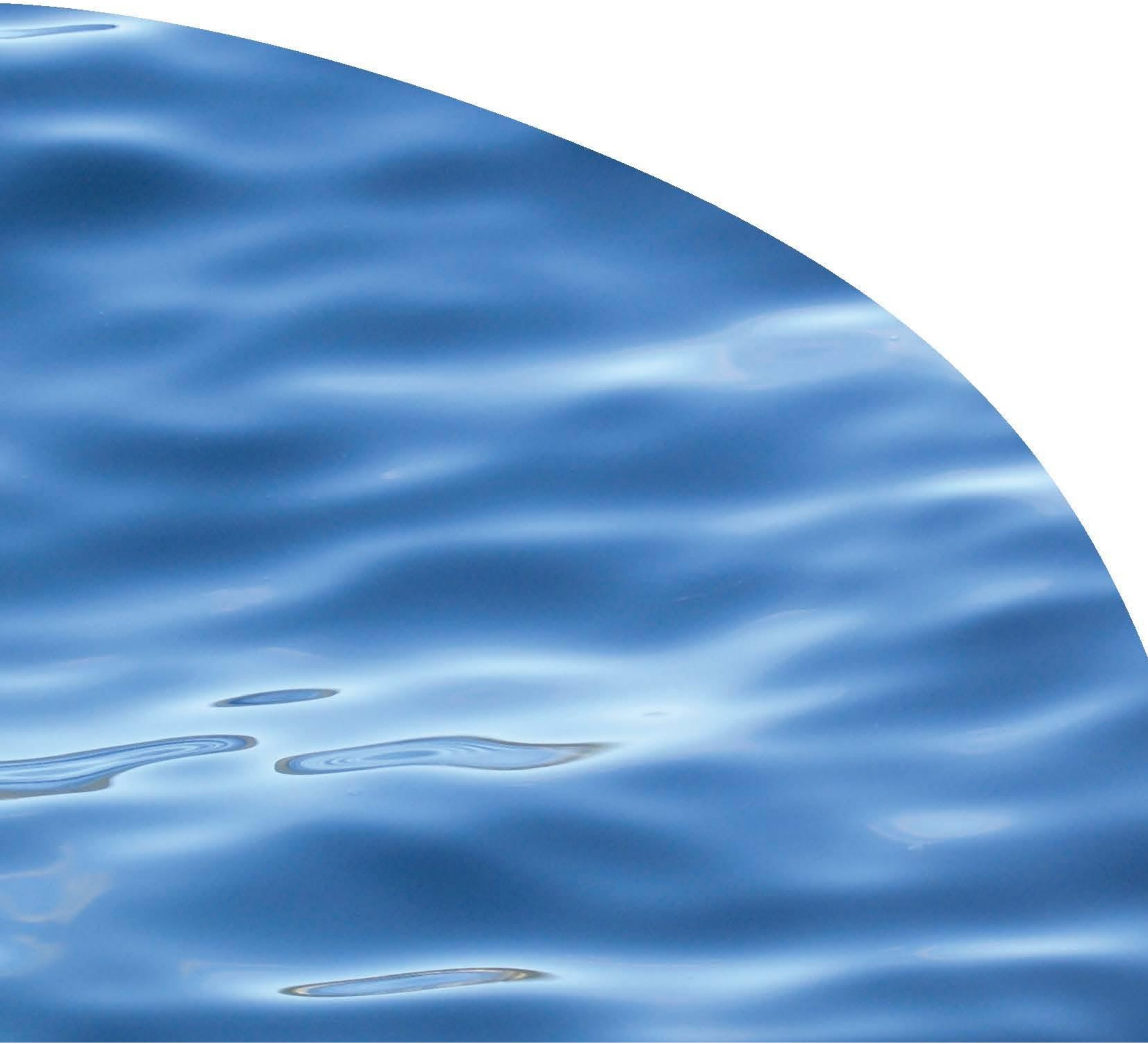
APPENDIX 18

EFFECTS ON BIOSECURITY

REPORT NO. 2598

LYTTELTON PORT RECOVERY PLAN: ASSESSMENT OF MARINE BIOSECURITY RISKS



LYTTELTON PORT RECOVERY PLAN: ASSESSMENT OF MARINE BIOSECURITY RISKS

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EXECUTIVE SUMMARY

Lyttelton Port of Christchurch (LPC) is proposing a series of projects to recover from damage to Port infrastructure caused by the Canterbury earthquakes and to enhance part of the Port's operations. The objective of this report is to identify the potential adverse effects the proposed projects may have on local marine biosecurity and recommend options for mitigation where required. This report forms part of the overall assessment of ecological effects (AEE) prepared by LPC to support the Lyttelton Port Recovery Plan.

