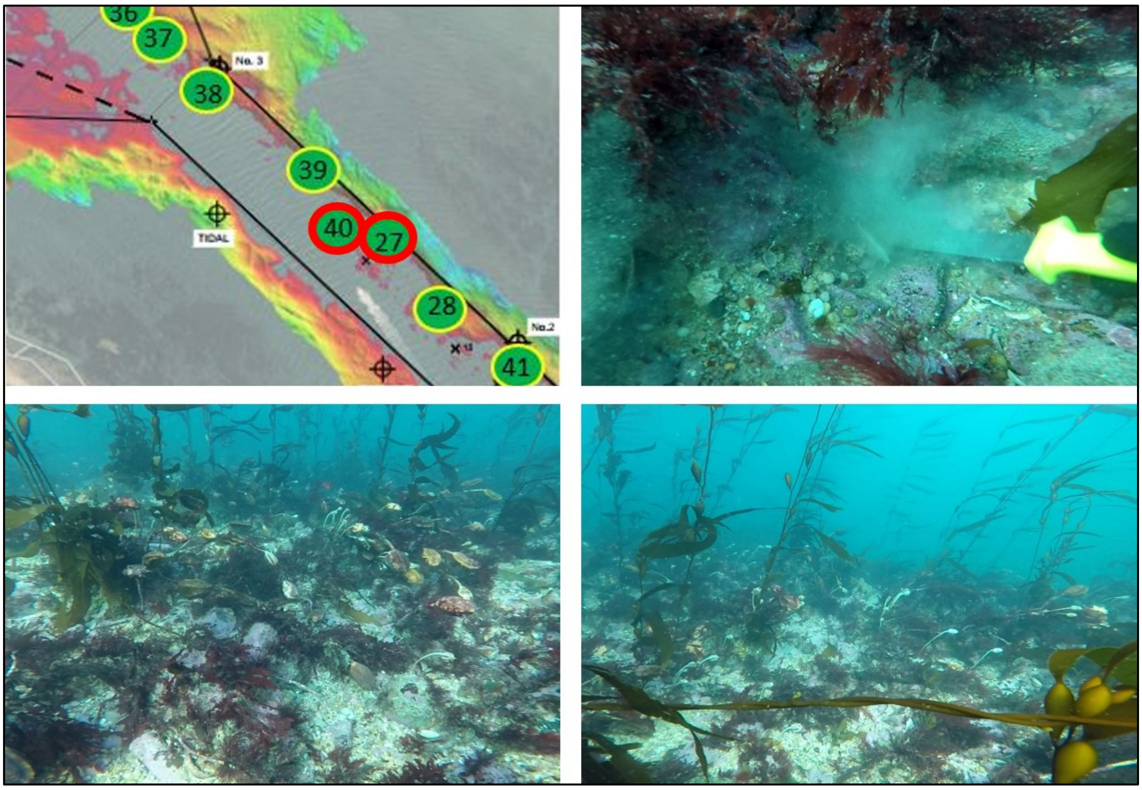

Figure 24: Previously surveyed rock outcroppings within main Bluff Harbour channel (images are from locations 40 and 27 – highlighted in red) (Miller & Davis, 2021).

In the shallower edges of the harbour entrance channel (3 – 6 m) a brown algae biotype is present on both sides of the harbour entrance, predominantly on boulder habitat. This algal assemblage is dominated through the water column and at the sea surface by the bladder kelp *Macrocystis pyrifera*, while at the seabed a mixture of *Marginariella, Carpophyllum*, *Ecklonia* and small quantities of *Durvillaea* are present. No green algae were obvious in this biotype (Stevens & Clarke, 2004). The seabed beneath the algae cover supports common rocky habitat species similar to the deeper section of harbour channel. Pāua are

[viii] All fish Threat Classifications based on IUCN 3.1.

abundant on the Bluff Township side of the harbour entrance, particularly at Argyle Beach which is noted as a productive area for pāua with regular recreational take of this species.

On the Tiwai side of the harbour entrance a Brown and Red algae biotype is present at a depth of 3 – 6 m. This habitat consists of a mix of species, including foliose brown and red algae, sea tulips and brown algae *Marginariella, Carpophyllum, Ecklonia* present above foliose reds and browns. Beneath the algae common rocky habitat species including cushion stars, sponges, topshells, paua, anemones, kina and coralline algae are present and fish species include greenbone, blue cod, red moki, triplefin species and spotties (*Notolabrus celidotus*; Least concern) (Stevens & Clarke, 2004).

Appendix B contains further survey images completed in May 2020 as part of the Capital Dredging Project (Miller & Davis, 2021).

5.4.4 Outer Harbour Entrance (Motupōhue Mātaitai & Tiwai Peninsula)

The Motupōhue Mātaitai[ix] was established in 2014 and covers 7.3 km^2. It is a high value rocky shore habitat, supporting both mahinga kai and taonga species but also possessing intrinsic mauri for the region. Mussels and barnacles occur in the intertidal zone above substantial southern bull kelp (*Durvillaea antarctica*) beds which provide canopy and cover for highly valued pāua (*Haliotis* spp.) beds in addition to blue cod (*Parapercis colias*) and rock lobster (*Jasus edwardsii*) nurseries (Stevens & Robertson, 2011). The wider coastline and offshore seabed forms part of the local rock lobster and blue cod fishery which are most likely supplemented by the mātaitai. Fur-seals may be seen on rock promontories or outcrops, along with the occasional yellow-eyed penguin at Lookout Point.

The Tiwai Peninsula encompasses a range of high energy marine habitats. Previously surveyed sites exhibit common and resilient marine species largely characterised by wheel shells, hermit crabs and polychaetes. Epifauna at these sites were highly mobile and would not likely remain solely within these sites. Other Control Sites contained coarse sand habitats which exhibited brachiopod beds, bryozoans, sea tulips and sand dollars. These sessile species generally range from sensitive (brachiopods) to resilient (sea tulips), indicating the habitat at this site is favourable for a wider range of species and providing habitat complexity.

[ix] A mātaitai is a fisheries management tool which recognises and provides for traditional fishing through local management.

Albatross, shags and little penguins are observed within this area, indicating that fish species are plentiful.

Some marine species emigrate from the coastal zone to offshore or northern waters during the late autumn to winter months, including shark species (broadnose sevengill, oceanic blue, spiny dogfish, school and white sharks), blue cod, flounder, and kingfish. Blue cod, for example, spawn in waters deeper than 20 m, young fish then remain at these depths until moving into the shallower waters in summer (Paul, 2000). Other marine species, such as octopuses, (*Octopus maorum),* remain in 'temporary' habitats all year round and are believed to spawn in spring to summer in shallow waters (Anderson, 1999). Breeding occurs in seahorses (*Hippocampus abdominalis*) year-round, but peaks in the warmer months (Bray & Thompson, 2014).

5.4.5 Sharks

Sharks are highly migratory species and are generally more prevalent around Bluff Harbour and Foveaux Strait during the summer months. The Not Threatened broadnose sevengill (*Notorhynchus cepedianus*) and spiny dogfish (*Squalus acanthias*) commonly feed in soft bottom subtidal bays and estuaries and are able to tolerate brackish waters where they often migrate to breed during summer. Both species are mainly benthic in nature and are opportunistic predators (Paul, 2000). The most famous of all shark species, the Threatened - Nationally Endangered[x] white shark (*Carcharodon carcharias*) is known to feed within the productive waters of Foveaux Strait during summer. Tagging of this species has shown that juveniles and adults migrate from Foveaux Strait/Stewart Island seasonally to the tropical and sub-tropical Pacific to the north (Francis, 2015). White shark males tagged at Tītī Islands/Stewart Island left these cooler waters to migrate north between early March and mid-June, whilst females are observed to leave between early July and late August (Duffy *et al*., 2012; Francis, *et al*., 2015). Peak abundance of white sharks around Stewart Island/Tītī Islands is known to be February to March and monitoring of tagged individuals in this area shows that of 25 receivers only 1 female remained within Fiordland and Foveaux Strait over the winter to spring months (Duffy *et al*., 2012). Capture rates, however, have found that white shark individuals can be present all year in this area, predominantly remaining near the Tītī Islands and Fiordland (Francis, *et al*., 2015). Despite the few apparent all year round individuals noted in the Stewart Island

[x] All shark Conservation status' are from Duffy *et al*., (2016).

and Foveaux Strait surrounds, the northern side of Foveaux Strait, i.e. Bluff Harbour, Tiwai Peninsula, Motupōhue mātaitai, Oreti Beach etc., is not commonly frequented by white sharks (Francis, *et al*., 2015; Miller & Davis, 2021).

5.4.6 Seabirds

An avifaunal study was completed in February 2021 by Brent Stephenson of Eco-Vista (Stephenson, 2021). The study included a field survey of Bluff Harbour, Motupōhue mātaitai and Awarua Bay. A desktop analysis of avian values and species at risk of potential impact from the proposed Bluff Harbour Capital Dredging project was also completed. A brief summary of the findings is provided below. However, for more information regarding potential impacts and proposed mitigations please refer to the Survey and Assessment of Avian Values; Bluff Harbour Capital Dredging Project report (Stephenson, 2021).

A total of 155 bird species were identified as being present within the vicinity of Invercargill, Bluff Harbour and Awarua Bay (Miller & Davis, 2021). A short list of fifty-nine species were determined to have a threat category of At Risk[xi], Naturally Uncommon or above, and forty-nine species without a threat classification. Bird species were classified into eight main categories with regards to potential impacts from the proposed projects – these were waterfowl; penguins; albatross; petrels, shearwaters and their allies; Cormorants/shags; shorebirds; herons; and gulls and terns.

Four cormorant/shag species are common in the Bluff environs: little pied, pied cormorant, spotted shag and Foveaux shag. Of these, the three latter species have threat classifications and the Foveaux shag is range restricted and uncommon (Threatened – Vulnerable). Foveaux shags were noted to have a breeding colony on Rabbit Island within the inner harbour and may roost here year-round.

Three species of gull and four species of tern are known from the Bluff Harbour and Awarua Bay area. Of these species, the black-billed gull (Threatened – Critical) and black-fronted tern (Threatened – Endangered) have the highest threat classification, followed by Caspian tern (Threatened – Vulnerable), red-billed gull (At Risk – Declining), and white-fronted tern (At Risk – Declining) (Stephenson, 2021).

[xi] All avian threat classifications are from Robertson et al. (2021).

5.4.7 Marine Mammals

A marine mammal assessment of effects was completed by Simon Childerhouse (Childerhouse, 2021) as part of the Bluff Harbour Capital Dredging ecological impact assessment conducted by e3s (see Miller & Davis, 2021). This was completed via desktop analysis of potential marine mammals present in the wider Foveaux Strait vicinity and the deployment of marine mammal acoustic mooring devices within the Bluff Harbour channel capturing 12 months of data. The data collected by these mooring devices assisted in a more targeted approach to mitigating potential effects on marine mammals. A brief summary of the findings is provided below; however, for more information please refer to the South Port Capital Harbour Dredging Assessment of Environmental Effects – Marine Mammals report (Childerhouse, 2021).

The greater Southland and Foveaux Strait region is considered an important area for a large number of New Zealand's whale, dolphin, and seal species. The more common species occurring within the wider Bluff Harbour and Tiwai Peninsula areas include Hector's dolphins (*Cephalorhynchus hectori hectori*), NZ fur seals (*Arctocephalus forsteri*), NZ sea lions (*Phocarctos hookeri*), bottlenose dolphins (*Tursiops truncates*), southern right (*Eubalaena australis*) and humpback whales (*Megaptera novaeangliae*) and the occasional orca/killer whale (*Orcinus orca*). All of these species are considered Threatened or At-Risk, with the exception of the NZ fur seal which is Not Threatened (Baker, *et al*., 2019).

The 12 months of collected acoustic monitoring in Bluff Harbour identified unknown whale and dolphin species approximately 0.08% of the time, with Hector's dolphins and Southern right whales being detected 0.01 and <0.01% of the time respectively (Childerhouse & Pine, 2022). Childerhouse (2021) more generally found that 24 cetacean and four pinniped species have been recorded within the wider Foveaux Strait and larger Stewart Island area. The majority of these sightings are 'opportunistic rather than systematic,' meaning they do not necessarily represent unique animals or actual distributions. Overall, the report notes that "*there is no evidence indicating that any of these species have home ranges restricted solely to the BPA* [Bluff Port Area]."

Table 14: Marine mammal acoustic monitoring data collected from within Bluff Harbour (Childerhouse & Pine, 2022).

Species	Minutes Recorded	% Time Detected (acoustically)	Threat Classification*
Dolphin (other than Hector's)	1095	0.07%	N/A
Hector's Dolphin	70	0.01%	Threatened – Nationally Vulnerable
Southern Right Whale	30	<0.01%	At-Risk - Recovering
Whale (other – unknown)	68	0.01%	N/A

* Threat classification from Baker et al. (2019).

5.5 Summary of Marine Ecological Values

Table 15 below summarises the ecological values found within the Syncrolift dredge site and the larger Bluff Harbour marine environments.

Table 15: Syncrolift dredge site and Bluff Harbour (receiving environment) ecological values summary.

	Syncrolift Dredge Site	Receiving Environment
At Risk or Threatened Marine Species	No high value species were observed at the Syncrolift site. While mobile high value species may briefly transit this area, significant residence times are not anticipated.	Ecologically important species identified within Bluff Harbour include Threatened and At-Risk birds, sharks and marine mammals. Hector's dolphins (Threatened – Nationally Vulnerable) and Southern right whales (At-Risk - Recovering) were infrequently recorded from within the vicinity 0.01 and <0.01% of the time respectively. 59 bird species were identified in the area with a threat category of At-Risk, Naturally Uncommon or above; and 49 species identified without a threat classification. The Threatened - Nationally Endangered white shark is known to feed within Foveaux Strait during summer.
Ecologically Important Habitats	Habitats with the Syncrolift site are primarily soft sediments. These habitats were not found to be unique within the harbour and do not support ecologically important assemblages.	Bluff Harbour and the Tiwai Peninsula encompasses a range of high energy and ecologically important marine habitats. These include rocky reefs, seagrass beds, fringing intertidal coastlines and dynamic subtidal environs associated with the harbour mouth and estuary. Rocky reef habitats contribute to habitat complexity and provides abundant interstices for small invertebrates, fish, and algal species. These reefs and fringing coastal habitats support seabird and penguin feeding grounds. Marine mammals and shark species utilise these dynamic habitats in pursuit of fish and prey. The high rate and volume of tidal flushing likely maintains the high water quality. The inner harbour and Awarua Bay supports At Risk – Declining seagrass, sponge, and intertidal sand flat habitats supporting a range of species throughout their lifecycle. Wading and shore birds, as well as sharks, utilise the soft sediment intertidal and subtidal areas as

		feeding habitats to herd and capture smaller fish species during the summer months.
Benthic Communities	No unique, Threatened or rare species were identified with the proposed dredge site (all soft sediment). Berth sites appear to have similar or greater infaunal diversity and densities than nearby channel environments (this may be attributable to slight enrichment in the berth sites). Both infauna and epifauna are likely mobilised during tidal movements and therefore should recolonise quickly after disturbances.	Rocky reef species found were generally common and resilient; including cushion stars, sea tulips, sponges, topshells, brittle stars, wandering anemones, kina, pāua and coralline algae. Soft sediment benthic habitats include At Risk – Declining seagrass beds providing enhanced species diversity, productivity and ecosystem functioning. No unique, Threatened or rare soft sediment fauna was identified.

6 Ecological Impact Assessment

This section assesses the effects on the marine environment from both the proposed Syncrolift maintenance dredging operations (removal) and the deposition into the main channel of Bluff Harbour (receiving environment). The assessment of effects is based on the ecological values of the coastal marine environment that may be impacted by the proposed activities, and the level of effect that may occur. The approach to the assessment is set out in Section 4.4, which provides a structure where ecological value and the magnitude of the proposed activity can be assessed. A summary of marine ecological values is provided in Section 5.5, with specific impacts and recommended management hierarchical strategies provided in the following Sections. These impacts and management recommendations are then summarised in Table 16.

The approach generally follows the Ecological Impact Assessment guidelines published by EIANZ in 2018 (Roper-Lindsay, *et al.*, 2018). We note that these guidelines were developed for terrestrial and freshwater environments and not coastal and marine environments. However, in the absence of similar guidelines specifically developed for New Zealand marine ecosystems, the EIANZ 2018 guidelines have been adapted to and used for a number of significant marine developments. They provide the best current approach available and are generally accepted by ecological professionals, to support a nationally consistent approach to assessing ecological effects of development activities.

6.1 Effects of Removal of Dredge Spoil (Syncrolift Location)

The proposed Syncrolift maintenance dredging is essential to the operation of the shiplift, which currently cannot be fully lowered to receive vessels. As with most dredging operations, it is possible that ecological and environmental effects will occur. These effects need to be considered against both the ecological values within the site, and against other High value marine species which utilise Bluff Harbour. This section discusses the potential effects from the disturbance and removal of species and habitat from the Syncrolift site to be dredged, and sets out management actions to avoid or mitigate the risk of the effects being realised. These are then summarised in Table 16.

6.1.1 Disturbance of Soft Sediments (Resuspension on Site)

Dredging will remove soft sediments with a venturi suction dredge from underneath the Syncrolift, and in doing so will disperse material to the water column both locally at the site, and to a larger extent, at the dispersal point. The local disturbance of these materials can reduce water clarity and can impact flora and fauna by reducing their ability to locate food and/or photosynthesize. Resuspended material may also directly or indirectly expose aquatic organisms to contaminants, which may present a range of adverse effects.

The South Port berth pockets and Syncrolift are predominantly depositional zones, as they are deeper, outside the main channel and restrict tidal flows. Consequently, these locations tend to have higher proportions of silt and contaminants than the wider harbour[xii]. Sediment, including silts and contaminants, were present underneath the Syncrolift and this material will be mobilised into the water column during dredging. Contaminants above ANZG (2018) or CCME-TEL (1999) ecological guidelines included arsenic, copper, nickel, zinc and tri-butyltin. The overall silt component of this material was 40% compared to the adjacent benthic environment which averaged 20.72% silts (see Section 5.1).

Modelling of the potential sediment plume created at the dredging site (from excavation) was not included, as these volumes are hard to quantify. Based on the bay-wide modelling conducted by Oceanum (Zyngfogel & McComb, 2023), it is hypothesised that any dredge head plumes would follow the overall pattern of modelled plume dispersal. This would likely consist of localised resuspension around the Syncrolift, which uncontrolled, would maintain a south-easterly flow along Berth 8 and towards the harbour entrance[xiii].

In order to restrict the dispersal of suspended sediments from the dredging site, it is recommended that a sediment curtain be placed around the Syncrolift site to minimise dispersal which will occur during dredging. This methodology can largely follow the same technique proposed in Beardmore & Miller (2022) during the Syncrolift dredge trials in 2022. The sediment curtain will also help exclude sensitive mobile species identified within this report and across the wider area. This will assist with local containment and make sure that suspended material is appropriately

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[xii] The exception to this is Berth 8 whereby the seabed is eroding as opposed to accreting due to greater exposure to high tidal flows resulting in lower silt contents than inner berths.

[xiii] Assuming operation under the optimal dredging window on an ebb tide from 1 hour before to 4 hours after high water (see Section 5.3.1).

transported to the pipeline dispersal point in the main channel. Further mitigation of risks to the inner harbour environments and sensitive habitats will be achieved by restricting dredging to the optimal dispersal window which will move suspended material towards the harbour mouth. The likelihood that ecologically concerning concentrations of this material will be transported to inner harbour high value habitats (such as Awarua Bay and nearby seagrass habitats) is very small. In short, dredge head sediment should be controlled, and make use of tidal mechanisms for transport of material away from inner harbour environs.

Given the highly modified benthic environment within the immediate site to be dredged (Low ecological value) and the recommended sediment curtain which further constrains the risk of fine silts in the water column affecting nearby environments (Low magnitude) the **overall effect is considered Low**.

6.1.2 Removal of Benthic Flora and Fauna

The removal of soft sediment benthic habitat from under the Syncrolift will entrain benthic flora and fauna in the process, with potential for adverse impacts on benthic species present. Based on previous monitoring and site investigations, fauna present in the proposed dredging sites are resilient, common and will readily recolonise the sites post-dredging. No Threatened or At-Risk marine invertebrate species were identified and Shannon Diversity Index values were consistently low, ranging from 0.3 to 2.1 over the sampled Berth sites. The majority of species included annelid worms and amphipods, with three mollusc species and three decapods identified. Due to their small size, some of these species will likely pass through the pipeline unaffected. Furthermore, no flora is attached to benthic substrate within the propose dredging sites, and it is expected that any mobile species will depart the works area due to noise vibrations from the pre-dredging set-up.

Based on the site investigations the infaunal and epifaunal communities within the Syncrolift site to be dredged have Low ecological value. The magnitude of the maintenance dredging activity will be initially High within the dredge footprint before species recolonise from nearby. This equates to an overall **Low level of effect**. It is also worth noting that the benthic habitat at this location post-maintenance dredge will be improved due to the removal of fine silts.

6.2 Effects of Spoil Dispersal to the Marine Receiving Environments

At the dispersal point, a slurry of soft sediment and water is proposed to be discharged via pipeline to the main channel near Berth 8 (Figure 5). The initial and most effective avoidance strategy to reduce impacts on ecologically important habitats such as seagrass, intertidal sediment flats and rocky reef habitats was to identify and constrain the dredging window to ensure suspended and deposited sediment from the maintenance dredge avoided these habitats to the extent possible. The modelling conducted by Oceanum (Zyngfogel & McComb, 2023) identified the P3 location as the optimal disposal location, which is ~400 m away from the Syncrolift in ~8 m of water (modelled at 0.5 m off the seabed). The optimal window to reduce impacts on noted sensitive marine environments was identified at ebb tide from 1 hour / 30 minutes before high water to 4 hours after high water. During this tidal range, the dredge spoil will be transported within the main channel entrance of Bluff Harbour and into Foveaux Strait with very few depositional sites found within ecologically sensitive areas (see Section 5.3.1).

The following sections describe the potential effects on species and habitats within the tidally modelled receiving environment, as well as further mitigations and recommendations to minimise effects. These are then summarised in Table 16.

6.2.1 Reduced Water Clarity from Sediment Pluming

Reductions in water clarity can impact flora and fauna by reducing their ability to locate food and/or photosynthesize. Suspended sediments in the water column near preferred seabird feeding habitats (such as the Bluff Harbour entrance) can reduce visual feeding abilities. This is particularly detrimental during breeding seasons as it forces breeding pairs with new chicks to search further afield for food, increasing the risks for the nesting parent.

Reduced water clarity can also have a detrimental effect on sensitive ecological habitats such as seagrass (*Zostera muelleri*) if light availability is reduced over an extended time frame. Robertson *et al.* (2016) state the "*preferred water clarity for seagrass*" in Tool 2 of the New Zealand Estuary Trophic Index Toolbox is "*an average value of at least 20% of the sunlight that strikes the water's surface (incident light) should reach the estuary bed*". The average minimal light requirement for seagrass was determined to be 10.8% by Duarte (1991); however, there is a wide range of minimal light requirements amongst different seagrass species, from 4 to 29% (Turner & Schwarz, 2006). The ANZG (2018) guidelines acknowledge that turbidity may not be a particularly useful indicator, particularly regarding the protection of sensitive ecological habitats, such as seagrass: "*Low turbidity values are normally found in offshore waters. Higher values may be found in estuaries or inshore coastal waters due to wind-induced resuspension, dredging or the input of turbid water from the catchment. Turbidity is not a very useful indicator in estuarine and marine waters. A move towards the measurement of light attenuation in preference to turbidity is recommended*."

The oceanographic modelling conducted for plume dispersal illustrates that tidal flow, release location and the timing of works are critical to the avoidance of suspended sediment from sensitive habitats. 90^{th} percentile depth-averaged suspended sediment concentrations from the optimal release scenario suggest that exceedances of 100 mg/L will occur for only very short periods of time and only within the main harbour channel away from high value habitats (see Figure 16). Exceedances of 50 mg/L were found to occur for only three hours over the total working time[xiv], with a very small proportion impacting a section of mapped rocky reef within the main channel entrance. Similarly, the maximum time modelled suspended sediment concentrations[xv] exceed 2.5 and 5 mg/L is on the order of 24 hours and 12 hours respectively (see Figure 25). These concentrations can be assessed against background suspended sediment concentrations identified in Section 5.3.2, which were found to range between 11.4 and 1.3 mg/L (during 2016 sampling) and 3.88 to 5.98 mg/L at control sites in 2023. When compared to past dredging and disposal site monitoring (e.g., Capital Dredging), maximum downstream TSS was only found to be 6.22 mg/L. This data suggests that even under high-volume dredging operations such as the Capital Dredging project, only slight turbidity increases are observed within the mixing zone.

[xiv] ~10% of the total working time estimated at <30 hours.

[xv] 90^{th} percentile depth-averaged suspended sediment concentrations from the optimal release scenario: P3 location on ebb tide from 1 hour before to 4 hours after high water.

Figure 25: Maximum amount of time (in hours) the depth-averaged suspended sediment concentration is above 2.5 (left) and 5 (right) mg/L for discharge location P3 over a spring tide cycle from 1 h before to 4 h after high water. The green and red contours show 24 h and 48 h respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12 h is masked (Zyngfogel & McComb, 2023).

The modelling of suspended sediments across the dispersal footprint suggest that effects will be largely constrained to the main channel, forced seaward and away from sensitive habitats with the strong ebb tidal flows. Based on this, measurable effects are not expected near seagrass beds, the mātaitai or at all within Awarua Bay. High value habitats such as rocky reefs will be largely avoided, and water clarity should be rapidly restored after each dredging cycle. Given the short period required to dredge (maximum of two weeks annual working time total) and low volumes (6,000 m^3 maximum), fine sediments should rapidly disperse and dilute with outgoing tides and the influence of wave driven resuspension (which would be in addition to the modelled parameters). Sediment pluming is expected to be exceedingly short-lived and of limited ecological effect relative to background observations. These effects are anticipated to have no measurable impacts on mahinga kai species health or abundance. The primary areas affected by reduced water clarity such as the harbour Swing Basin and Channel (entrance area) are considered highly dynamic regions. These areas are subject to storm and wave events with constricted tidal forcing pushing event-driven land-based sediments from the estuary through this area. Because of this, species utilising these areas will be accustomed to elevated suspended sediments, for similar short duration events.

To further mitigate any chance of suspended sediments causing an adverse effect on marine species, soft sediment dredging is recommended to occur outside of little penguin breeding months (September to March), and outside of the flowering and most productive season for seagrass (*Zostera muelleri)* (December to March) as both species are most vulnerable during this period.

Marine mammals can be affected by reduced visibility from dredging operations. Within Bluff Harbour these would likely include Hector's dolphins, New Zealand fur seal, New Zealand sea lions, bottlenose dolphins and killer whales. Both Hector's dolphins and southern right whales were infrequently recorded near Bluff Harbour. These are all highly mobile and intelligent animals with the ability to seek preferred conditions within the area. Other transient and mobile species such as fish, birds, and benthic infauna/epifauna may utilise this space; however, should be able to temporarily avoid areas of high suspended sediment over the short durations. Based on the small footprint and short durations, these animals should have sufficient capacity to avoid or tolerate these areas. Because of this, effects on marine species are expected to be very low. However, given the proposed mitigation to avoid maintenance dredging within the months September to March, this would also effectively avoid the predominant season marine mammals have been found to utilise the harbour and nearby marine environment.

Taking the above into account, although ecological value of the species within the harbour and nearby marine environments are considered High, the tidal restriction of the dredging disposal, the low spoil volumes and modelled impact zones create a Low magnitude. Therefore, any water clarity impacts are expected to have a **Low overall effect** on seabirds, sensitive marine species, habitats and mahinga kai resources.

6.2.2 Physical Effects from Dredged Material Dispersal

Sedimentation and sediment plumes can cause adverse effects to both rocky shore and soft-substrate marine species. Increased levels of suspended sediments in the water column and ongoing sediment deposition could lead to a reduction in photosensitive benthic productivity and potential smothering of species. Other effects can include gill clogging, reduction in light availability or feeding ability and increased acidification (Law, *et al*., 2018).

Particle size analysis of dredged sediments shows a high proportion of very fine particulate matter (40.45% on average), suggesting that suspension and resuspension rates could result in widespread dispersal due to very slow settling rates combined with dynamic local oceanography. However, this will also assist in smaller effects on individual species, as dilution ratios and dispersal will be high. Likewise, the majority of sediment to be dredged will be similar to natural environments within the harbour and surrounds, and modelling suggests seaward movement out of the harbour.

Modelling shows the persistence of accumulated benthic deposition above 1.5 mm for 48 hours in only a few select areas around the harbour wharf, outside Berths 5 & 6 and east of the outer harbour rocky reefs (see Figure 17). Thicknesses above 3 mm for 48 hours are constrained to outside Berths 5 & 6 only. These depositional areas are likely due to localised eddies which retain sediment across tidal cycles, allowing material to fall to the seabed. Because of this, these small areas are anticipated to already exhibit the depositional characteristics of soft sediment environments. While the distribution model used does not include resuspension from wave activity, it would be anticipated that these forces would assist with the transiency of material in the area due to further resuspension and dispersion. This additional force would likely reduce depositional times, helping to move material seaward and alongshore.

Little information exists on the physical effects of deposition on individual species; however, it is largely agreed that effects increase with the volume of overburden deposited, and also duration (e.g., Miller et al. 2002; Hewitt & Lohrer, 2013). Species can tolerate some level of depositional sediment by actively shedding material or repositioning vertically within the substrate. This would be in contrast to complete 'burial', which is undefined and would be species specific. Similarly, reduced feeding and photosynthetic ability can likely be tolerated for short duration events, such as the order of the storm-scale (days), with low impacts. Faunal assemblages in the modelled depositional footprint (see Figure 17) are considered of Moderate ecological value, being already modified due to historic alterations to the benthic environment (e.g. port operations and existing dredge activities). Despite historic activities, no observable or measurable effects have been noted to date at the community level, despite ongoing monitoring by e3s[xvi]. Marine species within these areas should be highly tolerant of suspended sediment and sedimentation due to port-related activities, but primarily, due to natural coastal processes and background parameters found across Bluff Harbour.

[xvi] South Port Capital Dredging Monitoring (2021 - 2023); Seabed and Wharf Monitoring (2023).

As mentioned before, the small volume of material and duration of works will be considered comparable to a storm event, large wave event or any other similar natural disturbance which commonly occurs in this region. Therefore, an effect magnitude of **Low** is considered applicable. Further limiting any risk, we have previously recommended dredging occur during the winter months where natural turbidity levels are lower due to less wind and phytoplankton production is low, so as to not create cumulative effects within the water column (e.g. outside September to March). Together, and in consideration of the proposed mitigations, the physical effects from spoil material dispersal to the channel is anticipated to have an **overall Low level of effect**.

6.2.3 Chemical Effects from Dredged Material Dispersal

Aquatic organisms may be directly or indirectly exposed to sediment contaminants if disturbed or distributed, and it is possible they may experience a range of adverse effects. Bluff Harbour and the surrounding marine environment contains a wide range of species (see Section 5.4) as well as mahinga kai resources (e.g., pāua, oysters, lobster) and extensive macroalgal habitat (Figure 23), including extensive beds of seagrass (*Zostera muelleri*).

Sediments from under and adjacent to the Syncrolift (where dredging will occur) were assessed for both organic and contaminant composition (Section 5.1.2). Differences in contaminant loading between the sediment under the Syncrolift and the immediate surrounding area appears small. Sediment samples were not significantly different, and all sets of samples generally show occasional exceedances of the adopted guideline values for arsenic, copper, nickel, zinc and tributyltin.

The chemical composition of dredge material primarily differed to the receiving environment in the heavy metal levels (see Sections 5.1.2 and 5.2.2). Elevated metals within sediments have derived thresholds based on measurable (direct) impacts to reference organisms. Of these, copper (Cu) was the only heavy metal exceeding the ANZG (2018) GV-High and CCME (1999) PEL guidelines, with an effect level 'probable' to aquatic species. The CCME (1999) report states that '*adverse biological effects for Cu in the BEDS* [study group] *include decreased benthic invertebrate diversity, reduced abundance, increased mortality, and behavioural changes, among others.*' The ANZG (2018) guidance states that "*some species of marine algae are particularly sensitive to copper*" and that "*invertebrates, particularly marine crustaceans, corals and sea anemones, are* *sensitive to copper, with concentrations of copper as low as 10 µg/L causing sublethal effects."* The guidelines recommend using multiple lines of evidence as part of the weight-of-evidence process to better assess the risk to an ecosystem if a threshold is exceeded. In this case, elevated Cu could impact both flora and fauna within the receiving environment. Based on the extent of the depositional modelling, this sediment should primarily be deposited over an area outside sensitive habitats and within a highly dynamic part of the harbour mouth. This should assist with seaward dispersal and ultimately dilution. The species within this part of the channel should be considered resilient due to the dynamic nature of this area and with sediment persistence estimated at days, the transient nature of elevated copper loadings should be low.

For other metals, exceedances of the ANZG (2018) DGV guidelines and CCME (1999) TEL indicate a *possible* ecological effect may occur. For most other elevated contaminates (including tributyltin), results were highly heterogeneous over space and time. For tributylin, sampling suggests that discrete particles or clumps (likely paint chips) may have been acquired within samples, and may not reflect ambient background levels. Tributyltin has widespread usage in marine antifouling paints and wood preservation. Tributyltin is highly toxic to marine bivalves and has been restricted in Australia and New Zealand due to deformities and population impacts (ANZG, 2018). It should be noted that tributylin (TBT) was identified in both the dredge sediments and at select dispersal locations including Berths 5 & 6, 7 & 8, and 8a (see Table 7 & Table 11).

Adverse biological effects can occur in benthic invertebrate assemblages, microorganisms and phytoplankton from elevated arsenic, nickel and zinc concentrations also. Elevated contaminants have the potential to impact marine benthic diversity and abundance, with a wide range of sublethal effects considered possible, both directly and indirectly. In general, species can be exposed to contaminants through both ingestion (directly or indirectly) and contact (CCME, 1999). While indirect ecological impacts are much more complex, hard to measure and highly site-specific, general food-web theory and well documented species interactions are more straightforward. Food-web theory suggests that certain contaminants can bioaccumulate up the food chain, potentially influencing a wide range of taxa. However, at the concentrations found in the Syncrolift samples and the volumes proposed to be discharged it is unlikely that observable effects would occur. A further discussion of the potential effects of elevated heavy metals and contaminants within these sediments is provided in Appendix C.

Across other analytes, Syncrolift sediment samples were similar to the proposed primary receiving environments (e.g. Berths 8, 5 & 6, 3A, Swing Basin and Harbour Control). Nutrient and PAH levels were all low or below laboratory detection limits across all sites (dredge site and receiving environment) and Total Organic Carbon (TOC) readings were below the ecological stressor level of 3.5 g/100 g, maintaining consistency with a 2% 'average' coastal guideline (Hyland, et al., 2005).

Overall, the chemical composition results likely reflect a long history of vessel traffic, shipping and maintenance within the harbour. Within the modelled depositional footprint, high value habitats are largely avoided, and measurable impacts to sensitive seagrass beds, rocky reef habitats and the mātaitai are not anticipated. Dilution will also significantly reduce the potential for any adverse chemical effects on individual species. However, although the majority of epifaunal and infaunal species found within the modelled receiving zone were considered common and resilient species, there are **High** ecological value species found across the Bluff Harbour environment, including pāua, oysters, algae etc., and it is possible they may be directly or indirectly influenced by elevated dredge contaminants.

Considering the select elevated heavy metals found within dredge sediments, the volume to be discharged and the avoidance strategy of utilising the tidal movements, the magnitude of effect on species in the receiving environment is considered **Low**, with an overall **Moderate level of effect**. To mitigate the potential for this to occur, it is suggested that annual sediment monitoring be undertaken to assess both source dredge material and potential accumulation within the receiving environment. Sampling should repeat the analysis conducted within this report for consistency and results should be provided to the consenting authority for annual review and long-term monitoring. Considering the previously proposed mitigations and recommendations are followed, and in light of the short duration, small sediment volumes and relative contribution of contaminants over the dispersal footprint, any residual chemical effects from spoil discharge should be considered **Low**.

6.3 Cumulative Effects from Annual Maintenance Dredging Activity

Based on the above Sections (6.1 & 6.2) the likely ecological effects of the Syncrolift dredging activity have been largely avoided or mitigated. However, as this activity could potentially occur annually, cumulative effects must also be considered. The modelling results show that the effects of each dredging event, which have been modelled for a maximum of 6,000 m^3 (a volume which has accumulated over the last 30 years) has small and transient effects on both the dredged and receiving marine environment. Based on these results, it is reasonable to assume that within a maximum of a 30 day, tidally restricted dredge window within each year, cumulative effects will not be evidenced. However, in order to verify this assumption annual monitoring has been recommended.

The proposed sediment sampling should include grab samples (via Van Veen or similar) at the following locations:

- At the Syncrolift site;
- At the disposal locations (i.e. location P3 & P4 in Figure 19);
- At one sediment deposition area identified by the model; and,
- One location within the mātaitai.

Sediments should be analysed for Particle size analysis (PSA), heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. Monitoring should aim to be completed at the same time each year and results along with any volumes dredged within last 12 months should be provided to the consenting authority (ES).

6.4 Assessment of Effects Summary

Table 16 below provides a summary of the above Sections 6.1, 6.2 and 6.3 including recommended management actions and the residual level of impact (assuming implementation of the mitigation measures).

Table 16: Summary of potential effects on the coastal marine environment from Syncrolift dredging and spoil dispersal to Bluff Harbour.

Proposed Activity	Potential Impacts [1]	Rationale [2]	Ecological Value	Magnitude of Effect	Level of Effect [3]	Recommended Impact Management/Mitigation	Level of Residual Impact
Syncrolift Dredging (Sediment Removal at the site)	Disturbance and resuspension of soft sediments at the site can have physical & chemical effects on aquatic/avian species.	• Benthic habitat at the site is primarily soft, fine sediments with low infaunal density & diversity. • Mobile epifauna is minimal at the site and species considered common. • Minimal volume and duration increases the dilution factor as well as the ability to control the material.	Low	Moderate	Low	• The use of a sediment curtain will contain resuspended material to the site and will exclude sensitive mobile species from the area.	Low
	The removal of soft sediment benthic habitat from under the Syncrolift will entrain benthic flora and fauna in the process, with potential for species mortality.	• Habitat is considered historically modified. • Fauna present at the Syncrolift dredging site are considered resilient & common. • No flora is attached to benthic substrate within the proposed dredging site. • Any mobile species will depart the works area due to noise vibrations from the operational establishment.	Low	High	Low	• No additional impact management required.	Low
Effects of Spoil Dispersal to the Marine Receiving Environments	Reductions in water clarity can impact flora and fauna by reducing their ability to locate food and/or photosynthesize.	• Dredging proposed to be restricted to the optimal slack and ebb tidal window (30 min/ 1 hr before to 4 hr after high water) from the P4 release location. • Modelling shows that high value habitats such as seagrass beds, rocky reefs and the mātaitai should be avoided. • Native flora & fauna with Threatened or At-Risk conservation status utilise the wider Bluff Harbour area, however seabirds & mobile species should be resilient to this level of effect as it is par with a natural event. These species can also actively avoid any areas of high suspended sediment. • The low sediment volumes and short duration of dredging, along with tidal flows (and wave energy) should ensure water clarity is maintained to a high level of clarity through dilution and rapidly restored post dredging.	High	Low	Low	• Recommend works occur outside of little penguin breeding months (September to March). • Recommend works occur outside of the flowering and most productive season for seagrass (*Zostera muelleri*) (December to March).	Low
	The physical effects from increased suspended sediments and sediment deposition could lead to a reduction in photosensitive benthic productivity and species smothering.	• Sedimentation and sediment plumes can cause adverse effects to both rocky shore and soft-substrate marine species. • PSA and oceanographic modelling suggests that fine material will be dispersed which will assist with dilution. • Deposition areas exceeding 3 mm for 48 hours are constrained to a previously modified area mid channel (outside Berth 5 & 6). • Flora and fauna within modelled affected areas are likely tolerant of acute impacts via storms and previous dredging. • Based on modelling results from tidally restricted dredge operations, highly sensitive habitats should be avoided.	Moderate	Low	Low	• No additional impact management required.	Low

	Chemical exposure: Aquatic organisms may be directly or indirectly exposed to sediment contaminants if disturbed or distributed, and it is possible they may experience a range of adverse effects.	• Aquatic organisms may be directly or indirectly exposed to sediment contaminants if disturbed or distributed, and it is possible they may experience a range of adverse effects. • Species can be exposed to contaminants through both ingestion (directly or indirectly) and contact, with bioaccumulation and food-web effects possible. • Depositional environments show comparable levels of total organic carbon (TOC), tributylin (TBT), nutrient and polycyclic aromatic hydrocarbon (PAH) levels to dredged materials. • Syncrolift sediment samples show occasional exceedances of the adopted guideline values for arsenic, copper, nickel, zinc and tributyltin. • Elevated copper levels could have adverse impacts on both flora and fauna within the receiving environment. • Natural or pre-existing conditions should return rapidly post-works and any potential effects will be short-lived and comparable to natural disturbance events.	High	Low	Moderate	• Recommend sediment sampling (via Van Veen or similar) at the following locations to monitor contaminant accumulation: ➢ At the Syncrolift site; ➢ At the disposal locations (i.e. location P3 & P4 in Figure 19); ➢ At one sediment deposition area identified by model; and, ➢ One location within the mātaitai. • Sediments should be analysed for PSA, heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. • Monitoring to be completed at same time each year and results along with any volumes dredged within last 12 months should be provided to consenting authority (ES).	Low
Cumulative Effects from Annual Maintenance Dredging		• Maximum of 30 days per year of dredge activity. • The maximum dredge volume required to be removed of 6,000 m^3 has taken 30 years to build up. • Dredge activity is tidally restricted to reduce dispersion and deposition to sensitive environments. • Modelling shows minimal deposition within the wider Bluff and Tiwai area after 48 hours.	High	Low	Moderate	• Ongoing annual sediment monitoring recommended (as above) to provide verification cumulative effects are not being realised.	Low

[1] **Based on Section 6.1, 6.2 & 6.3.**

[2] **Taking into account the described environment, proposed operations, survey results and natural conditions.**

[3] **Prior to management strategies, if required.**

7 Conclusions and Recommendations

The Syncrolift dredging operations will allow for improved use of South Port's shiplift and the ability to safely accommodate vessels for maintenance. The Syncrolift is an important piece of infrastructure for large South Island vessels, which require clean hulls for sensitive marine environments (e.g. Fiordland) and for fuel efficiency. However, coastal dredging operations are known to put additional pressures on often stressed marine ecosystems. Impact management and mitigation is therefore vital to maintain important habitats and ecosystem processes in and adjacent to these often highly modified marine environments.

Based on prior research conducted by e3s and South Port, along with supporting scientific publications, the dredge site and receiving environment has been characterised and assessed for adverse effects from the proposed works. In light of coastal port dredging operations nation-wide, the annual volumes and duration considered here (6,000 m^3 & 2-week annual duration) are minor in comparison. Recently completed, the South Port Capital Dredging project consisted of a dredged sediment volume of 120,000 m^3 and rock volume of 40,000 m^3 over the Bluff Harbour main channel. Preliminary monitoring results suggest that even at these relatively large volumes, measurable effects on sensitive marine habitats are less than minor for this area. This is largely due to the dynamic nature of Bluff Harbour and Foveaux Strait. Throughout the Capital Dredging project and in addition to the Syncrolift dredging proposal, South Port remains focused on the goal of ensuring impacts from works are as low as possible.

Sediment distribution to the Bluff Harbour main channel (near Berth 8 at the P3 location) has been modelled and mapped against habitats and nearby high value environments such as inner harbour environs, rocky reefs, seagrass beds and the mātaitai. Sediment plumes from fine sediment mobilisation were shown to be short lived due to the relatively small volume being removed and the expected timeframe. To further control depositional vectors and reduce impacts to high value inner-harbour habitats, optimal disposal locations and windows have been derived. Spoil dispersal should be restricted to slack and outgoing tides from 30 minutes / 1 hour before to 4 hours after high water and any site works should be contained via sediment barriers. In addition, works should occur outside of vulnerable little penguin breeding months (September to March), and outside of the flowering and most productive season for seagrass (*Zostera muelleri)*

(December to March). Due to the potential for dredge sediments to introduce elevated heavy metals concentrations to the receiving environment, annual sediment sampling (monitoring) at four locations has been proposed. Sediment monitoring should include testing for PSA, heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. Monitoring should be completed at same time each year and results along with any volumes dredged within last 12 months should be provided to consenting authority (ES).

Overall, this assessment finds that the proposed dredging and disposal operations have the potential to further modify the receiving environment. e3s has recommended management measures which can avoid and mitigate potential ecological impacts, ensuring effects are reduced to an acceptably low level. These proposed actions are summarised in the following section.

7.1 Recommendations

Mitigation and impact management recommendations outlined in Table 16 include:

1. Prior to commencement of any subtidal or surface operations, the Syncrolift 'site' should be contained within a sediment barrier.
2. Dredging and spoil release should occur during the optimal tidal windows of 30 minutes (from the P4 location) to 1 hour (from the P3 location) before to 4 hours after high water on an ebb tide to ensure sediment movement towards Foveaux Strait.
3. Sediment dispersal in the main channel should occur from the P3 location, with an alternate P4 location used for shipping conflicts (Figure 19). Dispersal should be used in conjunction with the optimal tidal windows noted above.
4. Soft sediment dredging should occur during the winter months outside of the most vulnerable avifaunal breeding seasons and seagrass (*Zostera muelleri*) flowering/growth seasons (September to March).
5. Annual sediment sampling is recommended to monitor any potential contaminant accumulation. This can be done via a Van Veen grab sampler at the following locations:
    e. At the Syncrolift site;
    f. At the disposal locations (i.e. location P3 & P4 in Figure 19);
    g. At one sediment deposition area identified by the model; and,
    h. One location within the mātaitai.

Sediments should be analysed for PSA, heavy metals, total organic carbon, Polycyclic Aromatic Hydrocarbons (PAHs), and nutrients. Monitoring should be completed at the same time each year and results, along with any volumes dredged within last 12 months, should be provided to consenting authority (ES).

In conjunction with the above findings and proposed mitigations, it is considered that all possible measures have been taken to avoid, mitigate or manage any potential adverse impacts on the marine environment from the proposed works.

8 References

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Appendices

Appendix A:

South Port Sediment and Infaunal Monitoring Summary 2014 - 2021

South Port Sediment and Infaunal Monitoring Summary 2014 - 2021

1 Introduction

South Port NZ Ltd (South Port) have had a Discharge Agreement with Environment Southland (ES) since 2014 and Schedule 2 of this agreement stipulates the monitoring required by South Port to remain compliant (Appendix A). Monitoring requirements 2, 3 and 4 have been carried out annually since 2014 and include marine sediment sample surveys for contaminants, sediment build-up monitoring, and wharf biota survey, within South Port berth sites and control sites in the inner harbour.

South Port also hold a Bluff Harbour Dredging Spoil Disposal Coastal Permit 201285 (Appendix A) which expires on 2 December 2037. This permit has a consent term of 35 years and permits the dredging, dumping and depositing of the following quantities of spoil:

i. Up to a maximum of 40,000 cubic metres (m^3) per year on three occasions during the term of this consent, these being once in the periods October 2005 to June 2006, January 2015 to January 2020 and January 2025 to January 2030.
ii. Except on those occasions specified in (i), a maximum of 20,000 cubic metres in each year of consent and, over the term of the consent, an annual average shall not exceed 12,000 cubic metres.

This permit requires the consent holder to keep a record of the areas dredged, the amount of material dredged, and results of monitoring and interpretation of results. Condition 5 requires the consent holder to undertake an annual sediment monitoring programme. This requires sediment sampling to be completed at South Port's berth sites, the sediment spoil disposal site and a nearby control site approved by ES. Condition 6 of this coastal permit requires a five yearly benthic assessment to be carried out at the spoil disposal site and nearby control site to assess the effects of the deposition of material on the benthic biota. The parameters of this study has been approved by the Director of Environmental Management at ES. Figure 1 illustrates the sediment and benthic sampling locations.

e3Scientific Ltd (e3s), on behalf of South Port, have carried out the last three Discharge Agreement annual surveys (2017 – 2019) and Cawthron carried out the two surveys prior to this (Peacock, *et al.*, 2014; Newcombe & Dunmore, 2015). No surveys were carried out in 2016. The annual sediment monitoring as stipulated by Coastal Permit 201285 has been carried out since 2001. MWH (now Stantec) completed the 2014 & 2015 monitoring (MWH, 2016) and possibly the monitoring previous to this, however due to personnel changes, raw data prior to 2014 is not accessible. e3Scientific Ltd completed the 2019 and 2020 monitoring (e3Scientific Ltd, 2020 & 2021) on behalf of South Port. The five yearly benthic assessment was carried out in 2008 by Cawthron (Dunmore & Barter, 2008) and in 2019 by e3s (Miller, 2020). No benthic assessments between these two surveys are known to have been completed despite being required by ES.

Sediment and infaunal sampling have also been carried out at harbour, spoil disposal and control sites specifically to inform South Port's capital dredging application. This sampling was completed in 2020 and again in 2021 to assess the effects of a 40,000 m^3 spoil maintenance dredge operation carried out by the trailer hopper suction dredge (THSD) Albatros in April and May 2020. Sites included specifically for the capital dredging assessment were Swinging Basin and Berth 3A (including the Berth 3A Drift Dive) (Figure 1) as these locations have not been dredged by South Port since their previous capital dredging in the 1980's and are proposed to be dredged as part of this application.

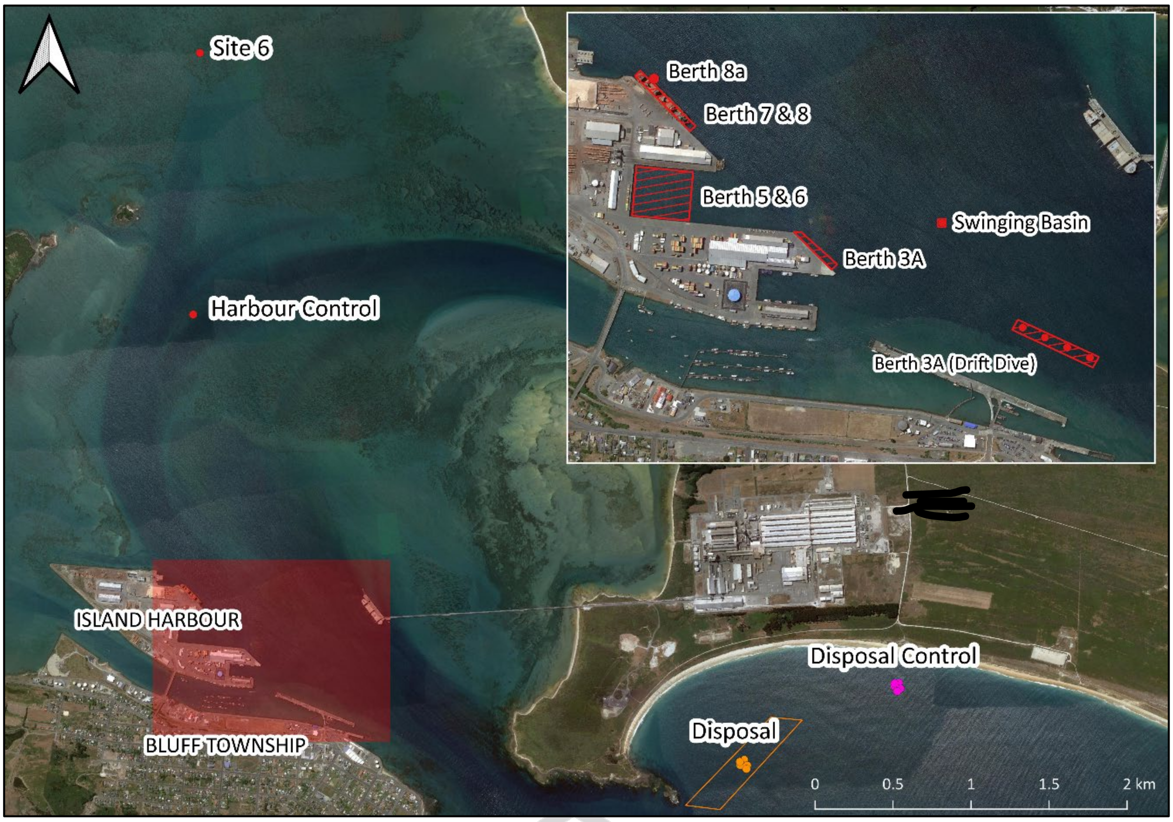


Figure 1: Sediment sampling locations within Bluff Harbour and Tiwai Peninsula.