Only limited detail is available on the extent and characteristics of infrastructure proposed to be replaced or added to the Port because LPC's present application does not encompass specific activities. This assessment is therefore focused on generic construction processes and their associated sources of biosecurity risk.

Several sources of marine biosecurity risks were identified in association with construction activities and future port operations. The most significant risk is the introduction of new non-indigenous species via international vessel movements during the construction and operational phases. This risk has been ongoing throughout the Port's operation and will largely be mitigated by border standards for biofouling (from 2018), ballast water and sediments. However, in the event that any specialised vessels (*e.g.* barges, dredges, crane vessels, pile-driving vessels) are sourced from overseas to assist LPC during the construction period prior to the currently voluntary Craft Risk Management Standard becoming mandatory (in 2018), we recommend the following (or similar):

> *The vessel owner / operator prepares and submits a Marine Biosecurity Management Plan to the Ministry for Primary Industries for approval that describes the measures that will be implemented to mitigate risk from biofouling, ballast water and sediments, in accordance with relevant border standards.*

This recommendation does not apply to other vessel traffic associated with ongoing Port operations. This assessment also briefly discusses additional approaches for managing biosecurity risks associated with LPC's proposed activities. However, these represent 'opportunities' for LPC rather than immediate options or recommendations for mitigation.

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ABBREVIATIONS

Term	Definition
BWMC	Ballast Water Management Convention
CRMS	Craft Risk Management Standard
IMO	International Maritime Organization
IHS	Import Health Standard
LPC	Lyttelton Port of Christchurch
MPI	Ministry for Primary Industries
NIS	Non-indigenous species
NZCPS	New Zealand Coastal Policy Statement
RMA	Resource Management Act

1. SCOPE

Lyttelton Port of Christchurch (LPC) is proposing a series of projects to recover from damage to Port infrastructure caused by the Canterbury earthquakes and to enhance part of the Port's operations (Port Lyttelton Plan). The proposed projects are expected to occur over a period of approximately 12–15 years and will enable the Port to continue to meet the growing freight demands for the next 30 years. The objective of this report is to identify the potential adverse effects the proposed projects may have on local marine biosecurity (from here on referred to as 'biosecurity risk') and recommend options for mitigation where required. This report forms part of the overall assessment of ecological effects prepared by LPC to support the Lyttelton Port Recovery Plan.

The identification of biosecurity risks and appropriate mitigation approaches in this report are based on the information made available to Cawthron Institute (Cawthron) by LPC ('Project descriptions' memo dated 28 July 2014), which is consistent with the project description contained in Chapter 2 of the cover report. Because detailed design for construction activities is yet to be undertaken, only limited information is available on the various proposed activities and the extent and characteristics of infrastructure proposed to be replaced or added to the Port. For this reason, this assessment is focused on generic construction processes and their associated sources of biosecurity risk. Absolute predictions of risk associated with specific activities or high-profile non-indigenous species (NIS) are beyond the scope of this report.

2. BACKGROUND TO NON-INDIGENOUS MARINE SPECIES

Non-indigenous plants and animals are a serious threat to the natural ecology of coastal marine systems worldwide (Mack *et al.* 2000; Ruiz *et al.* 2000). The main pathways for the transfer of marine organisms between international or domestic coastal environments are movements of commercial and recreational vessels (Hewitt & Campbell 2008). Vessels can transport organisms or their reproductive propagules (*i.e*. larvae or spores) in ballast water, in sea chests and other hull recesses and as fouling communities attached to submerged parts of hulls (Hewitt & Campbell 1999; Inglis *et al.* 2010). Aquaculture activities and the aquarium trade are other important pathways for the introduction and spread of non-indigenous marine species (Morrisey *et al.* 2011; Fitridge *et al.* 2012). Due to the relative importance of shipping as a transport mechanism, ports and marina facilities are often the sites where NIS become first established (Inglis 2001; Hayes *et al.* 2005). In New Zealand, *ca*. 200 marine NIS have already become established in ports and marinas and some natural areas (*e.g*. rocky shores, soft-sediment environments, *etc*.) around the country (Hayden *et al.* 2009a). While international vessel arrivals are generally the source of initial introductions, the domestic shipping, boating and aquaculture networks provide a mechanism for the transport of NIS among New Zealand's coastal locations (Hayden *et al.* 2009b). Not all NIS cause adverse effects. Of the many species that are transported by human activities, only a few become established in new locations. Of those that do become established, only a few go on to become invasive[1]. However, some invasive species cause extensive ecological or economic impacts and their control is difficult or impossible (Hunt *et al.* 2009; Forrest & Hopkins 2013). Preventive and precautionary actions are therefore considered the most cost-effective approach for minimising NIS risks (Mack *et al.* 2000; Colautti *et al.* 2006).