2 Sampling Methodology

2.1 General

All sediment sampling was completed either by sediment cores on SCUBA or by a Van Veen sediment sampler from a vessel. All infaunal sampling was completed via infaunal cores on SCUBA. All sites were located using fixed landmarks from previous surveys, or a portable global positioning system (GPS). All site positions are shown in Figure 1.

In 2014, the Harbour Control Site (previously referred to as Site 6) was situated to the northeast of Tikore and Rabbit Islands (Figure 1). In 2015, it was necessary to change the location of the control site due to high winds and tides preventing access to the original Harbour Control Site (Site 6). In 2017, the control sediment site was changed again due to weather and tide conditions preventing access to either of the above control sites, and in conjunction with recommendations made from previous surveys. The 2017 Harbour Control Site (Site 4) had similar characteristics to previous sites but greater depth (approximately 7 m) (Figure 1**Error! Reference source not found.**). The 2017 control site (Site 4) was resampled in 2018, 2019, and 2021.

2.2 Sediment Cores via SCUBA

To satisfy Schedule 2 of South Ports' Discharge Agreement (Appendix A) sediment cores are taken on SCUBA every 12 months from the berths and a harbour control site. Four sediment cores and a further 4 replicate cores (of an 80 mm dia) are collected within a 10 m^2 area at selected sites. To obtain the sediment cores, the sediment corer is manually driven into the sediments to a depth of 150 mm, capped in situ, and returned to the vessel. On board, each core is examined to qualitatively determine sediment texture, colour, and odour. The presence/ absence of apparent redox potential discontinuity (aRPD) and hydrogen sulphide odour are used as qualitative indicators of enriched conditions. Photographs are taken of each core to document the relative degree of enrichment to provide a long-term record (Appendix B).

This method was replicated to take additional sediment cores specifically to inform the capital dredging assessment in 2020 and 2021. Due to the strong currents experienced within the Bluff Harbour channel (within Berth 3A site), sediment cores were taken (one sample and one replicate) every 50 m on a drift dive covering approx. a 200 m distance (Figure 1- Berth 3A drift dive).

The surface layer (i.e. the top five centimetres) of each set of four cores is composited into pre-labelled, sterilised, sample jars. For additional quality control and assurance, the second composited replicate sediment samples from the working berth sites are split to assess the reproducibility of the laboratory analysis.

Therefore, a total of three samples were analysed for Berths 5, 8 and 8a:

- One composite sample (SS1);
- One composite replicate sample (SS2a); and
- One field split of the replicate sample (SS2b).

Two samples were analysed from Berth 3A, Swinging Basin, Harbour Control, Disposal and Disposal Control Sites:

- One composite sample (SS1); and
- One composite replicate sample (SS2).

Divers took representative photographs of the seabed at each site and recorded the following information:

- sampling date and time;
- water depth;
- stage of the tide;
- current direction;
- visual characterisation of the sediment present, including apparent redox potential discontinuity layer (aRPD); and,
- visual estimate of water clarity immediately above the seabed.

The laboratory analytical suite determined for the sediment samples is specified by Section 2 (c) of the South Port Discharge Agreement (Appendix A). Consequently, the following laboratory analytical suite is completed for these samples:

- Particle grain-size distribution (percent gravel, sand and silt / clay);
- Total Organic Carbon (TOC);
- Phosphorus (P);
- Heavy metals: arsenic (Ar), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), zinc (Zn);
- Tributyltin (Tbt); and,
- Polycyclic Aromatic Hydrocarbons (PAHs).

The laboratory methods utilised for analysis are included in the laboratory report (see Appendix C).

2.3 Van Veen Grab Sampler

To satisfy Condition 5 (a) of the South Port Coastal Permit (Appendix A), surface sediments at the Disposal and Disposal Control Sites are taken by a boat operated Van Veen grab sampler every 12 months. Each sediment sample or "grab" is examined to qualitatively determine sediment texture, colour, and odour. The presence/absence of aRPD and hydrogen sulphide odour are used as qualitative indicators of enriched conditions.

Samples comprising the surface layer (i.e. the top five centimetres) of each set of three grabs at the Disposal and Disposal Control Site are composited into pre-labelled, sterilised, sample jars. For additional quality control and assurance, a second composited duplicate sediment sample from the Disposal Site is taken to assess the reproducibility of the laboratory analysis. The laboratory analytical suite determined for the sediment samples was specified by Condition 5 (a) of the South Port Coastal Permit (Appendix A). The three Disposal and Disposal Control samples are analysed for:

- Heavy metals: arsenic (Ar), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), zinc (Zn) (trace);
- Polycyclic Aromatic Hydrocarbons (PAHs) (screen);
- Sulphate (S); and
- Phosphorus (P).

Tributyltin (Tbt) was tested for in 2021 but is not required by Condition 5 (a) of the Coastal Permit. The laboratory methods utilised for analysis are included in the laboratory report (see Appendix C).

2.3.1 Sediment Analytical Result Review

Following the receipt of the laboratory data, a detailed review of the data is performed to determine its accuracy and validity. All laboratory data are checked for analytical and typographical errors. Once the data quality is established, the sediment data is assessed with respect to results from the previous monitoring events and the adopted sediment quality guidelines.

2.3.2 Sediment Sample Field and Laboratory QA/QC

The QA/QC procedures performed during sediment sampling are listed as follows:

- Use of standardised field sampling forms and methods;
- Samples were transferred under Chain of Custody procedures;
- All samples were labelled to show point of collection, time and date;
- Headspace in sample jars was avoided; and,
- All samples are stored in a chilled polystyrene bin.

Sediment samples are couriered to Analytica Laboratories Limited (Analytica). Analytica is IANZ accredited for the analysis of heavy metals, hydrocarbons, phosphorous, total organic carbon, and tributyltin. Analytica conduct internal QA/QC in accordance with IANZ requirements. Particle grain-size distribution and total organic carbon analyses are sub-contracted to Earth Sciences Department, Waikato University, Hamilton.

2.4 Infaunal Cores via SCUBA

To inform the five-yearly benthic assessment at the Disposal Site, four infaunal samples were taken at the Disposal and Disposal Control sites in February 2020 (*n*=8). These sites were then resampled in January 2021 (*n*=8) along with a further five new sites (*n*=28) in response to PDP's request for more information regarding infaunal communities within the berths in Bluff Harbour. All infaunal samples were taken using a hand coring method on SCUBA. Figure 2 shows the infaunal sample locations within Bluff Harbour, Disposal and Disposal Control sites for both years.

Figure 2: Infauna core sites.

Each infaunal core has a 100 mm internal diameter and was driven approximately 150 mm into the sediment, capped in situ and returned to the surface whereby the contents were sieved through a 0.5 mm mesh. The residual was emptied into a clearly labelled plastic container, preserved with 70% ethanol and couriered to NIWA for processing. Identifications were made to the lowest practicable taxonomic level.

Infauna count data were analysed to determine individual species density (abundance), species richness (diversity) and standardised indices of community diversity and evenness for each sample (Table 1). The infaunal assemblages recorded during this survey were contrasted using classical multidimensional scaling (MDS) and Agglomerative Hierarchical Clustering using R statistical software. Dissimilarity values for the hierarchical clustering were calculated and then clustered using the ward.D2 agglomeration method.

A quantitative comparison of 2021 results with the previous survey in January 2020 (Miller, 2020) was made to help assess any infaunal effects of the 40,000 m^3 of berth spoil deposited at the Disposal Site in April and May 2020.

Table 1: Descriptions of infaunal indices.

Index	Equation	Description
Abundance (N)	Sum (n)	Total number of individuals in a sample.
Species Richness (S)	Count (taxa)	Total number of species in a sample.
Evenness (J')	$J' = H/\ln(S)$	Pielou's evenness. A measure of how evenly the individuals are distributed among the different species. Values range from 0 to 1; 0 indicates uneven distribution and 1 indicates an even distribution.
Diversity (H')	$H' = -SUM(Pi * \ln(Pi))$	Shannon-Weiner diversity index (H'). A diversity index that describes, in a single number, the different types and amounts of animals present in a sample. The index ranges from 0 for samples with a single species to high values for samples containing many species.

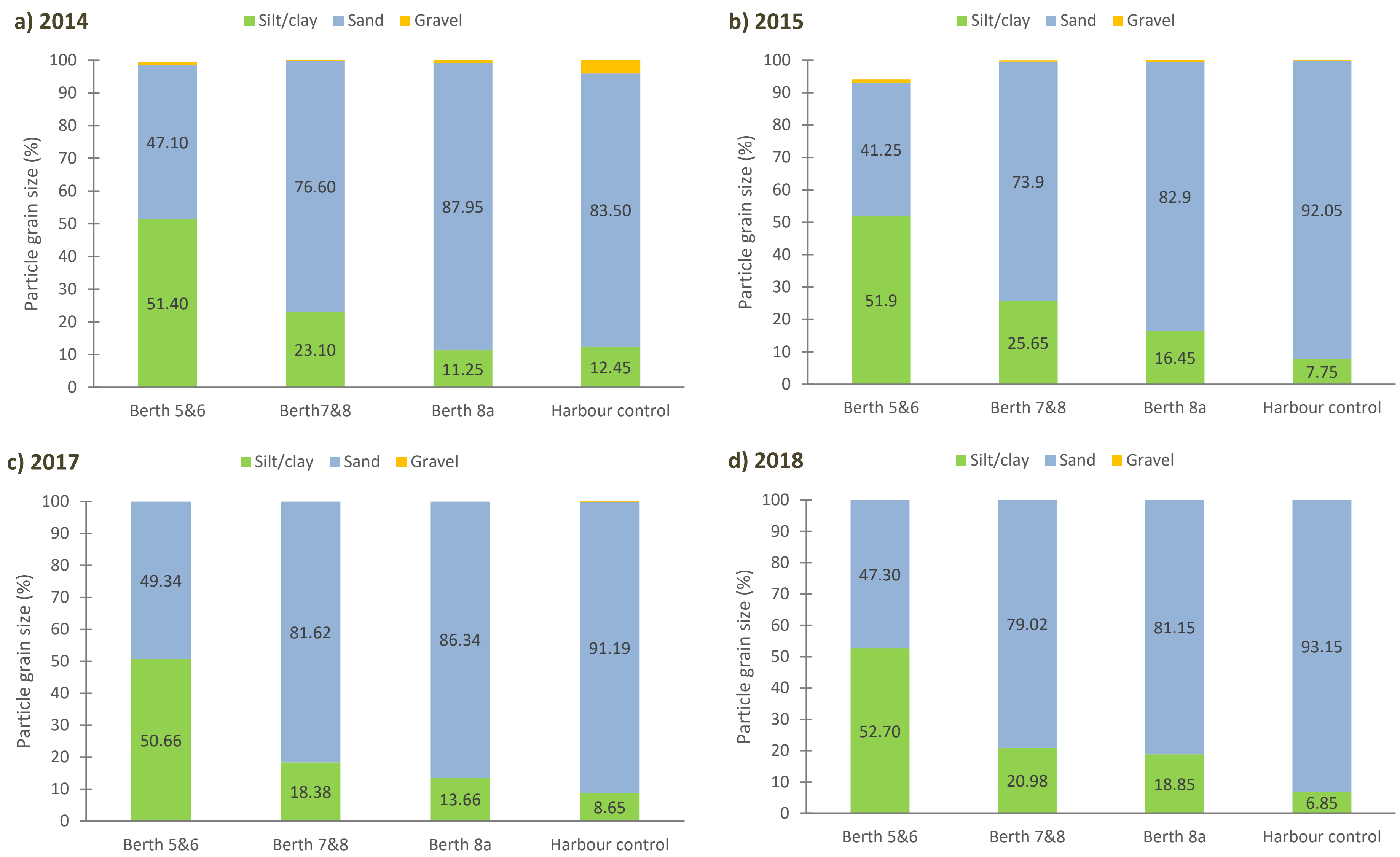
3 Ecological and Physiochemical Trends

3.1 Particle Size Analysis

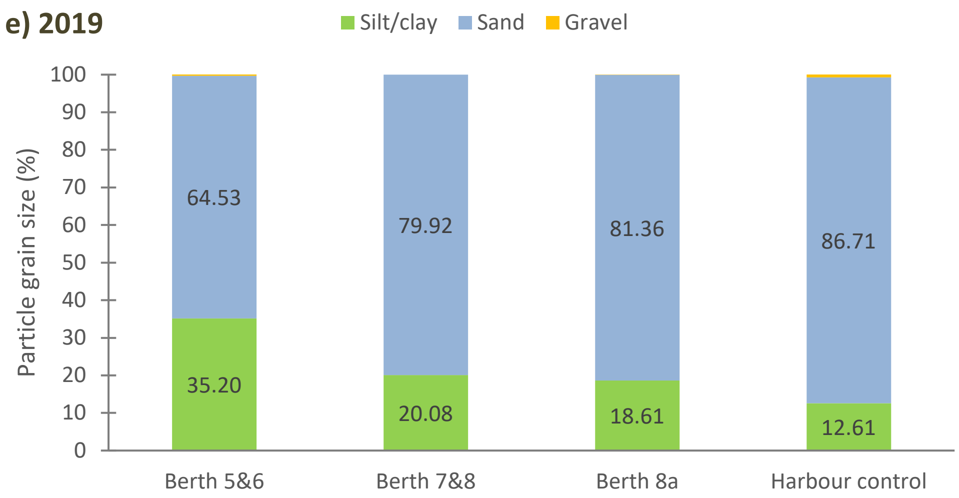
Particle size analysis is carried out at Berths 5, 8, 8a, and Harbour Control as per Monitoring Requirement 2 (c) of the Discharge Agreement. Particle size analysis is also required under Condition 6 of the Dredging Coastal Permit to be carried out every five years at the Disposal and Disposal Control sites. To aid in the assessment of effects for the proposed Capital Dredging application e3s also completed additional particle size analysis for sites in 2020 and 2021.

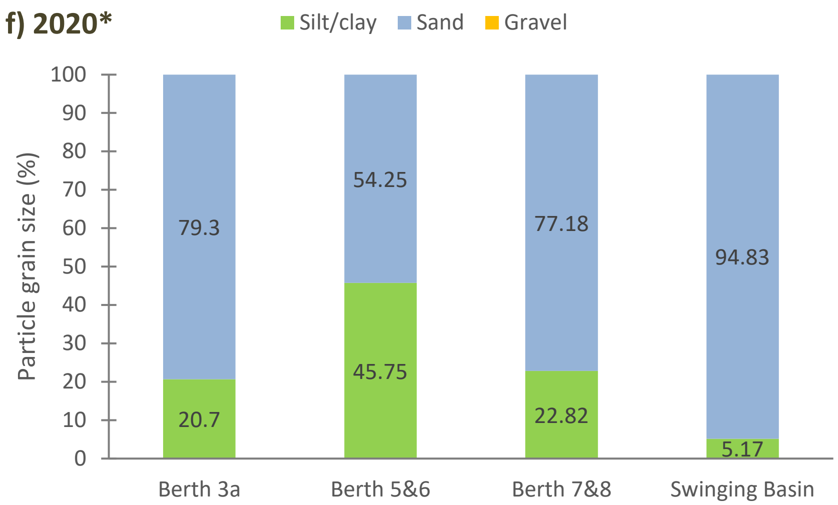
The results of the annual, five yearly and additional sampling in 2020 and 2021 are presented in Figure 3. Where two or three samples were taken within an area the results are averaged. Berth 8a refers to Site 1a (Figure 1) which is 20 m out from Berth 8. Swinging Basin and Berth 3A were only sampled as part of the Capital Dredging application in 2020 and 2021 and have not been dredged by South Port since previous Capital Dredging works in the 1980's. Berth 8a and Harbour Control sites were not sampled in 2020 due to a lack of advice from Environment Southland as to whether this sampling was required.

The silt proportion in Berth 5&6 samples has a range of 20.75% and a mean of 49.08% across the 7 surveys. This large range is due to the consistent build up of land-based silts in this berth basin and the maintenance dredging occurring. Berth 7 & 8 silt proportions have been relatively stable between 2017 and 2020 with an increase in silt observed in the 2021 survey and a mean of 22.66% silt to 77.23% sand. Berth 8a silt proportions have also remained relatively consistent throughout the 7 surveys with a range of 7.6% and mean of 15.89% silt. The Harbour Control site exhibited its highest proportion of silt in 2021 (15.34%) and the lowest proportion of silt in 2020 (5.17%), although these are still considered low silt proportions. The silt to sand ratio can fluctuate at this inner harbour site due to storm events mixing and flushing sediments and land-based sediment loading. The very low silt proportions found at the Swinging Basin site are consistent with areas that receive high tidal velocities (i.e. >0.5 m/sec) and Berth 3A silt proportions appear to be fairly consistent over the two surveys ranging between 20% and 22%.



a) 2014
Silt/clay
Sand
Gravel
Particle grain size (%)
100
90
80
70
60
50
40
30
20
10
0
47.10
51.40
76.60
23.10
87.95
11.25
83.50
12.45
Berth 5&6
Berth7&8
Berth 8a
Harbour control
b) 2015
Silt/clay
Sand
Gravel
Particle grain size (%)
41.25
51.9
73.9
25.65
82.9
16.45
92.05
7.75
Berth 5&6
Berth 7&8
Berth 8a
Harbour control
c) 2017
Silt/clay
Sand
Gravel
Particle grain size (%)
49.34
50.66
81.62
18.38
86.34
13.66
91.19
8.65
Berth 5&6
Berth 7&8
Berth 8a
Harbour control
d) 2018
Silt/clay
Sand
Gravel
Particle grain size (%)
47.30
52.70
79.02
20.98
81.15
18.85
93.15
6.85
Berth 5&6
Berth 7&8
Berth 8a
Harbour control





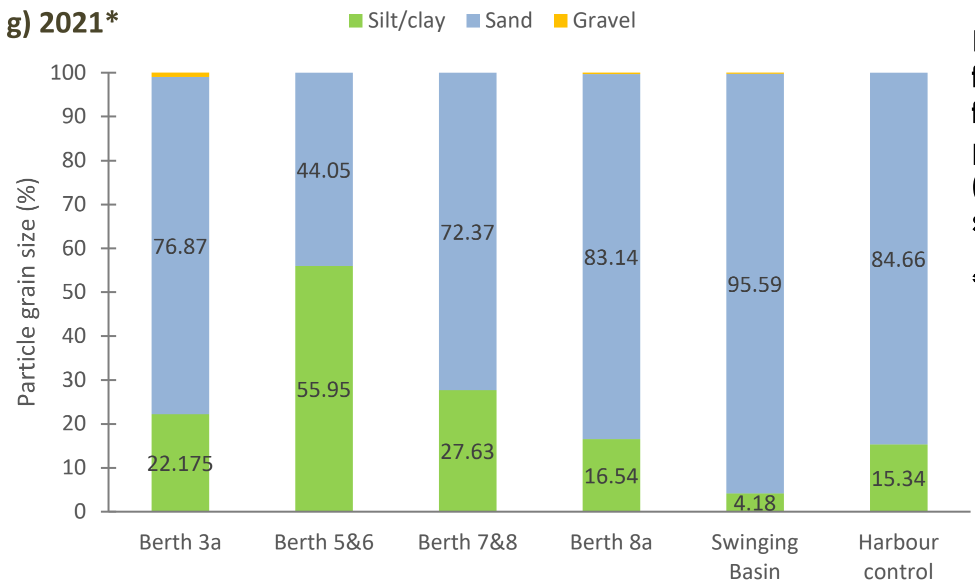


Figure 3: Particle grain-size distribution for sediment samples from South Port berths, Harbour Control Site and Swinging Basin for 2014, 2015, 2017, 2018, 2019, 2020 & 2021. Composition percentages of silt/clay (≤63 µm), sand (≤2 mm) and gravel (≤5 mm) size classes were averaged from two or three sediment samples at each location.

***Note changes in sites.**

3.1.1 Disposal and Disposal Control Pre- and Post-Dredging

Sediment samples were collected at South Port's Spoil Disposal Site and associated Disposal Control Site in February 2020 as part of South Port's Coastal Permit 201285 (Conditions 5 & 6) and resampled in January 2021 to inform South Port's Capital Dredging AEE. This follow-up sampling in 2021 aimed to assess any longer-term changes in sediment particle size composition due to a one-off dredging campaign in April 2020. The dredging campaign removed approximately 40,000 m^3 of spoil primarily from the South Port berth zones (i.e., finer sediment areas) and deposited this spoil at the Disposal Site over 4 weeks. This dredging campaign was undertaken by the trailer hopper suction dredge (THSD), Albatros.

Silt/clay, sand and gravel size class percentages at the Disposal Site and the Disposal Control Site were assessed for statistically significant changes in composition percentage between 2020 and 2021. A paired t-test was used to calculate the p-values at the 95% confidence interval for both sites. Results indicate no significant changes were observed between the 2020 and the 2021 sediment compositions (Table 2). Minor increases in the silt/clay compositions of samples were noted after the deposition of 40,000 m^3 in 2020 across the samples and changes to the sand and gravel composition of the Disposal Control Site from 2020 to 2021 is evident (Figure 4), although not statistically different (>0.05). The Disposal Site had a mean silt to sand proportion of 1:99 in 2020 and 3:97 in 2021. The Disposal Control had a mean silt to sand proportion of 1:99 in 2020 which increased within both silt and gravel compositions to a ratio of 7:83:10 silt:sand:gravel in 2021.

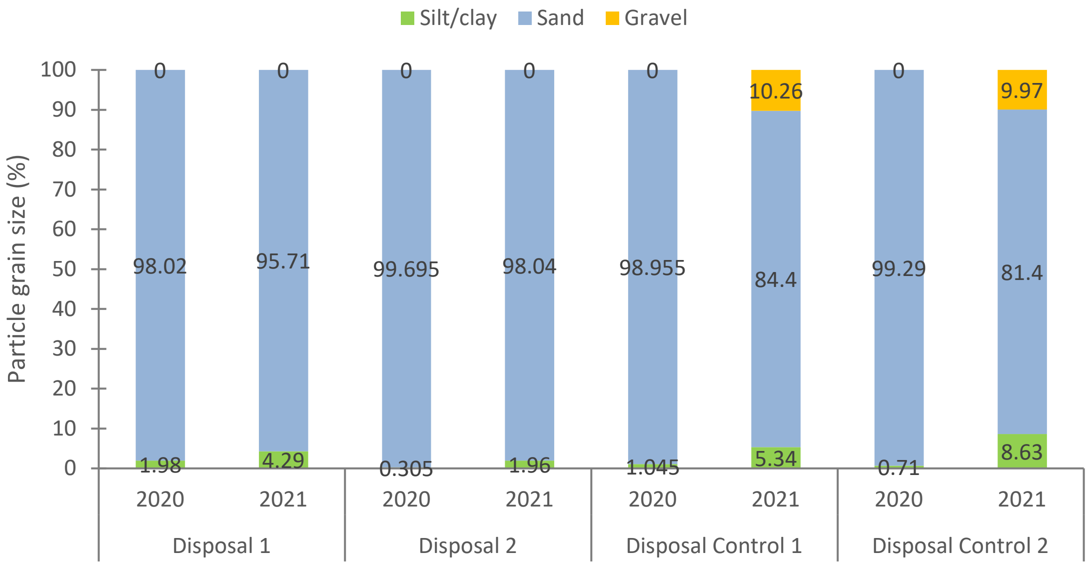


Figure 4: Particle grain-size distribution for sediment samples from the Disposal and Disposal Control Sites in 2020 and 2021.

Table 2: p-values for sediment composition comparison between 2020 and 2021 ($p<0.05$ = significant change).

Site	Silt/Clay ≤63 µm	Sand ≤2mm	Gravel ≤5mm
Disposal	0.1042	0.1042	n/a
Disposal Control	0.1837	0.0652	0.0652

3.2 Sediment Chemistry

The ANZG (2018) guidelines were used to assess and interpret the results of the sediment analysis. These guidelines present default guideline values (DGV) and upper guideline values (GV-High) as two threshold levels under which biological effects are predicted. The lower threshold indicates a possible biological effect, while the upper threshold (GV-High) indicates a probable biological effect. These trigger values are conservative criteria for water or sediment quality that, if complied with, should ensure environmental values are protected. The intent of these threshold values is to act as a trigger value for more intensive assessments if they are exceeded. The previous ANZECC (2000) guidelines were identified as Interim Sediment Quality Guidelines (ISQG) and although the name has changed in the updated ANZG (2018), the guideline values are predominantly the same.

3.2.1 General Sediment Observations

The apparent redox potential discontinuity depth (aRPD) refers to the often, visually distinct colour change (from brown to green/black), between surface and underlying sediments. The aRPD marks the transition from oxidising to reducing sediment conditions and, in conjunction with examination of odour, provides a rapid method of assessing organic enrichment (Gerwing, *et al.*, 2015). Minor changes have been observed in the aRPD depths and odour across each site but these have generally remained consistent. The exception appears to be in 2015 when aRPD depths were either distinctly smaller or larger at the sites than in all other years. This may have been an observed environmental change or a difference in personnel and methods from the other surveys. It was recorded that at Berth 5 in 2015 the samples were taken 22 m from the wharf (Newcombe & Dunmore, 2015), whereas other surveys attempted to take samples within 15 m of the wharf.

Table 3: Characterisation of sediments and measurements of depth to the apparent redox potential discontinuity layer (aRPD) in core samples from South Port wharf sites (Sites 1, 1a and 2) and sediment control site within Bluff Harbour (Site 4).

	Depth to aRPD and sediment characteristics				
	2014*	**2015***	**2017**	**2018**	**2019**
Berth 8	3 cm. Strong odour	0.2 – 0.4 cm. Moderate – strong odour	1 - 2 cm. Strong odour	3 – 4 cm, distinct aRPD layers. Strong odour	3 – 4 cm, distinct aRPD layer. Mild - Moderate odour
Berth 8a	3 cm. Mild – strong odour	0.5 – 1 cm. Moderate odour	3 - 4 cm. Mild odour	2 – 3 cm, distinct aRPD layers. Moderate odour	2.5 – 3 cm, distinct aRPD layer. Mild odour
Berth 5	1 – 3 cm.	3 – 5 cm, patchy aRPD layer. No odour	0.5 – 1 cm, patchy aRPD layer. Moderate odour	0.5 – 1 cm, indistinct aRPD layers. Mild odour	1 – 2 cm, indistinct aRPD layer. Strong odour
Harbour Control	2 – 3 cm, patchy aRPD layer	3 – 5 cm, indistinct aRPD layer.	3 – 4 cm, indistinct aRPD layer. Mild odour.	2 – 3 cm distinct aRPD layers. No odour.	6 cm, distinct aRPD layer. No odour.

* 2014 and 2015 observations from Peacock, *et al.*, 2014 and Newcombe & Dunmore, 2015.

3.2.2 Total Organic Carbon and Phosphorus

Total organic carbon (TOC) levels have primarily decreased since Discharge Agreement monitoring began in 2014 although an increase across the berth sites was observed in 2021 (Figure 5). These values are however significantly below the ecological stressor level of 3.5 g/100 g (Hyland, *et al.*, 2005). Berth 3A, Swinging Basin, Disposal and Disposal Control Sites were only tested for TOC in 2021 as part of the Capital Dredging investigations. Higher TOC levels at Berths 5 & 6 are consistent with the relative particle size and degree of water movement in this area, i.e., finer sediments and more sheltered sites exhibit higher TOC levels. TOC concentrations at the Disposal Control Site were below detection limits (Appendix C).

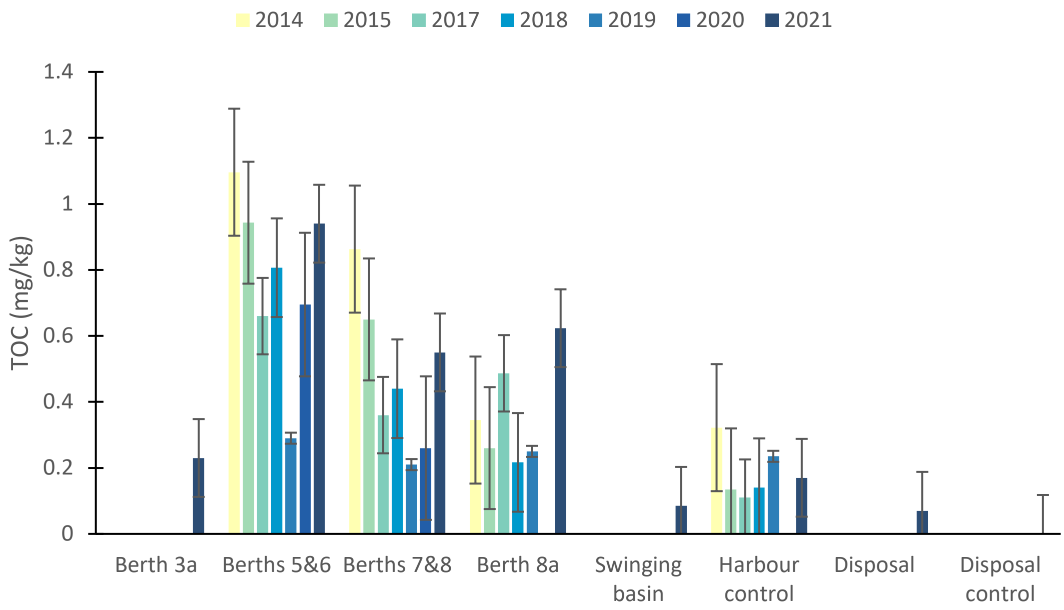


Figure 5: Results of sediment Total Organic Carbon (TOC) analyses from 2014 to 2021 (no surveys completed in 2016). All data are averages of the 2 or 3 samples taken at each site (±1 SE). Berth 3a, Swinging Basin, Disposal and Disposal Control sites were only sampled in 2021.

As there are no guideline values for phosphorus levels in sediment, the 2014 levels are utilised as baseline levels for comparison with subsequent monitoring events. Phosphorus levels have remained consistent across the majority of the berths since monitoring began in 2014 (Figure 6). However, at Berths 7 & 8 an increasing trend was evident between 2014 and 2018, before a significant spike was noted in 2019. Concentrations then decreased significantly in 2020 before rising to a level comparable with concentrations reported in 2017 and 2018. Phosphorus binds readily to sediment and the increase in concentrations at this site could generally indicate some form of accretion occurring from a contaminant source such as fertiliser run-off, animal waste or wastewater discharges. However, as the seabed at this site appears to be eroding rather than accreting (seabed sediment level monitoring shows a depth increase of 12 cm between 2018 and 2019, see Section 3.3), the high phosphorus levels observed in 2019 are more likely to be legacy phosphates from historic land use in this area.

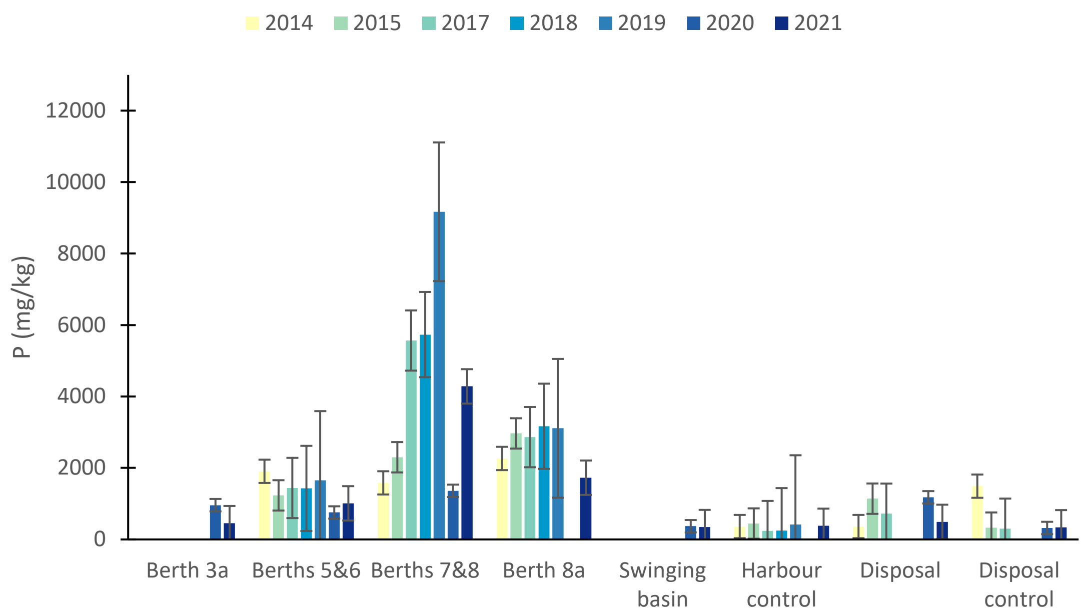
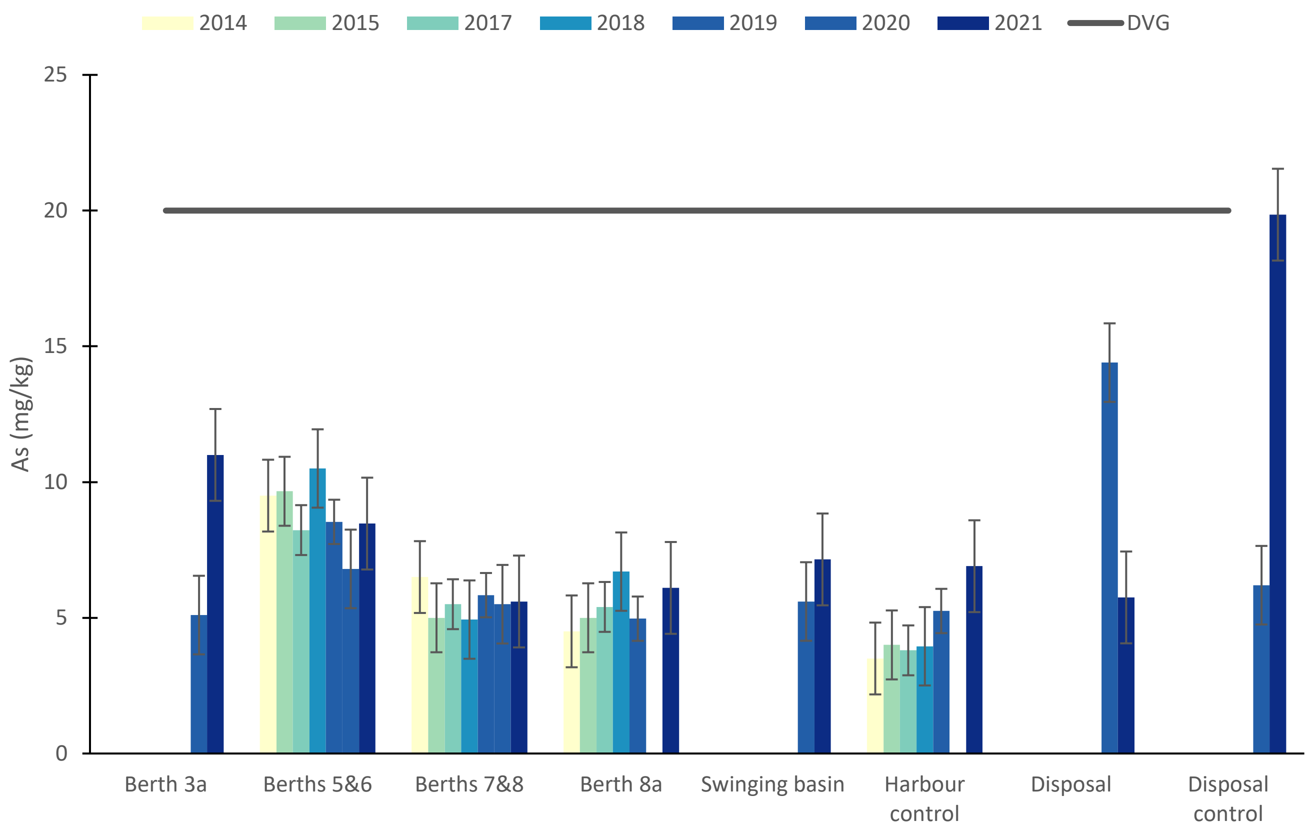


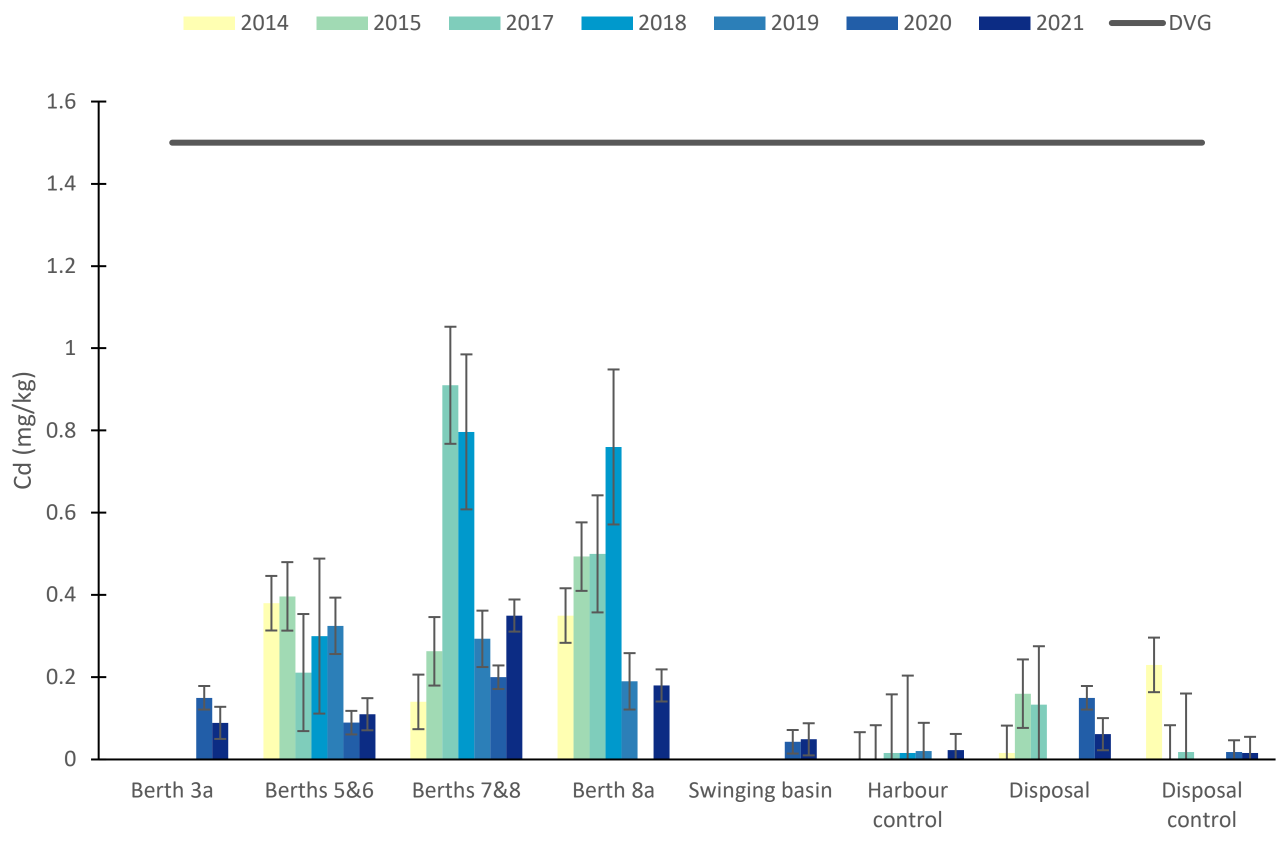
Figure 6: Results of sediment phosphorus (P) analyses from 2014 to 2021 (no surveys completed in 2016). All data are averages of the 2 or 3 samples taken at each site (±1 SE). Berth 3a and Swinging Basin sites were only sampled in 2020 & 2021.

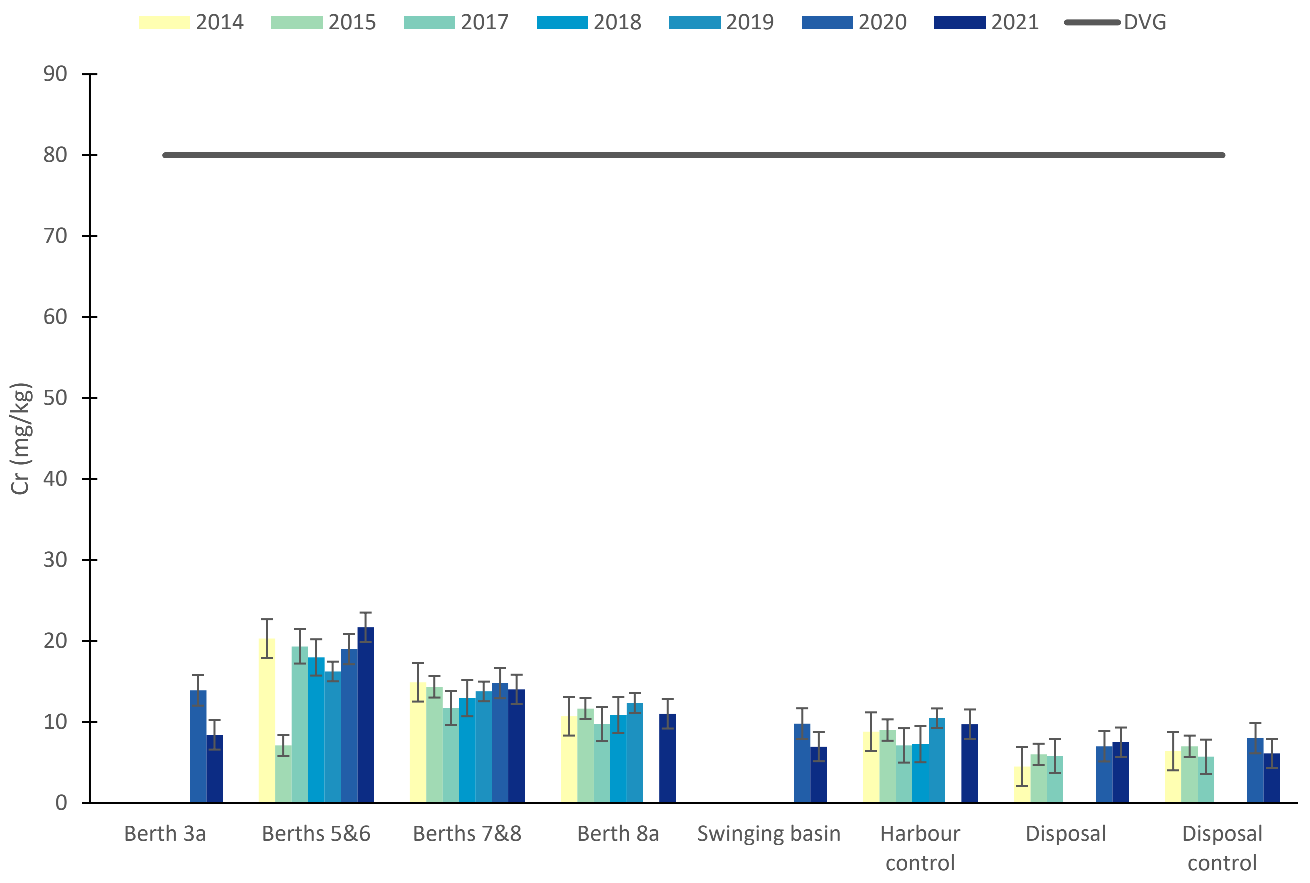
3.2.3 Heavy Metals and Tributylin

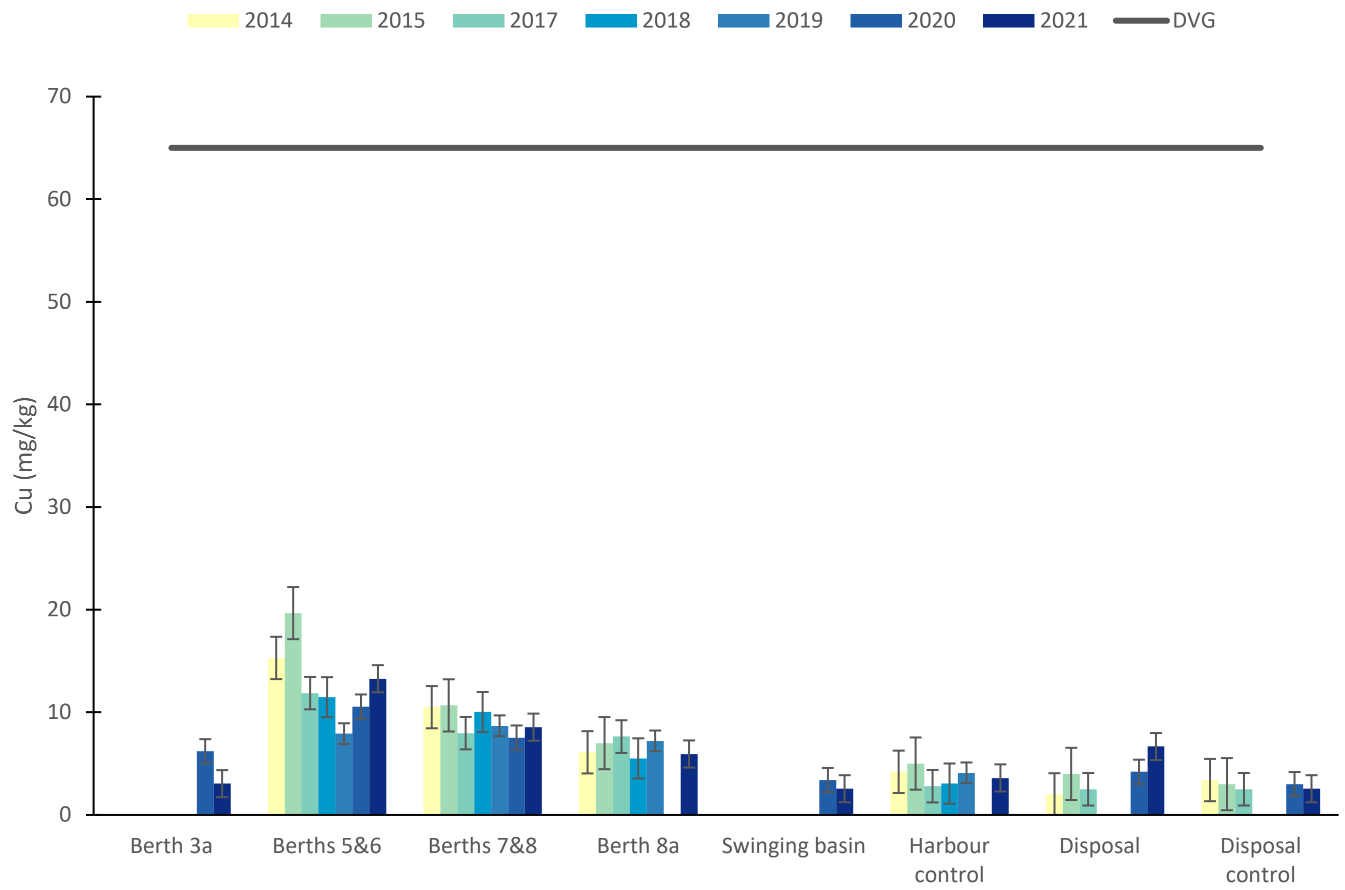
All heavy metal analysis of sediment samples collected between 2014 and 2021 have been found in concentrations less than the ANZG (2018) DGV threshold, with the exception of a single sample for arsenic at the Disposal Control Site in 2021. As no other samples have exceeded this threshold, averages of the two or three samples taken within each site are considered an appropriate representation of the data (Figure 7). Heavy metal concentrations are fairly consistent over the seven years within the berths although some variability in cadmium and nickel concentrations have been noted, however, no overall trend is apparent.

Arsenic was found to be more elevated than previous years in 2021 in harbour sites outside of the berth pockets (i.e., Berth 3A, Swinging Basin and Harbour Control Site). This increase in arsenic also correlated to the Disposal Control Site in 2021. This result is the only exceedance of the DGV threshold with a value of 20.3 mg/kg (Appendix C) and average of 19.85 mg/kg across the two samples. Interestingly, the Disposal Site which had been higher in 2020 was significantly reduced in 2021 after the deposition of 40,000 m^3 of berth sediment spoil. These results, although somewhat limited given the lack of historic data at the non-berth sites, in conjunction with the steady and reasonably low concentrations found within the berth pockets appear to be occurring from sources outside of South Port operations. This could potentially be attributed to nearby industrial activities and outfalls from the NZ Aluminium Smelter (NZAS) on the Tiwai Peninsula.