[1] The Invasive Species Specialist Group (www.issg.org) defines invasive species as; non-indigenous species that have become established, are agents of ecological change, and are undergoing spread.

3. BIOSECURITY IN NEW ZEALAND

3.1. Regulatory context

New Zealand operates a national 'biosecurity system' to protect its environmental, economic, social and cultural (including spiritual) values from the impacts of NIS (Hewitt *et al.* 2004). Biosecurity is defined as *the exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health* (Biosecurity Council 2003). New Zealand is one of few countries in the world to have included biosecurity into its national legislation. This is primarily done via the Biosecurity Act (1993). The Ministry for Primary Industries (MPI) is the central government agency charged with leadership of the national biosecurity system. Specifically, MPI establishes the policy framework, delivers effective interventions across the system and encourages participation and collaborations of effort for improved outcomes. Key provisions and regulatory mechanisms available under the Biosecurity Act (1993) include national policy direction, national and regional pest management plans, national and regional pathway management plans, government-industry agreements, craft risk management standards, controlled area restrictions, small-scale management programmes and unwanted organism declarations (Sinner *et al.* 2013). The government has overall responsibility for funding biosecurity, but the success of New Zealand's biosecurity system is contingent on active participation and collaboration by industry (Biosecurity Council 2003). New Zealand's biosecurity system covers activities at the pre-border, border and post-border stages that target different elements of risk in the invasion process.

The Resource Management Act 1991 (RMA) and the New Zealand Coastal Policy Statement (NZCPS) also play significant roles in the management of NIS. A recent review of New Zealand's statutory and legal framework concerning marine biosecurity is provided by Sinner *et al.* (2013).

3.2. Existing biosecurity risk management measures relating to shipping

A number of measures are in place to reduce biosecurity risks associated with the arrival of international vessels in New Zealand. These are outlined below.

3.2.1. Ballast water management

New Zealand is a signatory to the International Maritime Organization's (IMO) *International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004* (Ballast Water Management Convention; BWMC) (IMO 2005). The BWMC aims to minimise the risks posed by the transfer of harmful marine organisms and pathogens via ships' ballast water and sediments. More signatures are required before the BWMC comes into force internationally. However, New Zealand has already given effect to some of the BWMC provisions by implementing an Import Health Standard (IHS) for Ships' Ballast Water from all Countries under section 22 of the Biosecurity Act 1993. With the exception of emergency situations, this IHS requires that no ballast water originating from territorial seas outside of New Zealand may be discharged into New Zealand waters without approval from MPI (IHS 2005).

3.2.2. Craft Risk Management Standard

Until recently, hull fouling was a largely unmanaged pathway for marine species translocations into and within New Zealand. In 2014, MPI introduced a Craft Risk Management Standard (CRMS) that incorporates 'hull hygiene' and biofouling management requirements for vessels entering New Zealand territorial waters (MPI 2014). The CRMS requires all vessels to complete a biofouling declaration prior to entering New Zealand and to arrive with a 'clean hull' in accordance with specified biofouling thresholds. There are two different thresholds. 'Long-stay vessels' (vessels staying in New Zealand for > 20 days) are not allowed to arrive with more than a slime layer and goose barnacles on their entire submerged hull surface. 'Short-stay vessels' (vessels staying ≤ 20 days) are allowed to have more fouling, but it is restricted to macroalgae and very low abundance of one type of sessile animal biofouling such as barnacles, tubeworms or bryozoans. The CRMS has a 4-year voluntary lead-in period and will come into force in May 2018. The lead-in period is intended to allow for the development and implementation of improved biofouling management technologies and practices within the shipping industry.