2014
2015
2017
2018
2019
2020
2021
DVG
As (mg/kg)
25
20
15
10
5
0
Berth 3a
Berths 5&6
Berths 7&8
Berth 8a
Swinging basin
Harbour control
Disposal
Disposal control


2014
2015
2017
2018
2019
2020
2021
DVG
Cd (mg/kg)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Berth 3a
Berths 5&6
Berths 7&8
Berth 8a
Swinging basin
Harbour control
Disposal
Disposal control


2014
2015
2017
2018
2019
2020
2021
DVG
Cr (mg/kg)
90
80
70
60
50
40
30
20
10
0
Berth 3a
Berths 5&6
Berths 7&8
Berth 8a
Swinging basin
Harbour control
Disposal
Disposal control


2014
2015
2017
2018
2019
2020
2021
DVG
Cu (mg/kg)
70
60
50
40
30
20
10
0
Berth 3a
Berths 5&6
Berths 7&8
Berth 8a
Swinging basin
Harbour control
Disposal
Disposal control

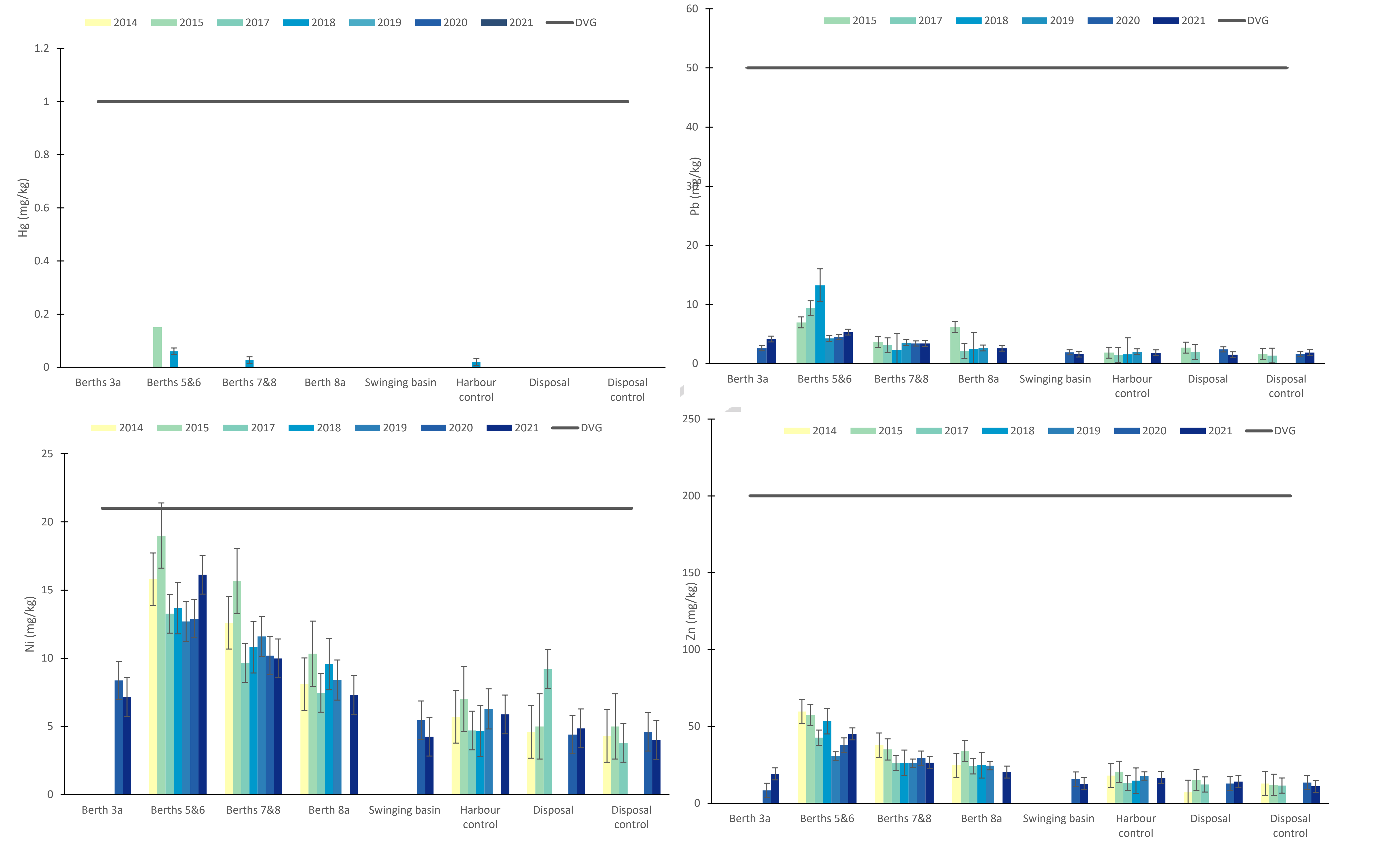


Figure 7: Results of sediment heavy metal analyses from 2014 to 2021 surveys (no surveys were completed in 2016). ANZG (2018) DGV thresholds are presented as lines on each graph. All data are averages of 2 or 3 samples (±1 SE), and values below the analytical detection limit have been excluded from plots and averages. Berth 3a and Swinging basin sites were only sampled in 2020 & 2021.

The purpose of measuring for Tributyltin (Tbt) is to monitor for possible inputs of antifoul paint from vessels using South Port's wharves in Bluff Harbour. All detected Tbt levels were normalised to 1% organic carbon (mg/kg OC) as the concentrations of Tbt (as an organotin compound) in the organic fraction of sediment is more relevant than dry weight concentrations with regards to assessing adverse ecological and biological effects. Table 4 shows that Tbt levels have exceeded the ANZG (2018) DGV threshold levels on six occasions since 2014 and exceed the GV-High threshold on two occasions, predominantly at Berth 8a, which is situated 20 m directly out from Berth 8. Tbt concentrations also exceeded the DGV threshold in 2014 at Berth 5 & 6 and in 2018 at Berths 7 & 8. All exceedances, with the exception of 2019, have not been consistent across replicate and duplicate samples, suggesting these levels are most likely attributable to discrete particles of antifoul paint. In 2019 two samples at Berth 8a exceeded the DGV threshold with 0.038 and 0.129 mg/kg OC (average of 0.567 mg/kg OC), indicating that these elevated levels may have been ambient and could be attributable to discrete particles of antifoul paint coupled with low levels of TOC within these samples which also add to the elevated normalised Tbt levels. All exceedances, with the exceptions of 2014 and 2021, had correspondingly low TOC levels of ≤0.3 g/100g. Berth 3a, Swinging Basin, Disposal and Disposal Control sites were tested for Tbt in 2021 and all results were reported below the laboratory limit of detection of 0.001 mg/kg (Figure 8).

Table 4: Tributyltin (Tbt) Results (mg/kg OC). N.B. Only sites that had Tbt present within a sample are included in the table.

Year	Berths 5&6			Berths 7&8			Berth 8a			ANZG (2018)	
	SS1	SS2a	SS2b	SS1	SS2a	SS2b	SS1	SS2a	SS2b	DGV	GV-High
2014	0.004	**0.020**	0.004	0.004	0.004	0.006	0.004	0.004	0.004	**0.009**	**0.07**
2015	0.004	0.004	0.004	0.004	0.004	0.004	0.004	**0.0167**[1]	0.004		
2017	0.004	0.007	0.008	0.004	0.008[1]	0.004	0.004	**0.011**[1]	**0.058**[1]		
2018	0.004	0.006	0.008	0.004	**0.0125**[1]	0.0079[1]	0.004	0.004	0.004		
2019	0.001	0.001	0.001	0.001	0.001	0.001	**0.038**[1]	0.003[1]	**0.129**[1]		
2021	0.001	0.001	0.001	0.001	0.002	0.002	0.001	**0.082**	0.002		

Notes:
Blue shading refers to laboratory limit of reporting.
[1] Samples had very low levels of TOC (≤0.3 g/100g).
*** Red font indicates exceedance of DGV threshold.**
*** Red square indicates exceedance of GV-High threshold.**

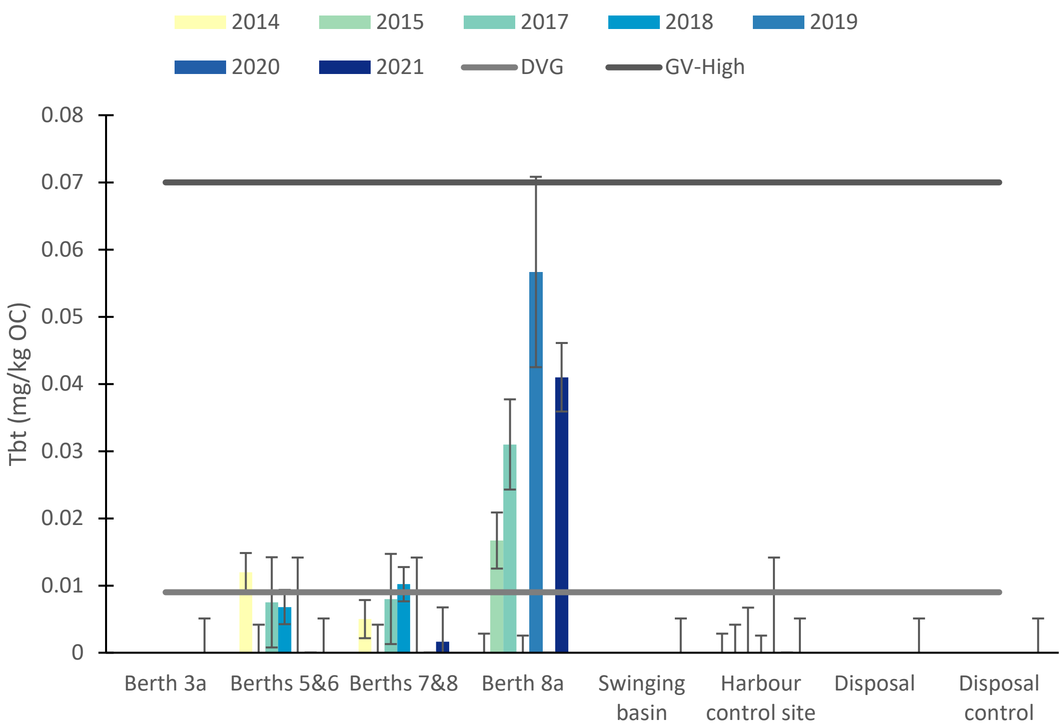


Figure 8: Results of sediment Tributyltin (Tbt) analyses from 2014 to 2021 surveys (no surveys were completed in 2016). The ANZG (2018) threshold levels are also presented on the graph. All data are averages of 2 or 3 samples from each site (±1 SE). Values below the analytical detection limit have been excluded from plots and averages. Berth 3a, Swinging Basin, Disposal and Disposal Control sites were only tested for Tbt in 2021.

3.2.4 Polycyclic Aromatic Hydrocarbons

Table 5 presents the summarised polycyclic aromatic hydrocarbon (PAH) results from 2014 to 2021 within the berths, Control Sites and Disposal Site. All PAH levels have remained below ANZG (2018) DGV guidelines since monitoring began in 2014 and raw data pertaining to the most recent sampling is in Appendix C. Data regarding the individual hydrocarbons can be found in previous monitoring reports[i]. Berths 5 & 6 exhibit slightly elevated PAH levels consistently which is likely attributable to the lack of tidal flushing and finer sediment particles observed at this site. Overall, there is no evidence to suggest the current PAH contaminant levels are likely to cause an effect to the ecology in the vicinity of the berths, nor are they accumulating in the sediment at the Control or Disposal Sites.

[i] Dunmore & Barter (2008); Peacock, *et al.*, (2014); Newcombe & Dunmore (2015); MWH (2016), e3Scientific Ltd (2017, 2018, & 2019); & Miller (2020).

Table 5: Polycyclic Aromatic Hydrocarbons (PAHs) sediment analysis results (mg/kg). Blue shading denotes laboratory limit of reporting.

		Berth 5&6			Berth 8a			Berth 7&8			Harbour Control		Disposal		Disposal	ANZG (2018)	
		SS1	SS2a	SS2b	SS1	SS2a	SS2b	SS1	SS2a	SS2b	SS1	SS2	SS1	SS2	Control	DGV	GV-High
Total low MW PAHs	2014	0.017	0.024	0.014	0.259	0.011	0.01	0.055	0.039	0.03	0.01	0.01	0.001	0.001	0.001	0.552	3.16
Total low MW PAHs	2015	0.013	0.013	0.023	0.01	0.01	0.131	0.022	0.02	0.018	0.023	0.01	0.029	0.001	0.001		
Total low MW PAHs	2017	0.212	0.015	0.011	0.013	0.015	0.011	0.028	0.064	0.075	0.012	0.01	0.001	0.001	0.001		
Total low MW PAHs	2018	0.02	0.026	0.022	0.02	0.02	0.129	0.039	0.131	0.034	0.02	0.02	0.001	0.001	0.001		
Total low MW PAHs	2019	0.006	0.031	0.006	0.006	0.02	0.008	0.006	0.009	0.012	0.006	0.006	0.001	0.001	0.001		
Total low MW PAHs	2020	0.005	0.003	0.002	-	-	-	0.008	-	-	-	-	0.001	0.001	0.001		
Total low MW PAHs	2021	0.005	0.003	0.007	0.002	0.002	0.05	0.001	0.002	0.003	0.003	0.001	0.037	0.001	0.001		
Total high MW PAHs	2014	0.053	0.072	0.016	0.859	0.006	0.006	0.319	0.313	0.221	0.016	0.016	0.001	0.001	0.001	1.7	9.6
Total high MW PAHs	2015	0.028	0.013	0.082	0.069	0.051	0.476	0.109	0.115	0.045	0.067	0.0006	0.07	0.001	0.001		
Total high MW PAHs	2017	0.444	0.042	0.019	0.021	0.026	0.032	0.276	0.519	0.947	0.041	0.01	0.001	0.001	0.001		
Total high MW PAHs	2018	0.023	0.138	0.046	0.029	0.061	0.493	0.594	0.767	0.364	0.02	0.02	0.001	0.001	0.001		
Total high MW PAHs	2019	0.017	0.111	0.021	0.019	0.088	0.016	0.04	0.099	0.143	0.02	0.018	0.001	0.001	0.001		
Total high MW PAHs	2020	0.139	0.105	0.053	-	-	-	0.087	-	-	-	-	0.001	0.001	0.001		
Total high MW PAHs	2021	0.112	0.077	0.132	0.032	0.073	0.119	0.075	0.076	0.047	0.167	0.009	0.556	0.001	0.001		
TOTAL PAHs	2014	0.07	0.096	0.03	1.118	0.017	0.016	0.374	0.352	0.251	0.016	0.016	0.001	0.001	0.001	4	45
TOTAL PAHs	2015	0.041	0.026	0.106	0.079	0.061	0.607	0.13	0.135	0.063	0.091	0.016	0.099	0.001	0.001		
TOTAL PAHs	2017	0.66	0.058	0.03	0.035	0.042	0.043	0.305	0.584	1.022	0.053	0.02	0.001	0.001	0.001		
TOTAL PAHs	2018	0.043	0.164	0.068	0.049	0.081	0.622	0.633	0.898	0.398	0.04	0.04	0.001	0.001	0.001		
TOTAL PAHs	2019	0.046	0.284	0.054	0.05	0.216	0.043	0.052	0.216	0.31	0.052	0.048	0.001	0.001	0.001		
TOTAL PAHs	2020	0.144	0.108	0.055	-	-	-	0.095	-	-	-	-	0.001	0.001	0.001		
TOTAL PAHs	2021	0.117	0.08	0.139	0.034	0.075	0.169	0.076	0.078	0.05	0.17	0.009	0.593	0.001	0.001		

3.3 Seabed Sediment Levels

The seabed level at Berth 8 is recorded at the same site every year as part of the Discharge Agreement. This was recorded at 11.24 m in 2019 and 2020, which is the first year with no change in depth recorded. A depth of 11.12 m was recorded in 2018, 11.07 m in 2017, 11.03 m in 2015 and 11.08 m in 2014 (Table 6). The 2019 and 2020 depth represents a 0.21 m increase in depth since 2015. The measurement of seabed level is taken at the base of the exposed wharf piles. The high tidal flow and the increase in seabed level depth at Berth 8, indicates that there is limited opportunity for sediment accretion at this site.

Table 6: Results of seabed level monitoring at Site 1, dropline B.

	Seabed level (m)	Difference between years (m)
2014	11.08	n/a
2015	11.03	- 0.05
2017	11.07	+ 0.04
2018	11.12	+ 0.05
2019	11.24	+ 0.12
2020	11.24	0.00
	TOTAL Difference	**+ 0.21**

3.4 Infaunal Results

The results from infaunal sampling in 2021 are presented in Table 7 and are summarised as follows:

- Multivariate community analyses showed Berth 8a exhibited the highest abundance and taxa richness of all the sites with a mean of 104 individuals (*S.E.* = *26.5*), 12 taxa and a high infaunal density of 13,248 individuals/m^2 (within the top 15 cm of sediment). Polychaetes were the most numerous at this site with high numbers of individuals in the Spionidae, Oweniidae and Capitellidae families. *Ampelisca* spp. amphipods and the razor mussel *Solemya parkinsonii* were also found in moderate numbers.
- The Swinging Basin Site was found to have the lowest infaunal density of all the sites with 732 individuals/m^2 and the lowest taxa richness with an average of 3 taxa along with Berth 5. Diversity indices also showed low diversity at both Swinging Basin and Berth 5.

- The Disposal Control had similar overall diversity to Berth 8a, however it had greater numbers of gastropods and bivalves and less polychaetes than Berth 8a.
- Infaunal density at the Disposal Control is 3,758 individuals/m^2 which is comparable with the infauna density found at the Harbour Control Site (3,854 individuals/m^2). Both control sites have a range of polychaetes in moderate numbers however the Disposal Control Site had gastropods and a greater diversity of bivalves. This is likely due to the more sheltered nature of this site having less tidal flow and it is also less exposed to wave action than the nearby Disposal Site. The only bivalve found at the Harbour Control was the southern tuatua, *Paphies donacina*, which is likely due to its burrowing ability to withstand the strong currents at this site.
- The Disposal Site had an infaunal density of 860 individuals/m^2, dominated by polychaetes which is comparable with the Swinging Basin Site (732 individuals/m^2). Polychaetes were the only taxa found at the Swinging Basin which is similar to the Disposal Site community. Both of these sites are highly disturbed, the Swinging Basin through high velocity tidal movements and the Disposal Site through high wave action exposure and the deposition of spoil.
- Berth 3A is a non-dredged, relatively unmodified site in the outer harbour and shows similar characteristics to the Harbour Control Site whereby total diversity and density is low and the community is dominated by Capitellidae polychaetes.

Table 7: 2021 Infauna Results from Bluff Harbour and Disposal Sites.

Phylum	Class	Order	Family	Genus/Species	Disposal Control				Disposal				Swinging Basin				Harbour Control Site				Berth 5				Berth 3A				Berth 8a			
					CS 1	CS 2	CS 3	CS 4	DS 1	DS 2	DS 3	DS 4	SB 1	SB 2	SB 3	SB 4	HBC 1	HBC 2	HBC 3	HBC 4	B5 1	B5 2	B5 3	B5 4	B3A 1	B3A 2	B3A 3	B3A 4	B8a 1	B8a 2	B8a 3	B8a 4
Annelida	Polychaeta	Phyllodocida	Glyceridae			1	1	4		2	2											1						2	1			
		Phyllodocida	Nephtyidae		1			1		2			1				2	2		1	1				1		2			1		1
		Phyllodocida	Nereididae									1								1												
		Phyllodocida	Syllidae																										1			
		Phyllodocida	Polynoidae																										1			
		Phyllodocida	Hesionidae			1																								2		1
		Phyllodocida	Goniadidae																													1
		Scolecida	Aricidea		3				1	4	2		1	2	1		4	4		2					1	2		1	5	7	3	7
		Scolecida	Opheliidae											1										1			2		6		6	1
		Scolecida	Capitellidae			9	4	16		5		1	1	6	3	3	14	14	17		5		1	11	9	2	4	17	35	24	6	5
		Scolecida	Scalibregmatidae									2		1																2		
		Scolecida	Maldanidae													1	1		1				4			5	2		9	11	6	4
		Scolecida	Orbiniidae																								1					
		Spionida	Spionidae			1	1				2			1				1			1				3	3	2		81	15	9	11
		Spionida	Magelonidea					2																	1							
		Terebellida	Cirratulidae				4	1									3	7	8	1							1		1		2	
		Terebellida	Terebellidae				2																									
		Eunicida	Lumbrineridae		1							1				1			1	1		1			1	1			2			
		Sabellida	Oweniidae								1						7	2	18	3		1				1	1	2	39	22	38	20
Porifera																				1												
Nematoda								2												2									1			
Nemertea																															1	
Mollusca	Gastropoda	Calyptraeoidea	Calyptraeidae	*Sigapatella tenuis*				1																								
		Vetigastropoda	Trochidae	*Zethalia zelandica*	1	12	22	7																			1					
	Bivalvia	Arcida	Glycymerididae	*Glycymeris modesta*	1	3	1																									
		Venerida	Veneridae	*Tawera spissa*		3	3																									
		Heterodonta	Veneridae	*Paphies donacina*														1		1												
		Solemyida	Solemyidae	*Solemya parkinsonii*																										9		1
		Cardiida	Semelidae	*Leptomya retiaria retiaria*																											1	
Arthropoda	Malacostraca	Decapoda	Paguridae			1		1																								
		Decapoda	Macrophthalmidae	*Hemiplax hirtipes*																			1									
		Decapoda	Portunidae	*Nectocarcinus antarcticus*																											1	
		Decapoda	Crangonidae			1																										
		Eumalacostraca	Ogyrididae		2																									1		
		Cumacea	Leuconidae					1																					1			
		Amphipoda	Haustoriidae															1														
		Amphipoda	Phoxocephalidae																										1			2
		Amphipoda	Ampeliscidae	*Ampelisca sp*	3						1														1				8		1	
Abundance					12	32	38	36	1	13	8	5	3	11	4	5	31	32	45	13	7	3	6	12	17	14	16	22	192	94	74	54
Taxa richness					7	9	8	10	1	4	5	4	3	5	2	3	6	8	5	9	3	3	3	2	7	6	9	4	16	10	11	11
Shannon-Weiner Diversity Index					1.80	1.7	2.0	1.8	n/a	1.3	1.6	1.3	1.1	1.3	0.6	1.0	1.5	1.6	1.2	2.1	0.8	1.1	0.9	0.3	1.5	1.6	2.1	0.8	1.9	1.9	1.6	1.9
Evenness					0.9	0.8	0.9	0.0	n/a	0.9	1.0	1.0	1.0	0.8	0.8	0.9	0.8	0.8	0.8	1.0	0.7	1.0	0.8	0.4	0.8	0.9	1.0	0.6	0.7	0.8	0.7	0.8

3.4.1 Disposal and Disposal Control Pre- and Post-Dredging

Comparisons of the Disposal (DS) and Disposal Control Sites (CS) in 2020 and 2021 are presented in Figure 9. Raw infaunal data from 2020 is provided in Appendix D. The findings are summarised as follows:

- Mean species abundance was highest at CS in the 2021 survey and lowest at DS in 2021. The 2021 CS was also found to have the greatest taxa richness, and diversity out of the two sites over the two surveys. In 2021 the CS samples had a mean infaunal density of 3,758 individuals/m^2 compared to the CS in 2020 with a mean density of 1,911 individuals /m^2. A paired t-test showed the difference in CS 2020 and 2021 abundance was not significant at 95% confidence interval (CI) (*p=0.12*).
- DS mean infaunal density ranged from 1051 individuals/m^2 in 2020 to 860 individuals/m^2 in 2021. A paired t-test showed the difference in DS 2020 and DS 2021 abundance was not significant at 95% CI (*p=0.62*).
- Predominant differences between DS in 2020 and 2021 were the absence of the wheel shell *Zethalia zelandica* in all 2021 samples, compared to 17 found within the four 2020 samples; and a reduction in Spionidae polychaetes in 2021.
- Taxa richness and diversity was found to be higher at the CS over both years compared to the DS. Although CS is not considered an overly sheltered site it has greater protection from the significant easterly swell than the DS, and therefore can allow for more diverse benthic assemblages. Impacts of spoil deposition over numerous years will also add to the lower richness and diversity of the DS.

The infaunal assemblages recorded during these two surveys were contrasted using classical multidimensional scaling (MDS) and Agglomerative Hierarchical Clustering using R statistical software. Dissimilarity values for the hierarchical clustering were calculated and then clustered using the ward.D2 agglomeration method.

The results of the multivariate analyses presented in Figure 10 shows the relative similarities or dissimilarities of the samples with regard to the infaunal assemblage composition. The dendrogram is clustered into four groups, predominantly resolved by the presence/absence of *Z. zelandica* and diversity of polychaeta within each sample. The 2021 Disposal Control Site 4 (CS4 2021) is the significant outlier of these groups based on its' higher abundance of Capitelllidae and polychaeta diversity. The MDS plot also illustrates CS4 2021 as a significant outlier and identifies CS2 2021 and CS3 2021 as having dissimilarities to the other samples. These dissimilarities include the presence of the *Tawera spissa* bivalve and the moderate abundance of Capitelllidae polychaetes. The 2021 Disposal Site 2 sample (DS2 2021) has a similar abundance of Capitelllidae polychaetes to these two samples (CS2 2021 and CS3 2021) but has less overall polychaeta diversity.

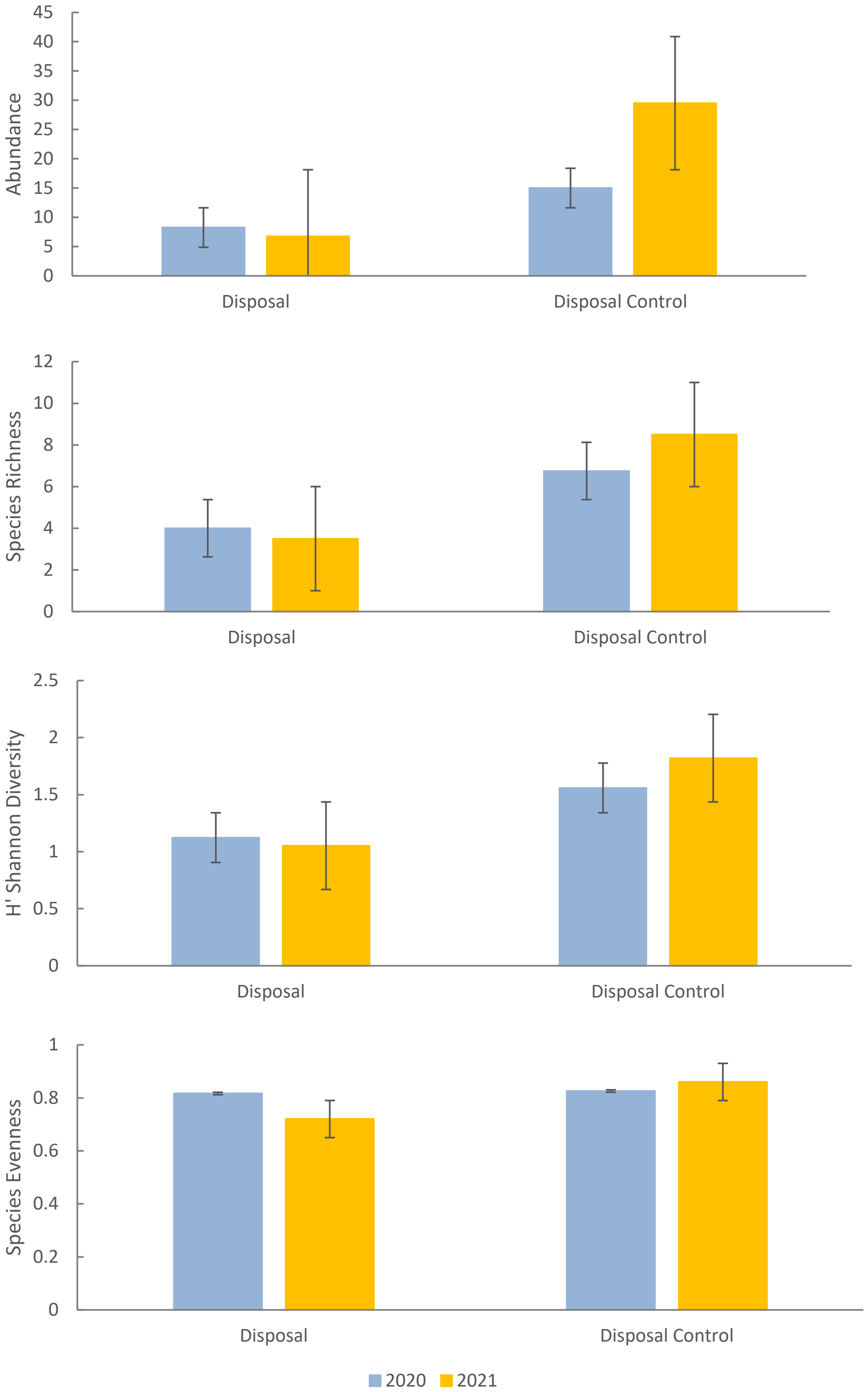


Figure 9: Mean infauna indices at Disposal and Disposal Control sites for 2020 and 2021 surveys.

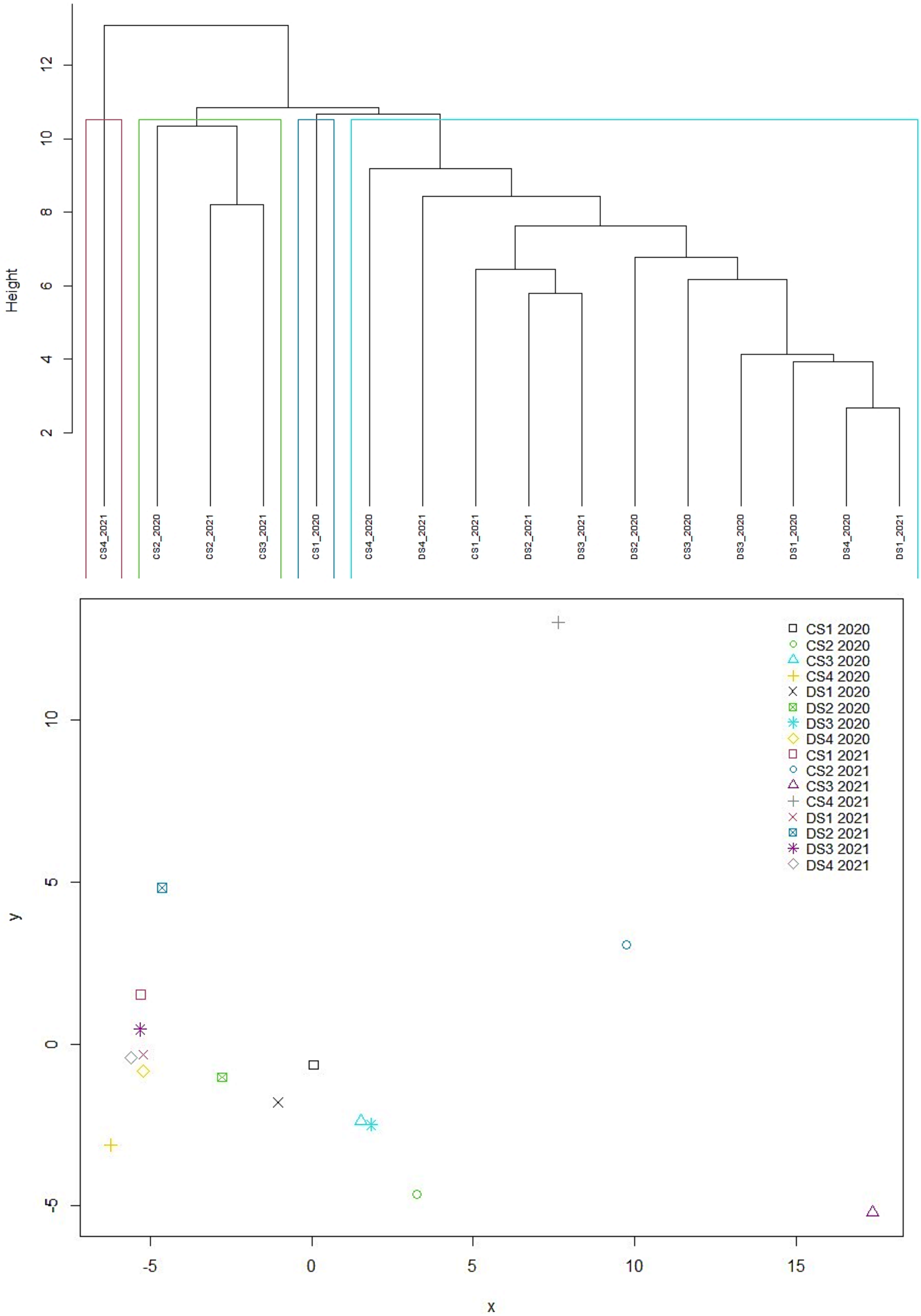


Figure 10: Four cluster grouped dendrogram (top) and non-metric MDS plot showing similarity of infaunal assemblages at the Disposal (DS1 – DS4) and Control (CS1 – CS4) Sites for 2020 and 2021.

4 Conclusions

Sediment analysis at South Port berths, the Disposal Site and Control Sites over 7 years of annual surveys provides a substantial assessment of the sediment characteristics occurring in the Port surrounds in Bluff Harbour and within the nearby Tiwai Peninsula marine environment.

Particle size analysis of the berth and harbour sites shows that the Berth 5 & 6 basin has the highest proportions of silt at roughly 50:50 silt to sand ratio. Due to the finer sediments accumulating at this site, the sediment contaminant concentrations, although still below ANZG (2018) guidelines, are predominantly more elevated than at any other berths. This site is also noted to have the shallowest aRPD layer consistently over the years, indicating reducing oxygen conditions within the upper sediment layer.

The Swinging Basin exhibits low proportions of silt and sediment contaminant concentrations comparable with the Harbour Control Site. Berth 7 & 8 and Berth 8a exhibit approximately 20% and 15% silt proportions, respectively, and also have relatively low contaminant and TOC concentrations. The exception to this is the tributyltin ANZG (2018) threshold exceedances that have occurred predominantly at Berth 8 and 8a (20 m from Berth 8). Tributyltin (Tbt) has historically been an active constituent in anti-fouling paint for vessels which can bond to suspended material and is deposited in benthic sediments within the berths of working Ports. It is a highly toxic biocide which affects both target and non-target organisms within the aquatic environment via slow release into the water column and adsorption onto sediment particles. Tbt also bioaccumulates in organisms because of its solubility in fat (International Programme on Chemical Safety, 2017). The use of Tbt in hull paints has largely been discontinued due to the United Nations Environmental Programme (UNEP) placing severe regulations restricting the manufacture, sale, use and importation of Tbt in 2014 (United Nations Environmental Programme, 2014). However, Tbt can last unaltered in sediment for decades, particularly in anoxic conditions and has been linked to deformities in benthic organisms, particularly molluscs (King, Miller, & de Mora, 1989). The recorded Tbt exceedances at Berth 8a, and single exceedance at the adjacent Berth 7 & 8, are most likely attributable to discrete paint particles in the sediment rather than ambient levels due to their inconsistent concentrations across replicate and duplicate samples. Also, as the concentrations are normalised to 1% TOC the low TOC at this site further exacerbates concentrations. Large international vessels regularly utilise Berth 8 at South Port and some may still have

Tbt present in their hull paint, or levels could be legacy Tbt concentrations due to its' long half-life. Polycyclic aromatic hydrocarbons (PAH) were found to be below ANZG (2018) guidelines for all samples.

The Disposal and Control Site sites exhibited slight increases in silt proportions between 2020 and 2021 surveys although this change was not statistically significant. An increase in silt proportions was expected at the Disposal and potentially the Disposal Control Site in the 2021 survey due to the deposition of 40,000 m^3 of berth spoil at this location in April and May 2020 (i.e. between the 2020 and 2021 surveys). However, the low magnitude of change in particle size observed indicates that siltation is not readily occurring at these sites. Sediment contaminant levels were found to be consistently low or below laboratory reporting limits at these two sites, with the exception of arsenic which was found in higher concentrations than in the harbour and exceeded ANZG (2018) DGV threshold within one sample. These results, although somewhat limited given the lack of historic data at the Disposal and Disposal Control sites, in conjunction with the steady and reasonably low arsenic concentrations found within the berth pockets, appear to be occurring from sources outside of South Port operations. This could potentially be attributed to nearby industrial activities and outfalls from the NZ Aluminium Smelter (NZAS) on the Tiwai Peninsula.

Infaunal communities ranged in density from means of 13,248 individuals/m^2 at Berth 8a to 732 individuals/m^2 at Swinging Basin and diversity ranged from means of 12 taxa at Berth 8a to 3 taxa at Swinging Basin and Berth 5. Based on this it would appear that one of the primary limiting environmental factors on the infaunal communities is water velocity, via tidal flow or wave action; followed by sediment composition and characteristics. This is evidenced by the second lowest densities at Berth 5 where silt composition was significantly higher than other sites and anoxic conditions were found within the upper sediment layer. Sediment contaminant concentrations appear to be low enough across all sites to have minimal impact on the infaunal communities although this may potentially be affecting infaunal communities at Berth 5 alongside the higher silt proportion. Gastropods, shallow-burrowing bivalves (such as clams *Glycymeris modesta* and *T. spissa*), decapods and cumacea were predominantly found at the most sheltered site where some flow is still evident, the Disposal Control.

Overall, berth sites appear to be representative of mildly enriched sediment characteristics with evidence of some land-based silt accumulation at the more sheltered berths and polychaete-dominated infauna. The spoil disposal area does not appear to be accumulating the berth-based silts nor contaminants from spoil deposition although the infauna does exhibit assemblage changes that are likely attributable to this. The control sites within the inner harbour and near the spoil disposal area show consistently low sediment contaminant results independent of changes within the berths, which could indicate that South Port's dredging and operations are localised to the berth and spoil disposal areas. No regionally or nationally significant infaunal species, communities or habitats were identified within any of the sites surveyed.

4.1 Site Summary

The following provides sediment characteristics and infaunal communities summarised by site:

Berths 5 & 6

- The Berth 5 & 6 basin has the highest proportion of silt within the berths with an approximately 50:50 silt to sand ratio. Contaminants are also generally the highest at this site but are still below the ANZG (2018) guidelines for 95% species protection.
- Infaunal communities have low density, diversity and are dominated by Capitellidae polychaetes which are common in muddy and slightly enriched harbour environments.

Berth 7, 8 & 8a

- Berths 7 & 8 have moderate silt proportions (23:77 silt to sand) and 8a has silt proportions which are comparable with the Harbour Control Site in the inner harbour. Sediment contaminant concentrations are generally lower than those found in Berths 5 & 6 with the exceptions of phosphorus (which is not considered a contaminant by itself), cadmium and tributyltin. All contaminants, except for tributyltin, are below the ANZG (2018) guidelines for 95% species protection.
- Infaunal communities at Berth 8a had the highest diversity and density of all sites sampled and included polychaetes, bivalves and amphipods. The most abundant polychaetes were Spionidae and Oweniidae which can be both suspension and deposit feeders and are often found in *Zostera* beds (Morton & Miller, 1973). The infaunal community is representative of a common sandy intertidal habitat.

Berth 3A

- Berth 3A has had limited sampling but results find that this area has a silt ratio similar to Berths 7 & 8 (21:78 silt to sand) and sediment contaminant concentrations are consistently low and below the ANZG (2018) guidelines.
- Infaunal communities at Berth 3A within the drift dive exhibited diversity within the polychaeta taxa and were dominated by Capitellidae polychaetes. The section of this site where infaunal sampling was completed experiences significant tidal velocity similar to the Swinging Basin.

Swinging Basin

- Swinging Basin area also has had limited sampling however results showed that this site has low silt proportions (5:95 silt to sand) and low sediment contaminant concentrations comparable with the Harbour Control Site in the inner harbour.
- Infaunal communities exhibited the lowest diversity and densities of all sites with predominantly only Capitellidae polychaetes found in numbers greater than one per sample.

Spoil Disposal

- The Disposal Site exhibited very low silt to sand proportions, 1:99 in 2020 which increased marginally to 3:97 in 2021. Sediment contaminant concentrations are consistently below levels found in the berth sites with the exception of arsenic which was observed in 2020 to be higher than the berth sites, although still below ANZG (2018) 95% species protection guidelines.
- Infaunal communities showed low diversity and density in both 2020 and 2021. A minor reduction in both taxa diversity and density was observed in 2021 post-dredging deposition, however this was not found to be a statistically different change. The predominant change in taxa assemblage between the two years found that the wheel shell, *Z. zelandica* was absent in 2021. This is most likely attributable to the deposition of spoil at this site as they are unable to burrow into sediment. Infaunal communities are comparable with the Swinging Basin which is also subject to high velocity water movement, as is this site via significant wave action as well as tidal movement.

<u>Disposal Control</u>

- The Disposal Control exhibited the same silt to sand proportions as the Disposal Site in 2020 (1:99) but showed a change in particle size distribution to 7:83:10 (silt:sand:gravel) in 2021. Sediment contaminant concentrations are similar to the Disposal Site and are consistently below levels found in the berth sites, again with the exception of arsenic. The 2021 concentrations of arsenic have been the single heavy metal exceedance of ANZG (2018) DGV thresholds, outside of tributyltin, over the 7 surveys completed since 2014. As this is significantly higher than arsenic concentrations found within the berths it appears to be occurring from sources outside of South Port operations. This could potentially be attributed to nearby industrial activities and outfalls from the NZ Aluminium Smelter (NZAS) on the Tiwai Peninsula.
- Infaunal communities showed moderate taxa diversity and densities in 2020 which increased in 2021, with a range of polychaetes, bivalves, decapods, amphipods and the gastropod, *Z. zelandica*, present in high to moderate abundance. Predominant changes in community assemblages were an increase in polychaeta diversity and the presence of the small dog cockle, *Glycymeris modesta* in 2021. Diversity and community assemblage was most comparable with Berth 8a although more gastropods were present at the control site. This may be due to the reduced tidal velocity and the greater shelter from the significant easterly swells that this site experiences in comparison with the nearby Disposal Site.

If you have any questions regarding the information provided in this summary, please contact Bryony on 021 883 381 or via email at bryony.miller@e3scientific.co.nz

Yours sincerely,

Bryony Miller
Technical Director – Marine and Freshwater Ecology

Reviewed by,

Glenn Davis
Managing Director

Appendices

Appendix A: South Port Discharge Agreement & Bluff Harbour Dredging Spoil Disposal Coastal Permit 201285

Appendix B: Sediment Core Photographs

Appendix C: 2021 Laboratory Methods and Results

Appendix D: 2020 and 2021 Infaunal Results

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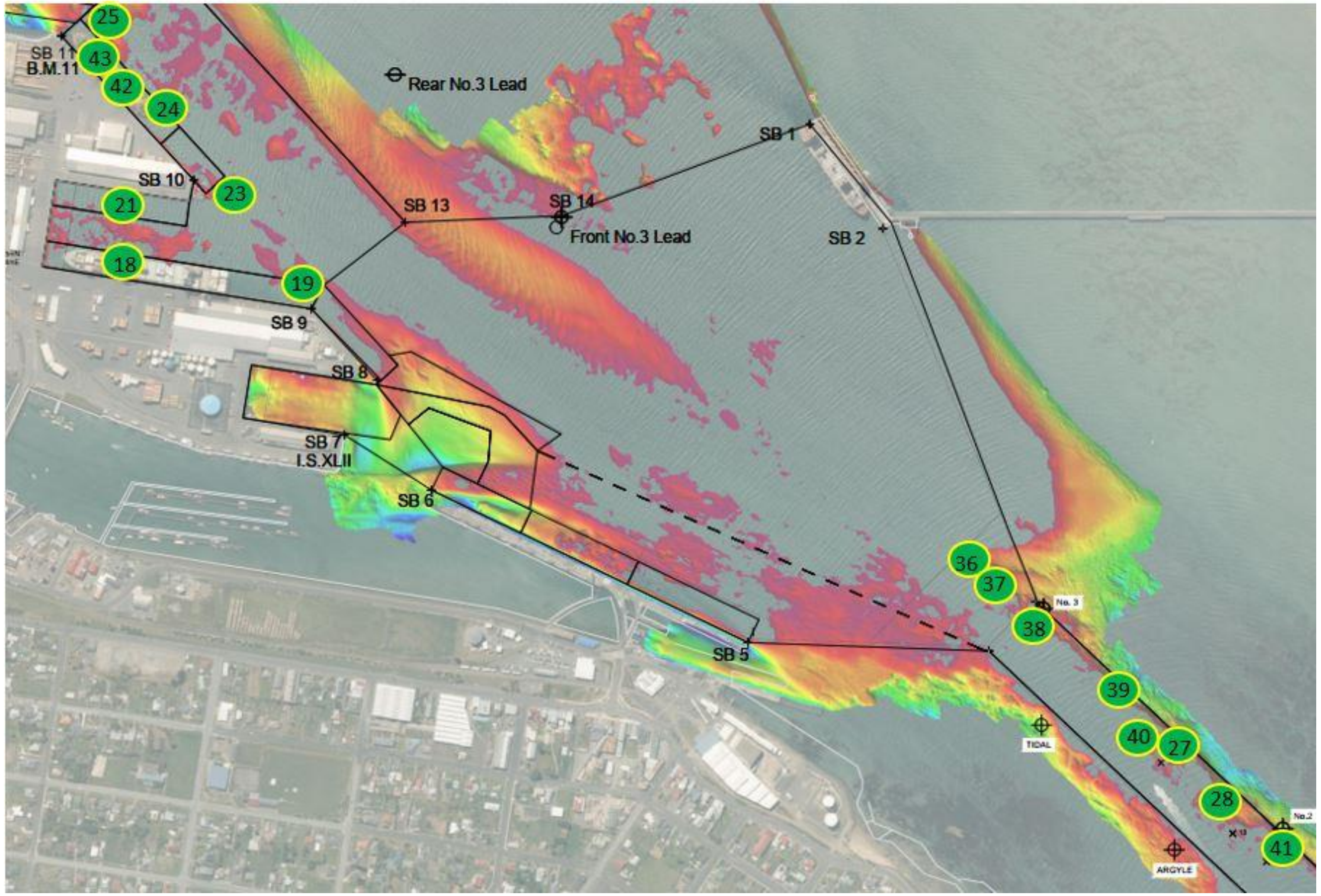
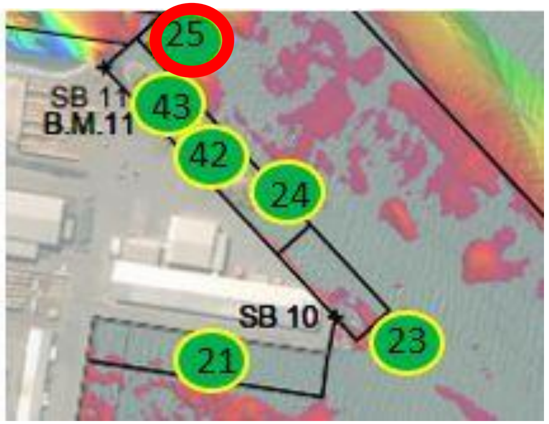
Appendix B:

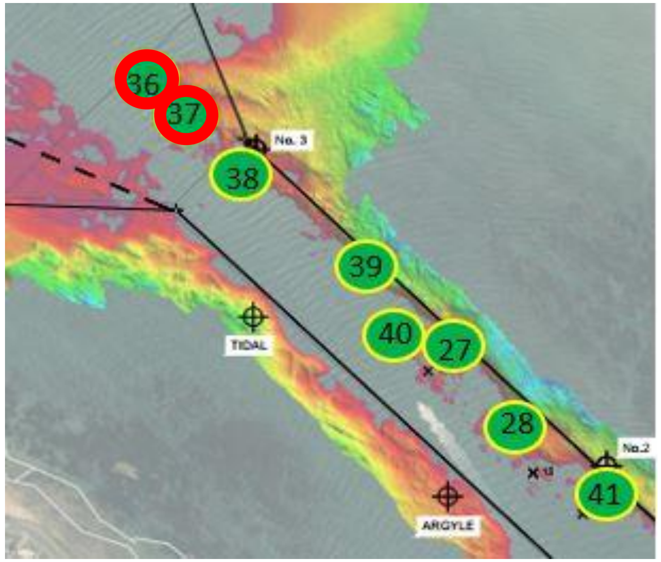
South Port Capital Dredge dive images from the main channel – 2021.