The CRMS can also be met via one of the following acceptable measures:

1. Complete hull clean within 30 days prior to arriving to New Zealand or within 24 hours following arrival.
2. Continual maintenance using best practice (application of appropriate antifouling coatings; operation of marine growth prevention systems in sea-chests; in-water inspections with biofouling removal as required). Following the IMO Biofouling Guidelines (IMO 2011) is recognised as an example of best practice.
3. Application of approved treatments for hull areas with biofouling. However, to date no approved treatments are listed on the MPI website.

As an alternative to the acceptable measures listed above, vessel operators can submit a Craft Risk Management Plan for MPI approval that outlines the steps to be taken to reduce biosecurity risk to an equivalent degree as meeting the requirements of the CRMS (MPI 2014).

The ballast water IHS and the CRMS target biosecurity risks associated with international vessel arrivals. Risks posed by domestic vessel traffic remain largely unmanaged, although there is a growing national and regional interest in managing domestic pathway risks (Sinner *et al.* 2013).

3.2.3. Nationwide high-risk site surveillance

Since 2002 the government has funded a national port surveillance programme ('Marine High-Risk Site Surveillance') that searches for several high-risk target species (some of which are designated as unwanted organisms under the Biosecurity Act 1993) that have the potential to threaten New Zealand's marine environment and economy. The current target list includes five primary species (not yet established in New Zealand) and four secondary species (already established in New Zealand) (Morrisey *et al.* 2014). Biannual surveys are carried out in and around 11 of the country's main shipping ports (Whangarei, Auckland, Tauranga, Taranaki, Wellington, Nelson, Lyttelton, Otago and Bluff) and marinas (Opua, Picton / Havelock). The objective of this programme is to detect new incursions at low abundances to maximise the chances for successful eradication or control measures.

3.3. Non-indigenous species present in Lyttelton Harbour

A baseline biological inventory was carried out at the Lyttelton Port in 2002 as part of a government initiative to survey major shipping ports and marinas in New Zealand (Inglis *et al.* 2006). These surveys included a range of sampling methods targeting available habitats (*e.g*. soft-sediment port basin, pilings, pontoons, breakwalls). A repeat inventory survey of Lyttelton Port was undertaken in 2004 (Inglis *et al.* 2008). Together these surveys represent the most comprehensive biological inventories of the Port and their reports also summarise earlier surveys and their results. Collectively, these surveys identified a total of 27 NIS from the habitats within the Port. Two of these species, the Asian kelp *Undaria pinnatifida* and the ascidian *Styela clava* are designated as unwanted organisms (Figure 1). Today, both species have distributions that include the South and North islands. The survey also detected 55 'cryptogenic' species whose biogeographic origin and status in New Zealand was at the time not known.