Dive Locations

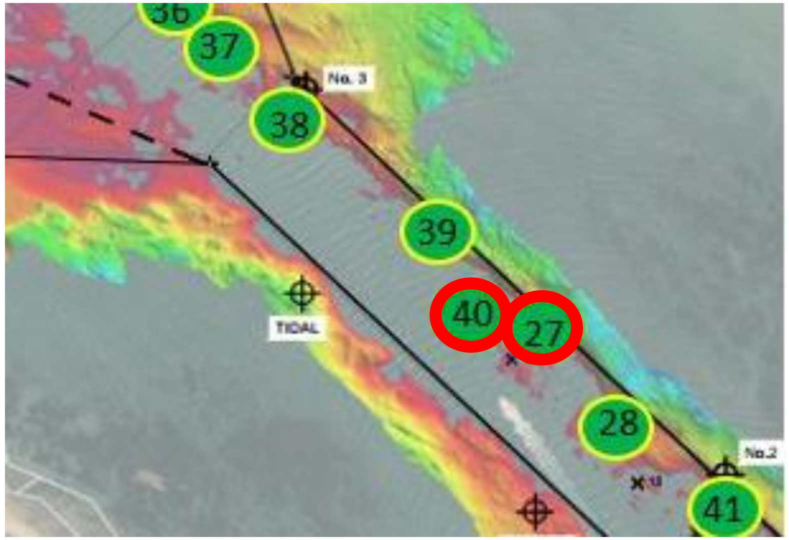




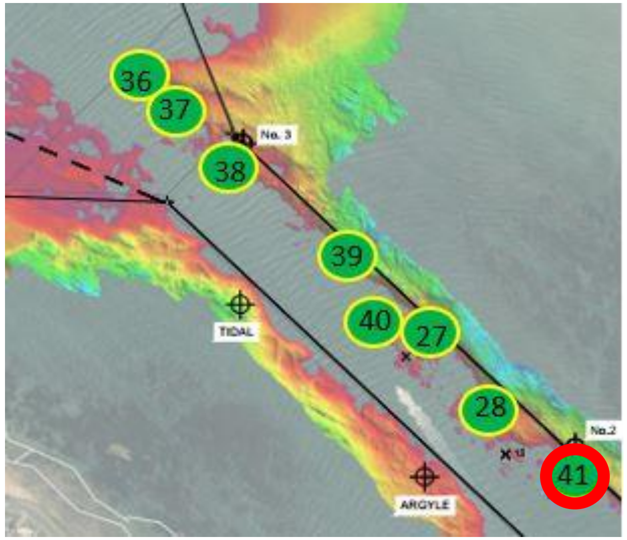
Berth 8
Location 25



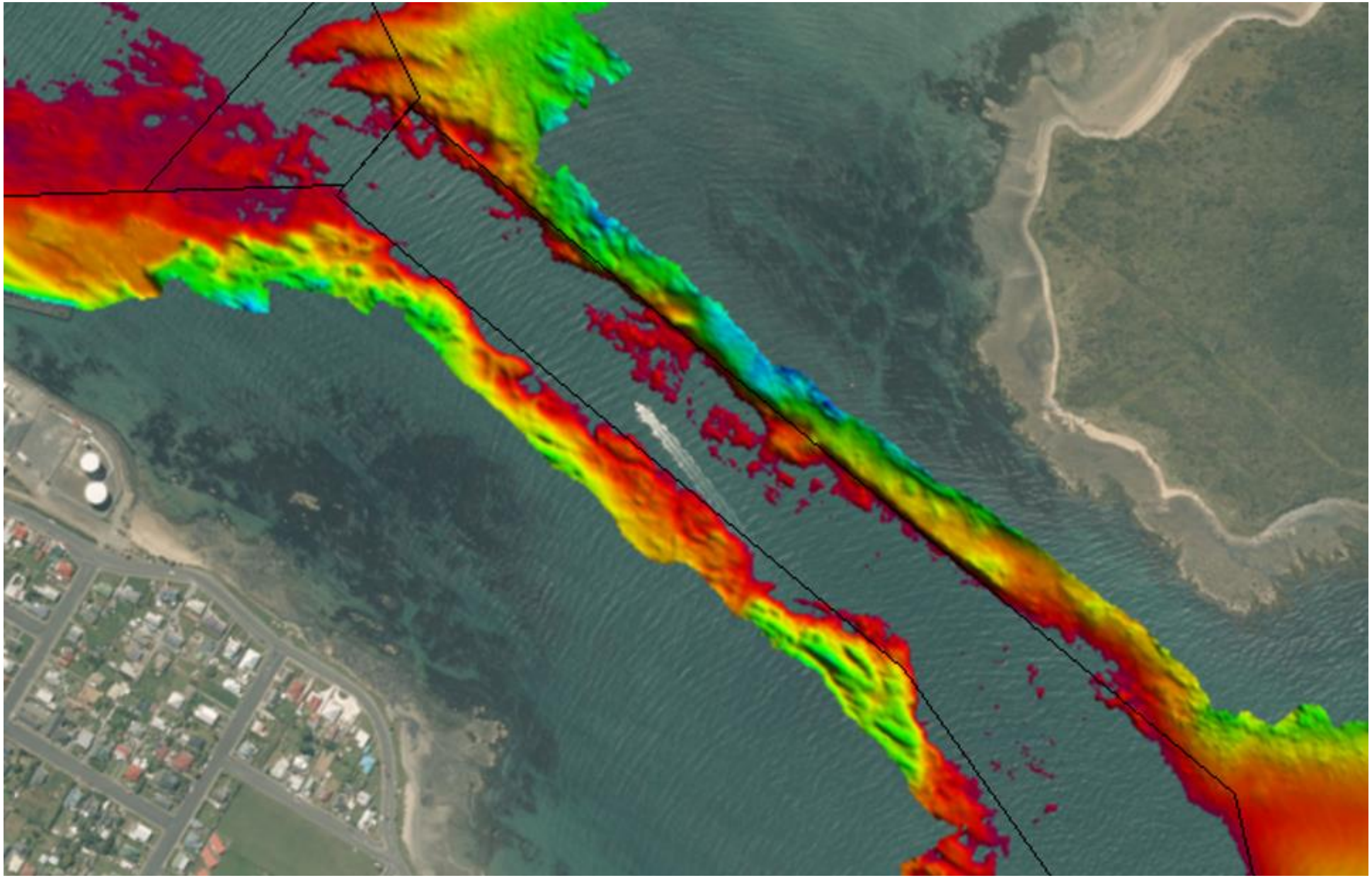
Locations
36 & 37

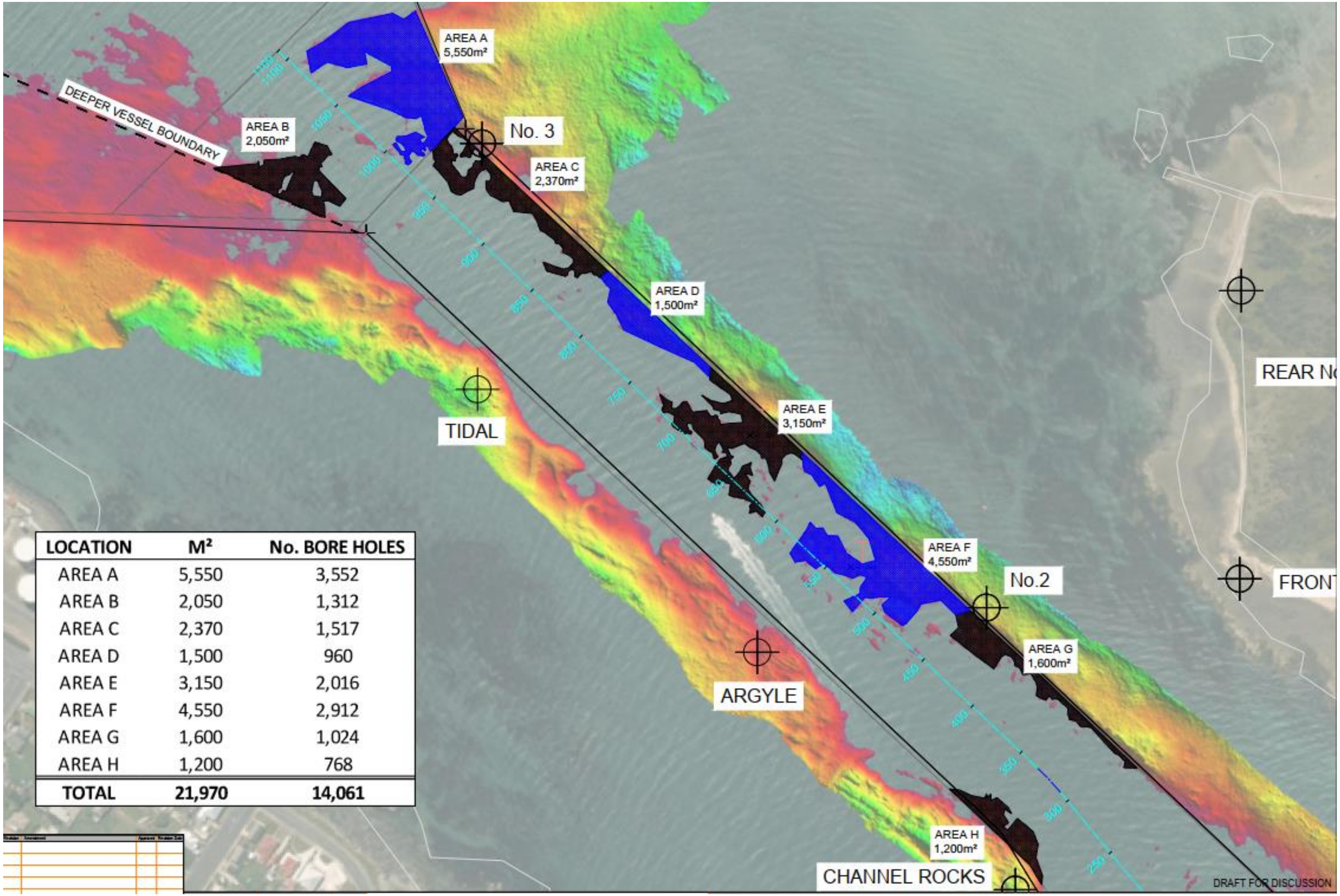


Locations
40 & 27



Location 41





LOCATION	M²	No. BORE HOLES
AREA A	5,550	3,552
AREA B	2,050	1,312
AREA C	2,370	1,517
AREA D	1,500	960
AREA E	3,150	2,016
AREA F	4,550	2,912
AREA G	1,600	1,024
AREA H	1,200	768
TOTAL	**21,970**	**14,061**

Appendix C:

Heavy metals discussion.

Arsenic

Arsenic (As) is a metalloid considered nonessential to flora and fauna; with adverse biological effects [in the study group] including decreased benthic invertebrate abundance, increased mortality, and behavioural changes (CCME, 2000). Benthic microorganisms in the sediments can transform inorganic arsenic into an organic form, which can ultimately [bio]accumulate (CCME, 2000). ANZG (2000) website states that "*both arsenic (III) and arsenic (V) form stable bonds with carbon, resulting in numerous organo-arsenic compounds, some of which are very toxic (e.g. methylarsine)* [and that] *phytoplankton are among the most sensitive organisms to both forms of arsenic.*" While arsenic is said to bioaccumulate in marine organisms, secondary poisoning is complicated by organo-arsenical compounds, yet 'unlikely'. Marine fish and invertebrates accumulate organo-arsenical compounds from food in tissue residues, but the most common forms have low toxicity to mammals (ANZG, 2000).

Copper

Copper tends to accumulate in sediments due to its affinity for organic matter, and therefore exposes organisms which feed or live in benthic environments (CCME, 1999). The CCME (1999) report states that "*adverse biological effects for Cu in the BEDS* [study group] *include decreased benthic invertebrate diversity, reduced abundance, increased mortality, and behavioural changes, among others.*" ANZG (2000) website states that "*some species of marine algae are particularly sensitive to copper*" and that "*invertebrates, particularly marine crustaceans, corals and sea anemones, are sensitive to copper, with concentrations of copper as low as 10 µg/L causing sublethal effects.*"

Nickel

An essential trace element for aquatic organisms, nickel is also considered toxic at higher concentrations and moderately toxic to aquatic species overall. Bioconcentration is not a significant problem in aquatic environments as nickel is '*weakly complexed by dissolved organic matter and is less bioavailable when adsorbed to suspended material* (ANZG, 2000).' In general, it was found that marine invertebrates are more sensitive than vertebrates, and that 'reduced growth was noted in several freshwater algae at concentrations as low as 50 µg/L' (ANZG, 2000 and references therein). ANZG (2000) states that: "*A marine high reliability guideline value of 70 µg/L was derived for nickel using the statistical distribution method at 95% protection. The 99% protection level was 7 µg/L and is recommended for slightly to moderately disturbed marine systems. The 95% protection level does not give sufficient margin of safety from acute toxicity for a juvenile mysid (152 µg/L, Gentile et al. 1982).*

Low acute toxicity figures, unconfirmed, were also reported for a mollusc (60 µg/L), a diatom (50 to 100 µg/L) and two dinoflagellates (100 µg/L). Hence, the 99% protection level (7 µg/L) is recommended for slightly to moderately disturbed marine systems."

Zinc

While zinc is an essential trace element for all trophic levels, being found in all tissues of mammals, fish and invertebrates, zinc is also considered to have various mechanisms of toxicity to aquatic organisms (ANZG, 2021). Very high reliability DGVs for zinc were derived from chronic toxicity data for 16 species (7 molluscs, 2 crustaceans, one annelid, one cnidarian, 2 macroalgae, one green microalga and two diatoms) (ANZG, 2021). Most aquatic fauna can regulate internal zinc concentrations by excretion of excess zinc or by storage of a detoxified form (ANZG, 2021 and references therein). However, when detoxification capacity is exceeded, the internal calcium balance is disrupted, leading to toxic effects including reduced growth/reproduction and increased mortality. Other toxic pathways include inhibition of oxygen consumption (invertebrates) and reduced cell division and growth rate (diatoms). Species sensitivity across data can be seen in Figure 1.

Organic Tin (Tributyltin)

Tributyltin or organotin (Tbt), have widespread usage in marine antifouling paints and for wood preservation. TBT strongly binds to sediments with remobilisation being caused by biota. Bioaccumulation has been noted in mollusc tissues, with reduced growth and thickening of shells even at very low concentrations (ANZG, 2000). Due to its high toxicity to marine bivalves, the use of TBT has been restricted in Australia and New Zealand, with deformities in oysters and induction of imposex in gastropods being major concerns to population declines (ANZG, 2000).

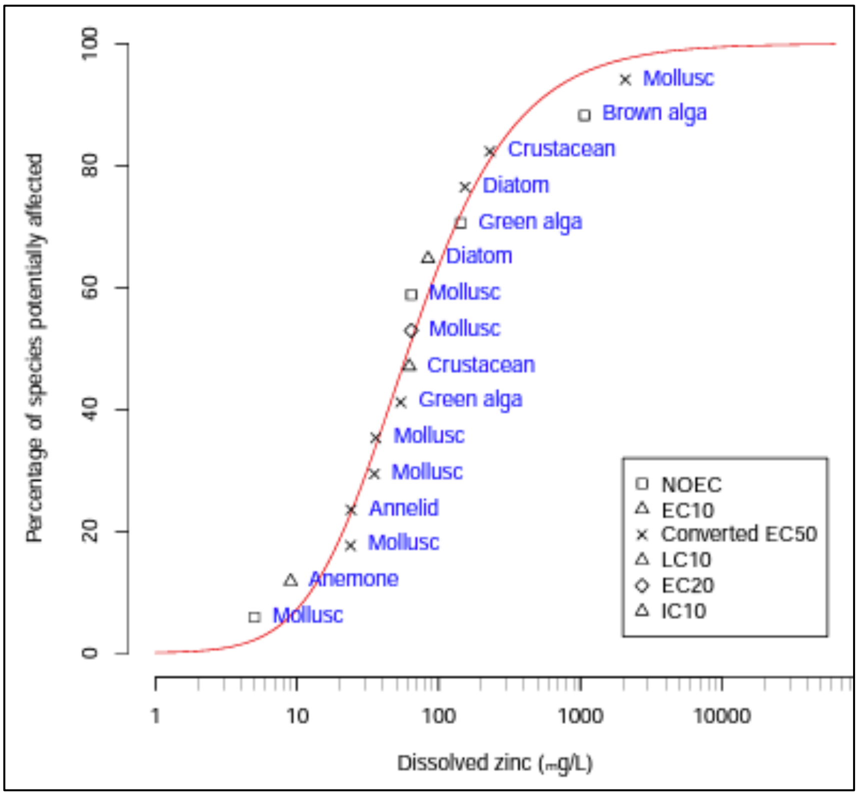


Figure 1: Species sensitivity distribution, zinc in marine water (ANZG, 2021).

Appendix 2: Plume Modelling of Proposed Dredging Activities at the Syncrolift Berth, Bluff Harbour

PLUME MODELLING OF PROPOSED DREDGING ACTIVITES AT THE SYNCROLIFT BERTH, BLUFF HARBOUR

Report prepared for South Port New Zealand Ltd

Version	Date	Status	Approved by
RevA	22/09/2023	Draft for internal review	Zyngfogel
RevB	27/09/2023	Draft for client review	McComb
RevC	09/10/2023	Updated draft for internal review	Zyngfogel
RevD	11/10/2023	Updated draft for internal review	Weppe
Rev0	12/10/2023	Approved for release	McComb

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Figure 3.8 Maximum amount of time (in hours) the depth-averaged suspended sediment concentration is above 2.5 (left) and 5 (right) mg.L^{-1} for discharge location P3 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours show 24 h and 48 h respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12 h is masked. 19

Figure 3.9 Maximum amount of time (in hours) the sediment deposition thickness is above 1.5 (left) and 3.0 mm (right) for a release from location P3 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours highlight 24 and 48 h respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12h were masked. 21

Figure 3.10 Maximum deposition footprint assuming no resuspension for a release from location P3 over a spring tide cycle from 1 h before to 4 h after high water (left) and 2 h before to 4 h after high water (right). The green and red contours highlight 2 and 4 mm respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Deposition thickness of less than 1mm were masked 22

1. INTRODUCTION

South Port New Zealand Limited has commissioned Calypso Science Ltd to undertake a numerical study to characterise the potential trajectory and settling of a sediment plume arising from the dredging of the Syncrolift berth (Figure 1.1). The proposed activity includes suction dredging at the berth and discharge to the seabed within 400 m of the berth. A lagrangian particle methodology has been adopted, using an existing 3D hydrodynamic model of Bluff Harbour (Calypso Science *et al.* 2020).

The aim of this study is to define the optimal location to discharge the sediment and the timing of release within the tidal cycle to minimise environmental impacts. The results of the study will be used to support a resource consent application.

The report is structured as follows. In Section 2, the numerical methodology and sediment analysis are described. The simulation results are presented in Section 3, and a summary of the outcomes is provided in Section 3.3.4.

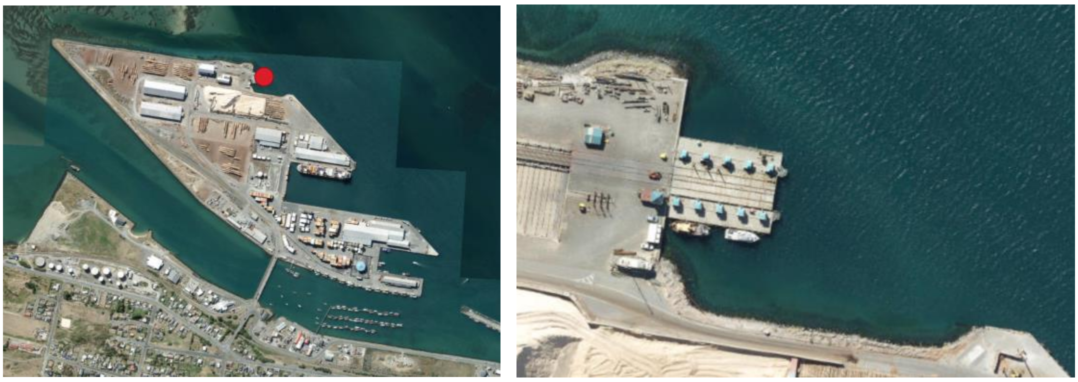

Figure 1.1 Aerial image showing the location of the proposed dredging (red dot) with a zoom in over Island Harbour and the Syncrolift berth (right).

2. METHODOLOGY

2.1. Dredging scenario

The proposed dredging operation to restore design depths at the Syncrolift berth involves the removal and discharge of approximately 6000 m^3 of sediment. Pumping rates of between 150 and 250 m^3 meters per hour are envisaged, with the discharged sediment being released near the seabed within a 400-m radius of the berth.

The dredging plant (example shown in Figure 2.1) will be relocated to various positions beneath the Syncrolift berth to achieve the design depths. For each relocation, a setup and positioning time of one hour is expected, followed by a continuous dredging period of around three hours. There are no restrictions regarding the timing of this work; it can take place anytime during day or night.

Considering the possibility that the dredged volume could be as minimal as 2000 m^3, and the relocation time might extend beyond 1 hour, this methodology is assuming a worst-case scenario.

In the context of this numerical modelling exercise, certain assumptions have been made:

- The discharge is set to an elevation of 0.5 m above seabed.
- The plume trajectory is solely influenced by tidal currents.
- The intake does not create a plume.
- Ambient in-water sediments concentration (varies from 1 to 10 $mg.L^{-1}$ .Miller, 2021) are not considered in the resultant concentrations.
- No bulking factor is used to derive the deposition thickness.
- This study does not consider sediment flocculation and consequently the predicted sediment concentrations are conservative. In reality, a fraction of the smaller particles may undergo flocculation, leading to increased settling velocities.

Figure 2.1 An example of possible dredging plant that could be used.

2.2. Sediment analysis

Sediment particle size distributions were derived from six core samples collected beneath the Syncrolift berth in June 2023. Half of the samples were 0-20 cm depth and the other half were at 1 m depth. Since all six measurements had similar physical characteristics, homogeneity over the upper 1 m is inferred, allowing a representative size distribution to be defined (Figure 2.2). A silty-sand distribution consists of 7% clay, 36.5% silt and 56.5% sand.

To effectively model this size distribution, a weighted average of the median size (d50) was calculated for five distinct sediment classes, as detailed in Table 2.1. For each of these classes, settling velocities were determined using the equations of Van Rijn (1993), along with the associated critical velocities based on Soulsby (1997). These are the same equations used in the South Port Capital Dredging Assessment conducted by Miller (2021).

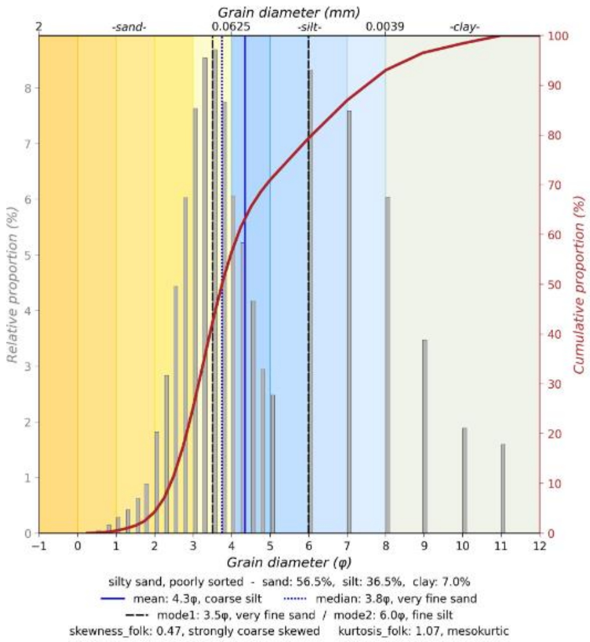

Figure 2.2 Representative sediment distribution calculated from the samples taken June 2023.

Table 2.1 Sediment distribution for the silty-sand representative distribution with associated settling velocities and critical velocities.

	Size range [µm]	D50 calculated [µm]	Settling velocity [mm.s^{-1}]	Critical velocity [m.s^{-1}]	Proportion [%]
Clay	<3.9	2.7	0.003	0.1	7.0
Fine silt	3.9 - 15.6	12.1	0.05	0.2	13.6
Medium silt	15.6 - 63.0	44.5	0.7	0.25	23.1
Fine sand	63.0 - 250.0	133.8	6.0	0.27	52
Medium sand	250.0 - 1000.0	389.5	30.0	0.28	4.3

2.3. Sediment plume modelling

2.3.1. Model description

The simulation of sediment dispersion resulting from the dredging operations was conducted using the python framework Oceantracker, a fast lagrangian particle tracking system (see Vennell *et al.* 2021).

Oceantracker simulates the trajectories of numerical particles using velocities from a high-resolution finite-element hydrodynamic model, allowing behavior to be resolved with a 4th order Runge-Kutta scheme. The core model settings are provided in Table 2.2.

Table 2.2 Oceantracker model settings.

Parameters	Value applied
Horizontal diffusion	1 $m^2.s^{-1}$
Vertical diffusion	0.01 $m^2.s^{-1}$
Model time step	60 sec
Particles per simulation	600 000
Load per particle	0.01 m^3
Duration of the simulation	20 days
Seabed	Resuspension
Shoreline	Re-float, resuspension

2.3.2. Processing of the results

For deposition, at each model timestep a kernel density estimate (KDE) was calculated at 50 m resolution over a grid of 10000 x 10000 m. Then, each simulation was summed to obtain the deposited volume in m^3. This was divided by the cell size to define the depositional thickness in mm.

For Total Suspended Solids (TSS), at each model timestep a KDE was calculated at 50 m resolution over a grid of 10000 x 10000 m. Then, a depth-averaged concentration was calculated (in $mg.L^{-1}$) for each timestep, applying 1700 $kg.m^3$ sediment density (Miller, 2021).

2.3.3. Simulations

To define the optimal timing and discharge location, a series of release simulations were made.

Four positions were tested, denoted as P0, P1, P2 and P3 (Figure 2.3). P0 represents the nearest position to the berth (100 m in a depth of 9 m). P1 is located 200 m away in 12 m depth,P2 is 400 m away in 11 m depth while P3 is 400m away in 8 m depth.

For each location, various discharge timings relative to high water were explored. This includes five scenarios, as outlined in Table 2.3, ranging from initiating sediment discharge 3 hours before high water to 5 hours after high water. In each scenario, it was assumed that the dredging operation would commence and continue for a period of 3 hours, followed by a 1 hour pause to facilitate relocation. If the dredging operation at a specific location was not completed by the end of the working window, it would be resumed during the subsequent window.

As an example, Figure 2.4 represents a dredging cycle from 2 h before high water to 4 h after high water. The blue line represents the tidal elevation at the berth and the green stars represent the discharge of sediments. In addition to this, discharge was also simulated over a neap tide and a spring tide

Figure 2.3 Position of the pipe in discharge testing.

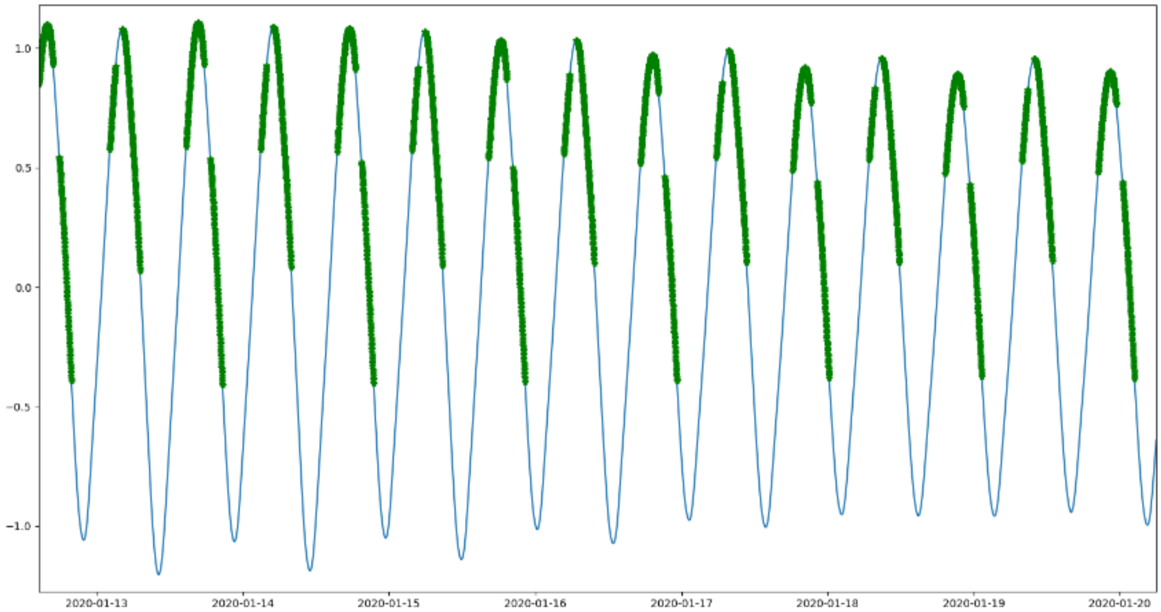

Figure 2.4 Time series representation of sea surface elevation (blue) and the time when sediment discharge occurs (green). Each cycle includes 3 h of continuous release followed by 1 h set up time.

Table 2.3 Release windows with the associated working time and mobilisation time.

	Length of the mobilisation	Working time [h]
-1 to 3h	4 days 18:27:00	29:49
-2 to 2h	4 days 18:20:00	29:42
-2 to 3h	3 days 16:29:00	29:46
-1 to 4h	3 days 16:18:00	29:35
-2 to 4h	3 days 05:21:00	29:57
-3 to 3h	3 days 05:01:00	29:37
-3 to 4h	2 days 08:18:00	29:42
-2 to 5h	2 days 08:22:00	29:47

3. RESULTS

3.1. Overall comparisons

The aggregate amount of discharged sediment retained within the harbour was compared for all 48 simulations within the tidal cycle, the discharge location and the working windows.

- An initial observation is that the quantity of suspended material potentially retained within the harbour can be reduced by almost 50% if the dredging operations occur during a spring tide, as opposed to a neap tide (Figure 3.1, left).

- Considering the discharge location, P0 and P1 provide similar outcomes, while P2 and P3 result in significantly less discharged sediment being retained within the harbour (Figure 3.1, right).

- By comparing all the working windows together (Figure 3.2), the amount of sediment in the harbour is directly related to length of the working window. Working over a 7-hour window (2 h before to 5 h after high water) compared to a 4 h hour windows (1 h before to 3 h after high water) can increase the retained sediment by about 30%.

- When considering only the simulation where sediment was release from P2 during the spring tides (Figure 3.3), the optimum timing to start discharge is 1-2 h before high water. The retained sediment load increases rapidly if the release occurs after 4 h following high water.

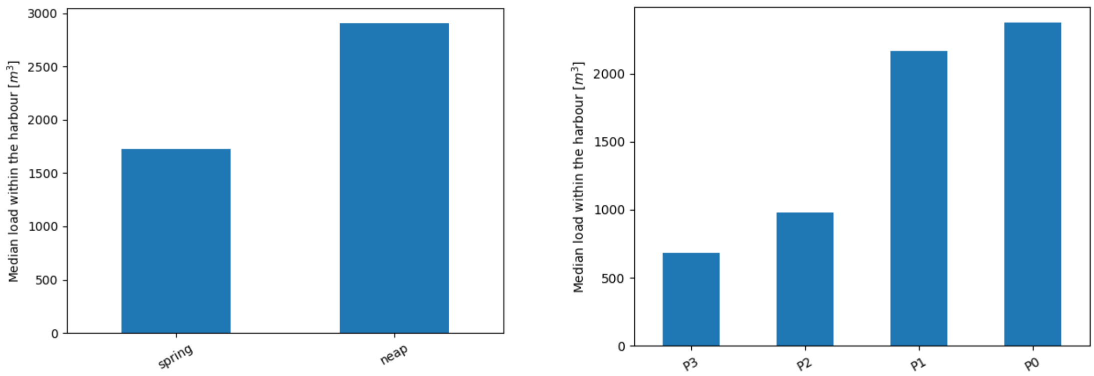

Figure 3.1 Comparison of the median amount of sediment within the harbour over the whole simulation for each of the tidal cycle (left) and release position (right).

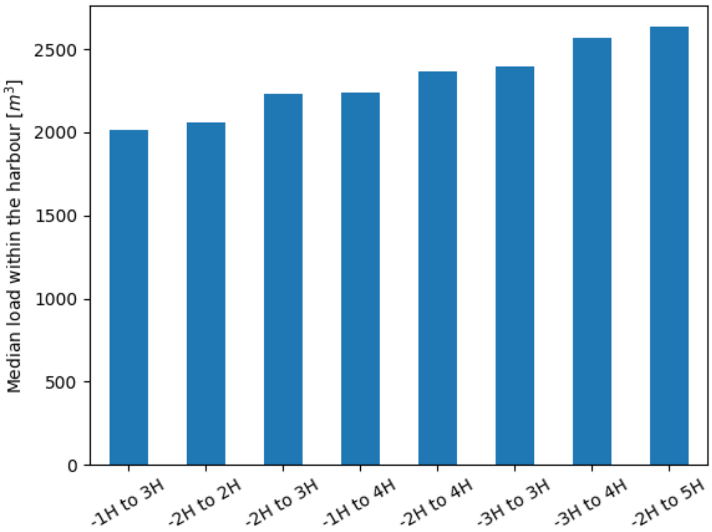

Figure 3.2 Comparison of the median amount of sediment within the harbour over the whole simulation for each of the working windows during spring tide.

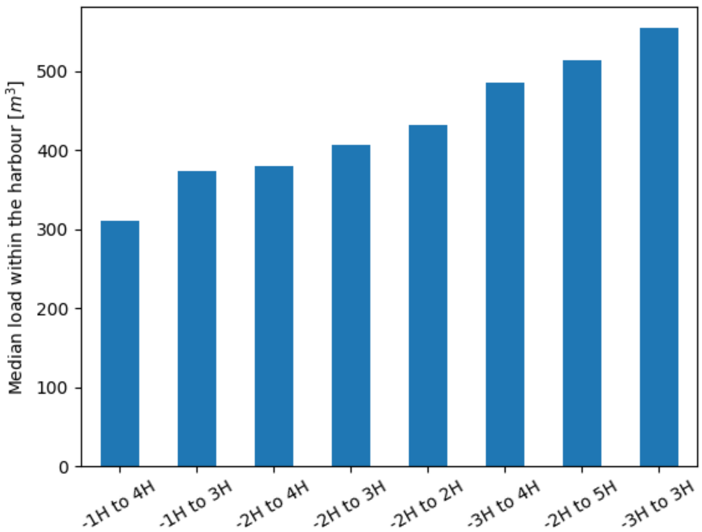

Figure 3.3 Comparison of the median amount of sediment within the harbour over the whole simulation for each of the working windows from the P3 location during a spring tide.

3.2. Simulation results from P2 (spring tide)

Based on the results presented in Section 3.1, location P2 during a spring tide was selected to examine further statistics of the plume dynamics. Two working windows are considered: 1 h before to 4 h after high water, and 2 h before to 4 h after high water.

3.2.1. Instantaneous total suspended sediment (TSS) concentration

The median and 90th percentile depth-averaged suspended sediment concentration over the whole dredging period for the two selected operational windows are presented in Figure 3.4.

The highest concentration patches are found just south of the discharge point. As the plume extends southward, it rounds Bluff Point before undergoing open water dispersion.

Overall the concentration is less than 30 $mg.L^{-1}$ for less than 50% of the time. For around 10% of the time, the concentration exceeds 50 $mg.L^{-1}$ from the discharge location toward the harbour entrance.

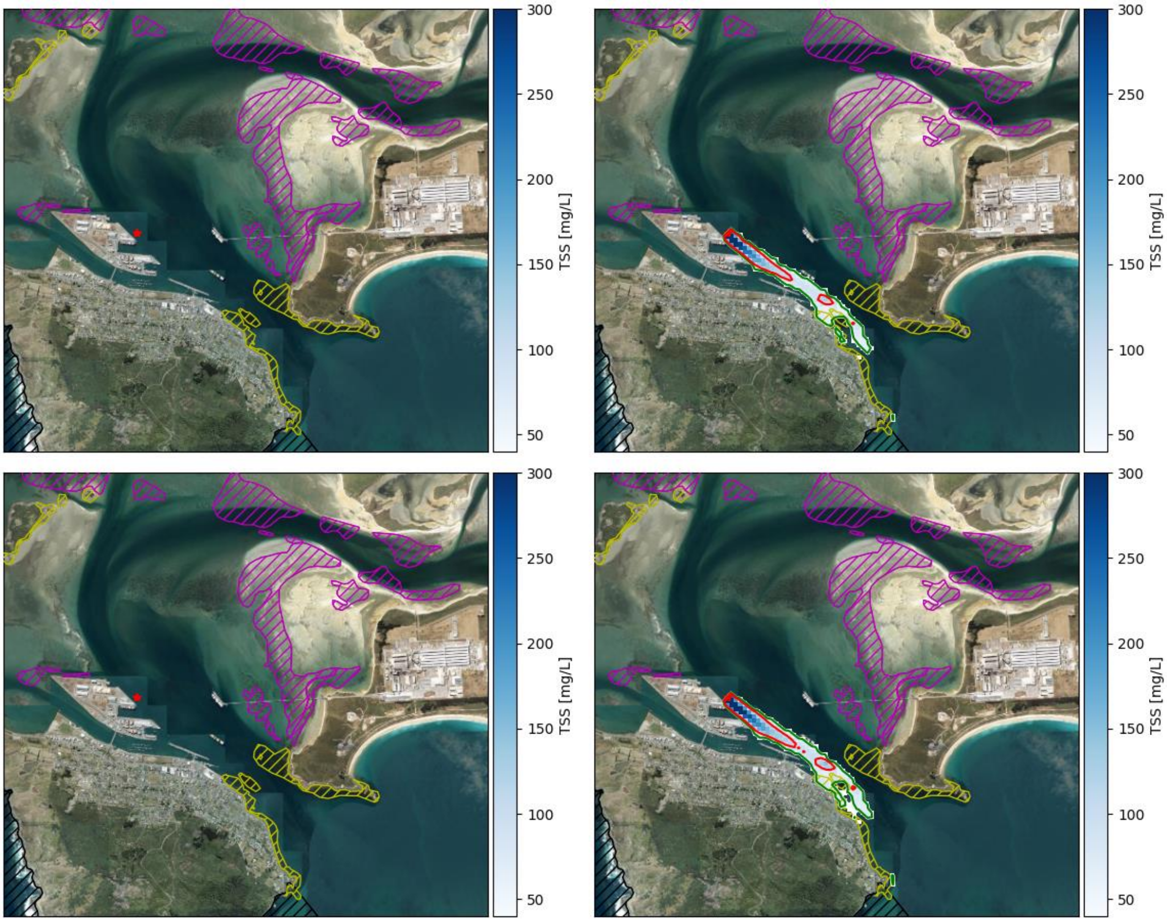

Figure 3.4 Median (left) and 90th percentile (right) of depth-average suspended sediment concentration during a release from site P2 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours highlight 50 and 100 $mg.L^{-1}$ respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. TSS were masked below 30 $mg.L^{-1}$.

3.2.2. Persistence of total suspended sediment (TSS) concentrations

The duration (in hours) when TSS concentration exceeds the 2.5 and 5.0 mg.L^{-1} thresholds over the two operational windows is provided in Figure 3.5.

The areas characterized by extended persistence are near the Harbour entrance where concentration above 2.5 mg.L^{-1} can persist for up to 24h. Concentration greater than 5.0 mg.L^{-1} does not persist more than one tidal cycle (12h).

Figure 3.5 Maximum amount of time (in hours) the depth-averaged suspended sediment concentration is above 2.5 (left) and 5.0 (right) mg.L^{-1} for discharge location P2 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours show 24 h and 48 h respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12 h is masked.

3.2.3. Persistence of sediment deposition

The expected persistence of deposited sediments above 1.5 and 3.0 mm is provided in Figure 3.6. Here, the settling of TSS is considered along with the resuspension of those sediments by the tidal currents.

The area with the highest persistent deposition is predicted to occur along Island Harbour, especially near berth 1-4 area where eddies tend to develop, allowing localised patches of potential sedimentation.

Figure 3.6 Maximum amount of time (in hours) the sediment deposition thickness is above 1.5 (left) and 3.0 mm (right) for a release from location P2 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours highlight 24 and 48 h respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12h were masked

3.3. Simulation results from P3 (spring tide)

Similar to P2, P3 over a spring tide was selected to examine further statistics of the plume dynamics. The same two working windows are considered: 1 h before to 4 h after high water, and 2 h before to 4 h after high water.

3.3.1. Instantaneous total suspended sediment (TSS) concentration

The median and 90th percentile depth-averaged suspended sediment concentration over the whole dredging period for the two selected operational windows are presented in Figure 3.7.

The highest concentration patches are found just south of the discharge point for the first working window, however, for the second window (2h before to 4h after) patches of high concentration (greater than 30 mg.L^{-1}) can be found slightly to the north of the discharge point.

Overall the concentration is less than 30 mg.L^{-1} for less than 50% of the time. For around 10% of the time, the concentration exceeds 50 mg.L^{-1} from near the discharge location toward the harbour entrance.

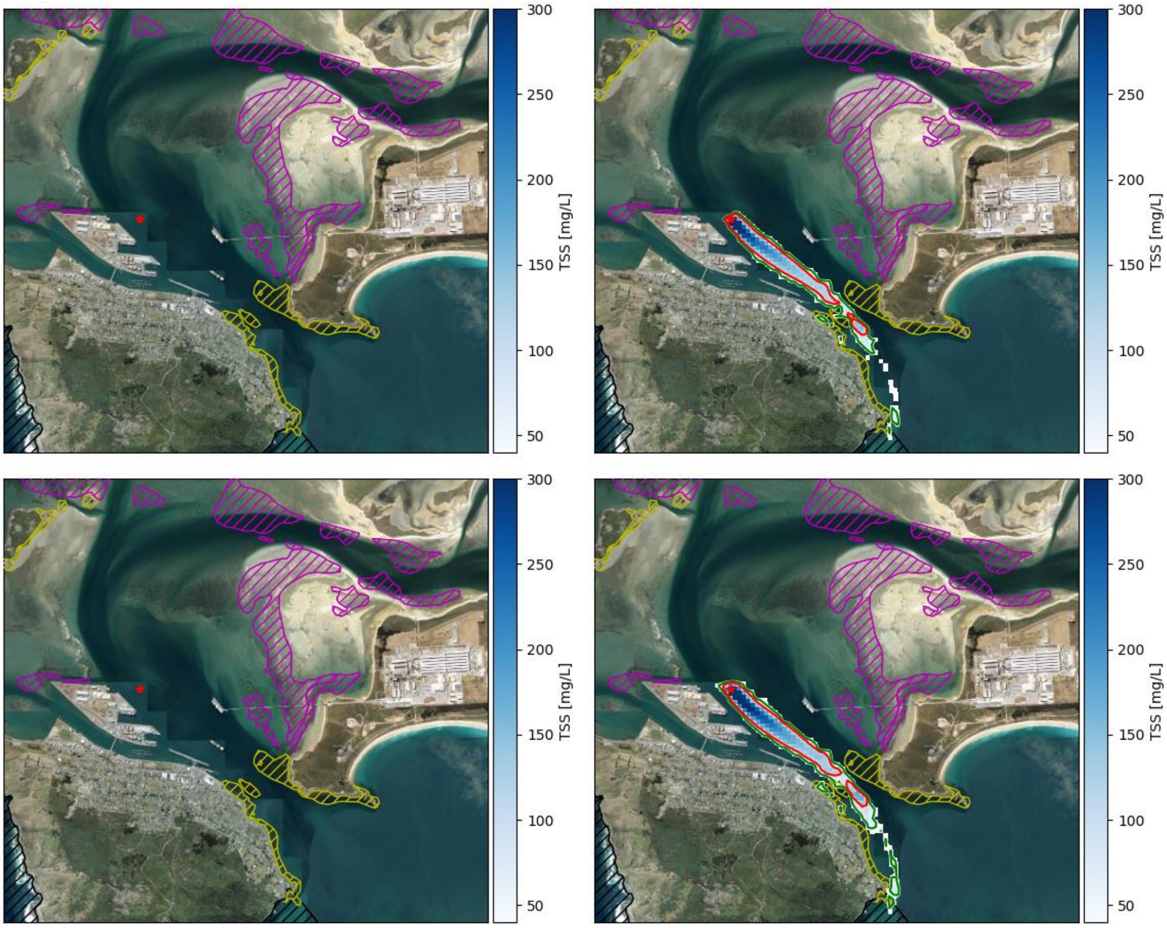

Figure 3.7 Median (left) and 90th percentile (right) of depth-average suspended sediment concentration during a release from site P3 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours highlight 50 and 100 mg.L^{-1} respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. TSS were masked below 30 mg.L^{-1}.

3.3.2. Persistence of total suspended sediment (TSS) concentrations

The duration (in hours) when TSS concentration exceeds the 2.5 and 5.0 $mg.L^{-1}$ thresholds over the two operational windows is provided in Figure 3.8.

The areas characterized by extended persistence are near the Harbour entrance where concentration above 2.5 $mg.L^{-1}$ can persist for up to 24h. At this location concentration greater than 5.0 $mg.L^{-1}$ can persist slightly over 12h.

Figure 3.8 Maximum amount of time (in hours) the depth-averaged suspended sediment concentration is above 2.5 (left) and 5 (right) mg.L^{-1} for discharge location P3 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours show 24 h and 48 h respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12 h is masked.

3.3.3. Persistence of sediment deposition

The expected persistence of deposited sediments above 1.5 and 3.0. mm is provided in Figure 3.9. Here, the settling of TSS is considered along with the resuspension of those sediments by the tidal currents.

Similar to P2 sediment deposition, the area with the highest persistent deposition is predicted to occur along Island Harbour, especially near berth 1-4. Overall, the release at the P3 site results in a reduced number of hours these thresholds are exceeded, however with reduced depositional footprints relative to a release at P2.

Figure 3.9 Maximum amount of time (in hours) the sediment deposition thickness is above 1.5 (left) and 3.0 mm (right) for a release from location P3 over a spring tide cycle from 1 h before to 4 h after high water (top) and 2 h before to 4 h after high water (bottom). The green and red contours highlight 24 and 48 h respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Persistence of less than 12h were masked.

3.3.4. Deposition footprint

To understand the deposition footprint, a worst-case simulation was conducted in which no resuspension was considered (i.e., once the sediment reaches the seafloor, it stays there).

The maximum deposition footprint at the end of the dredging for the two working windows is presented in Figure 3.10. The deposition pattern exhibits a resemblance to the TSS plume's shape and gradually diminishes as it approaches the harbour entrance. During a release occurring from 2 hours before high tide to 4 hours after high tide the footprint slightly extends towards the Syncrolift berth. There is no evidence of deposition in the berth 1-4 pockets.

Figure 3.10 Maximum deposition footprint assuming no resuspension for a release from location P3 over a spring tide cycle from 1 h before to 4 h after high water (left) and 2 h before to 4 h after high water (right). The green and red contours highlight 2 and 4 mm respectively. The purple, yellow and black hatched patch represents the seagrass, rocky and mataitai area respectively. Deposition thickness of less than 1mm were masked

4. SUMMARY

Numerical modelling of the expected characteristics of a discharge plume arising from dredging the Syncrolift berth has been undertaken.

Sensitivity testing was used to determine an optimal discharge site (within the constraints of the plant), the discharge timing (with respect to tidal stage), and the operational windows. The results have been used to determine an operational practice that minimises the potential for sedimentation to occur within the Bluff Harbour.

The optimal discharge site, within the expected constraints of the likely plant, is the maximum extent of a 400 m discharge pipe and is positioned toward the middle of the channel. The optimal discharge period extends from 1 hour before high water.

5. REFERENCES

Calypso Science and Oceanum (2020). High resolution hydrodynamic model of Bluff Harbour. Report prepared for South Port NZ Ltd by Calypso Science & Oceanum, Revision 0

Miller, B. & Davis, G. 2021. South Port Capital Dredging Assessment of Marine Environmental Effects. Final Report Prepared for South Port Ltd. e3Scientific Report 20041.100 p. plus appendices.

Soulsby, R. (1997). Dynamics of marine sands. UK: Thomas Telford.

Van Rijn, L.C. (1993). Principles of sediment transport in rivers, estuaries and coastal seas (Aqua publications Amsterdam).

Vennell, R., Scheel, M., Weppe, S., Knight, B. and Smeaton, M., 2021. Fast lagrangian particle tracking in unstructured ocean model grids, Ocean Dynamics, 71(4), pp.423-437.

Appendix 3: Customary Marine Title Correspondence

Proposed Maintenance Dredging at Syncrolift Facility, Island Harbour, Bluff.

SB **Simon Beale <simon@bealeconsultants.co.nz>**

Monday, 4 December 2023 at 3:38 PM

To: Kamaea Wi Repa; **Cc:** maca@ngaitahu.iwi.nz; TTW; 'Frank O'Boyle'; Eduardo Queluz

Description of Propo... 5.1 MB

TAMI Approval - Trial... 234 KB

Download All • Preview All

Kia ora Kamaea

In accordance with Section 62 of the Marine and Coastal Area (Takutai Moana) Act 2011 we seek your views on a proposal by South Port NZ Limited to undertake maintenance dredging beneath a ship and transfer facility or Syncrolift located at Island Habour, Bluff. A summary of the proposal is attached for your attention.

The maintenance dredging is required to improve the operation of the Syncrolift facility which is currently constrained by accumulated sediment beneath the facility.

We have also attach written approval received from Te Ao Marama for the initial trial operation for your information.

We look forward to your receiving your views in due course.

Ngā mihi
Simon

Appendix 4: Draft Consent Conditions

Draft Conditions

1. This consent authorises the maintenance dredging, discharge and deposition of up to a maximum of 6,000 cubic metres of soft sediments per annum comprising of predominately silt material.

2. The dredging of soft sediments shall be undertaken using a suction dredge and shall only be carried out across areas of seabed beneath the Syncrolift as shown on Attachment 1 and defined by centre point at the following co-ordinates (NZTM 2000):

Area	Easting	Northing
Syncrolift site	1242412.80	4829913.067

3. The seabed beneath the Syncrolift shall be dredged to a target depth of 7.50 metres (**m**) chart datum (**CD**).

4. The discharge of spoil to water shall be carried out at discharge points denoted P3 and P4 as shown on Attachment 2, and being at the following NZTM 2000 perimeter co-ordinates:

Discharge Points	Easting	Northing
P3 P4	1242819.000 1242743.844	4829903.000 4829989.759

5. The Consent Holder shall maintain a record of the *in situ* quantity of all sediments dredged from the seabed at the Syncrolift site by means of a hydrographic survey and shall report these records to the Consent Authority (email: escompliance@es.govt.nz) at the conclusion of each annual dredging campaign.

6. The Consent Holder shall notify the Consent Authority (email: escompliance@es.govt.nz) in writing;

   (a) at least 10 working days prior to commencing any dredging works. The Consent Holder shall include in these notices, indicative annual works programmes; and

   (b) no more than three working days after completion of the dredging works.

Timing of Works

7. Dredging shall be limited to the period 1 April to 30 September (inclusive).

   Advice Note: *The purpose of this condition is to ensure these works avoid the seagrass (Zostera muelleri) flowering and growing season and Little Penguin breeding season.*

Sediment Control

8. The Consent Holder shall ensure that dredging occurs between 1 hour before high tide and 4 hours after high water (ebb tide) at the P3 discharge location and to 30 minutes to 4 hours after high tide (ebb tide) at the P4 discharge location to reduce sediment re-accumulating within the Syncrolift site.

9. The Consent Holder shall install a sediment barrier at the Syncroloft site prior to commencement of any subtidal or surface operations associated with the dredging operation.

10. The Consent Holder shall, on five occasions during each annual dredging campaign, spot-monitor coastal water quality at the edge of the mixing zone of 200 m during the dredging. This shall involve the use of a Secchi disc and a calibrated meter (capable of measuring pH, temperature and dissolved oxygen) placed upstream and downstream of the mixing zone as shown on the plan included in Attachment 1. The discharges shall not result in any of the following effects based on the results of upstream and downstream monitoring:

    (a) reduce the ambient visual clarity by more than 20 percent;

    (b) change the pH;

    (c) change the natural temperature of the water by more than 3 degrees Celsius; and

    (d) change the concentration of dissolved oxygen by less than 80% saturation beyond the mixing zones

Biosecurity

11. (a) The Consent Holder shall inspect the dredge, dredge platform and discharge pipe for fouling organisms, including *Undaria pinnatifida* and other "exclusion" species specified in the Southland Regional Pest Management Plan (**SRPMP**), no more than one week prior to the dredge entering Bluff Harbour.

    (b) If such organisms are found, the Consent Holder shall ensure that the organisms are removed and disposed of to a designated refuse site on land, and any "exclusion" species identified in the SRPMP are reported to Biosecurity New Zealand and the Consent Authority.

    (c) The Consent Holder shall provide the Consent Authority (email: escompliance@es.govt.nz) with an updated biofouling management plan prior to commencement of the works.

    (d) The Consent Holder shall use Ministry for Primary Industries accredited operators to undertake inspection and cleaning of the dredge.

    (e) An inspection report shall be submitted to the Consent Authority (email: escompliance@es.govt.nz) prior to the dredge equipment entering Bluff Harbour detailing the timing, method, and findings of the inspection.

Noise Control

12. The Consent Holder shall ensure that the noise emissions arising from the dredging work complies with the Project Noise Standards set out in Table 1:

Table 1: Noise Standards

Time of Week	Time Period	Noise limits: Residential/ Rural Receivers		At the ICB		Industrial 1 and Business 2	
		L_{eq} (dBA)	L_{max} (dBA)	L_{eq} (dBA)	L_{max} (dBA)	L_{eq} (dBA)	L_{max} (dBA)
Weekdays (to 0730 Saturday morning)	0630-0730	55	75	55	75	70	85
	0730-1800	70	85	70	85		
	1800-2000	65	80	65	80		
	2000-0730	50	75	55	75		
Saturdays (to 0730 Sunday morning)	0730-1800	70	85	70	85	70	85
	1800-0730	50	75	55	75		
Sundays and public holidays (to 0630 Monday morning)	0730-1800	55	85	55	85	70	85
	1800-0630	50	75	55	75		

13. The Project Noise Standards in Condition (12) do not apply at any property or building under the ownership or control of the Consent Holder or its entities or subsidiaries in the port zone.

14. The Consent Holder shall ensure the dredging equipment is regularly maintained to minimise noise levels above and below water as far as practicable. Records of such maintenance shall be kept and provided to the Consent Authority upon request.

Soft Sediment Monitoring

15. The Consent Holder shall monitor sediment collected at the following sites (NZTM 2000) within one month of completion of the dredging works for PSA, heavy metals (total arsenic, total chromium, total cadmium, total copper, total nickel, total mercury, total zinc, and total lead), total organic carbon, polycyclic aromatic hydrocarbons, total phosphorus, tributyltin, sulphate, and sediment particle size analysis.

- Ocean beach slipway (Easting 1240669 ; Northing 4829823;
- Syncrolift site (Refer Condition 2 for details)
- Discharge locations P3 & P4 (Refer Condition 4 for details)

- Motupōhue mātaitai site (Easting 1244378.33; Northing 4826879.52);
- Sediment deposition site (Easting 1243001.33; Northing 4829687.43).

A report detailing the findings of this sediment monitoring and dredge spoil volumes shall be provided to the Consent Authority within three months of completion of analysis of the sediment samples.

Advice Note: *Monitoring shall be undertaken only if dredging has occurred in the last 12 months.*

Attachment 1: Coastal water quality monitoring locations.

Mixing zone sites — Features Total: 4, Filtered: 4, Selected: 0

	Location	Coordinates	y coordinate
1	200m Upstream P4	1242588.321	4830103.85420
2	200m Upstream P3	1242674.556	4830012.33915
3	200m Downstream P4	1242885.745	4829824.02934
4	200m Downstream P3	1242959.661	4829748.35344