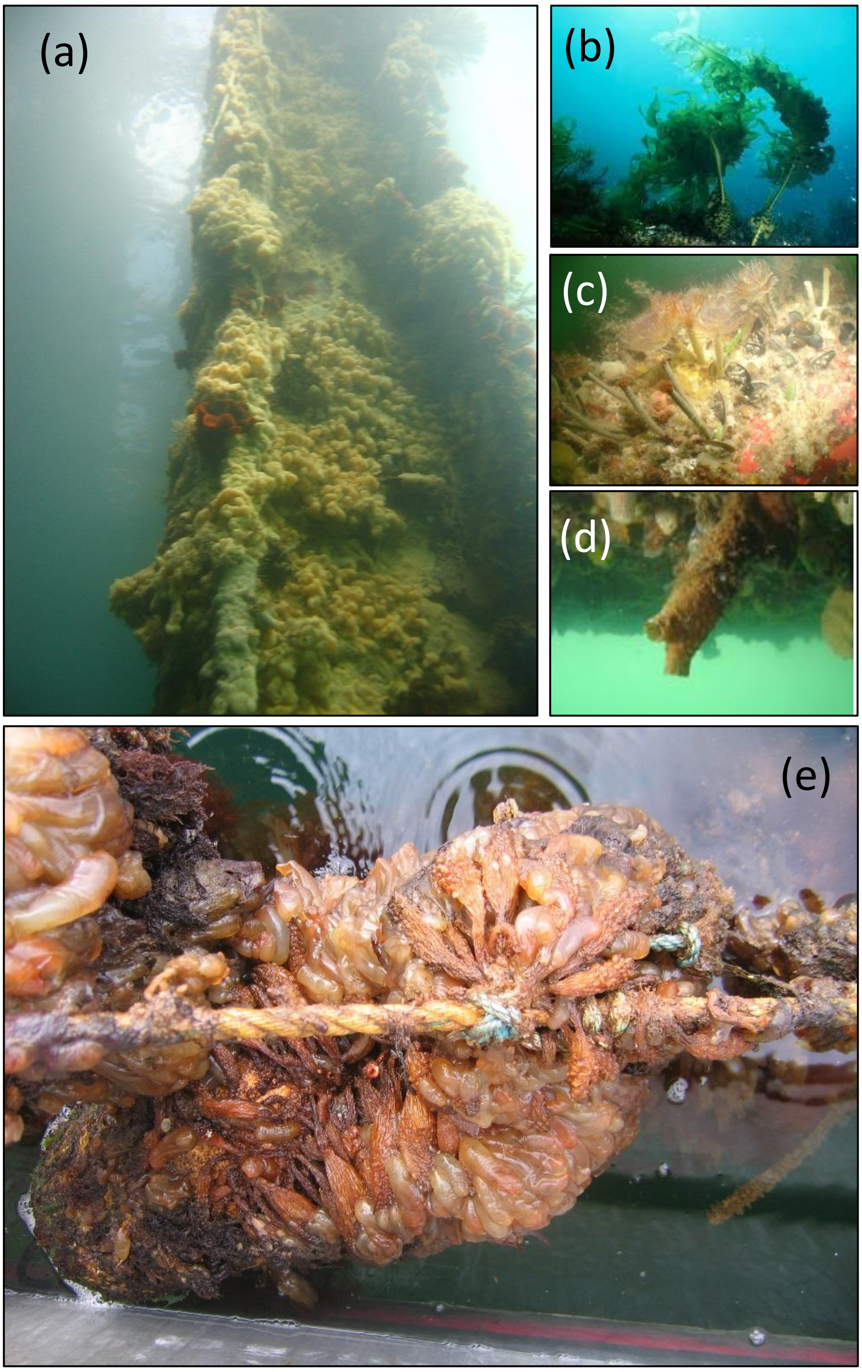

Figure 1. (a) Fouled wharf pile (image: A. Coutts), (b) *Undaria pinnatifida* (image: daff.gov.au), (c) *Sabella spallanzanii* (image: MPI), (d) *Styela clava* (image: Barrie Forrest), (e) *Styela clava* and *Ciona intestinalis* biofouling on mussel farms (image: Barrie Forrest).

Subsequent to the port baseline survey, the Mediterranean fanworm *Sabella spallanzanii* was detected on a wharf pile in Lyttelton Port in March 2008, during Marine High-Risk Site Surveillance (see Section 3.2.3). *Sabella* is one of the primary target species of this programme and is designated as an unwanted organism

(Morrisey *et al.* 2014). During a subsequent government-funded interim measures programme, considerable densities of adult and juvenile *Sabella* individuals were encountered within the Port. An attempt was made to eliminate the species locally. In June 2010, after the discovery of *Sabella* in Waitemata Harbour, the elimination programme in Lyttelton was terminated. During subsequent surveillance rounds, *Sabella* continued to be encountered in Lyttelton Port but at progressively lower abundances. During the 2013 winter surveillance round, only three individuals were detected within the Port (one on a vessel in Dampier Marina and two on Z-Berth). No fanworms were detected during the 2013 summer and 2014 winter surveillance rounds (Morrisey *et al.* 2014).

In summary, Lyttelton Harbour presently has numerous NIS, including some high-profile pest species. It is expected that over time, more NIS will arrive and become established in the region, either from international vessel movements or via domestic spread from other NIS populations in New Zealand. The rate of new NIS introductions will be determined by the success of pre-border efforts (*i.e*. the CRMS for biofouling and IHS for ballast water) and regional initiatives (*e.g.* risk pathway management). Given that LPC is a major industry in this environment, it makes sense that their activities align with central and regional government efforts to manage existing and future marine biosecurity risks, as discussed in the next sections.

4. DESCRIPTION OF LYTTELTON PORT OF CHRISTCHURCH PROJECT ACTIVITIES RELEVANT TO MARINE BIOSECURITY

The projects involved in the Lyttelton Port Recovery Plan incorporate a range of activities and form four distinct groups:

- Group A projects (Reclamation and Container Terminal)
- Group B projects (Cashin Quay)
- Group C projects (Inner Harbour)
- Cruise Berth Options

These activities are briefly outlined in this section, in accordance with the level of detail currently available. The location of these developments is shown in Figure 2.

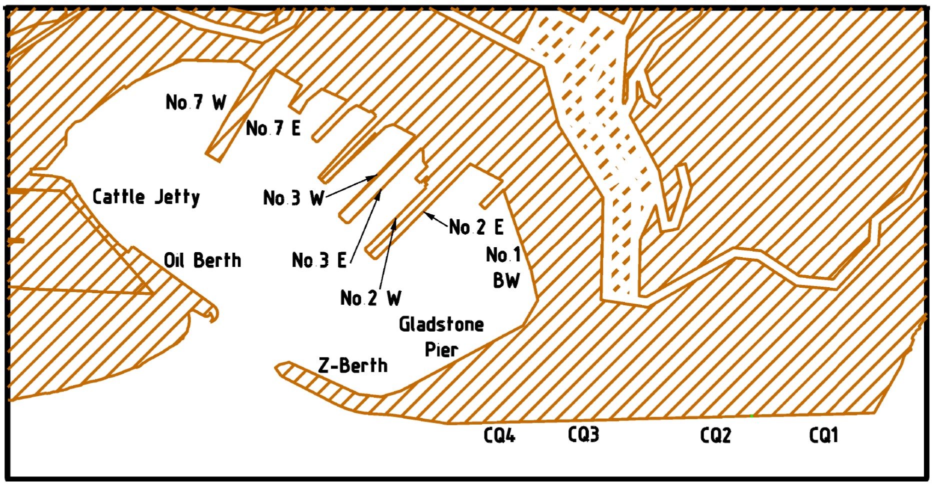

Figure 2. Map of the Port of Lyttelton showing the location of existing berthing facilities. Note this map excludes the proposed container and cruise ship terminals.

4.1. Group A projects (Reclamation and Container Terminal)

The reclamation will be developed using a range of methodologies, which will be influenced by the type and quantity of available fill. It will initially move in a southern direction to enable the construction of a new berth line, which facilitates the development of the first stage of a terminal in behind this. It is anticipated that this part will comprise approximately 8 ha directly south of the currently consented 10 ha area and would be constructed from quarry sourced hardfill (Gollans Bay quarry and / or Sumner Road reopening works), end-tipped in a similar way to the current 10 ha.

Land creation would then focus on moving in an easterly direction, and it is likely that a combination of hard and marine fill will be utilised. This area could be as much as 19 ha, and may require the construction of a containment bund if marine fill is to be utilised. Aggregate would need to be imported to form the foundation of the pavement layers. This then enables the extension to the east of the adjacent new berth line, and subsequent development of a container terminal in behind this.

This staged methodology will provide for the creation of critical additional container terminal capacity at the earliest opportunity.

The new terminal will include a container-handling yard connected to two modern berths designed to handle larger vessels. These are typically 6,000 twenty-foot equivalent units (TEU) vessels that are approximately 300 m long and have a draft of up to 14.5 m. The berths will be constructed in two stages and at full completion up to eight cranes could be used to serve two vessels.

Projects A01, A02, A03: Land reclamation

These three projects will involve the reclamation of a total of ~37 ha of land around the area of the current Coal Terminal. Detailed design is yet to be undertaken; it is assumed that it will involve either a rip-rap wall or a solid seawall.

Project A08: Terminal Development – Wharf

This project will involve the construction of two 350 m wharves along the proposed reclamation areas (A02, A03) with a width of ~35 m. Detailed design is yet to be undertaken. Based on the design of other wharves around Lyttelton Port and other large port facilities around New Zealand (*e.g*. Port Otago, Port Tauranga), it is assumed that the wharves will incorporate an array of steel or concrete pilings below an upper platform.

4.2. Group B projects (Cashin Quay)

Cashin Quay will continue to handle containers in the medium term, however, after the container handling facilities are established in Te Awaparahi Bay, Cashin Quay's focus will change to one of general, bulk and break bulk cargos such as logs, fertiliser, and scrap metal. Coal activities will continue at Cashin Quay berth No.1.

Projects B01, B02, B03: Cashin Quay rebuild and repair

These three projects will involve the demolition and reconstruction of Cashin Quay wharves 2, 3 and 4. Activities of relevance to biosecurity will include removal of existing structures, seabed excavation, and installation of new pilings and other foundations in the subtidal and intertidal zones.

Project B05: Cashin Quay seawall

Due to settlement during the earthquakes, the seawall associated with the Cashin Quay berths needs to be re-established to its original elevation above sea level. Detailed design is yet to be undertaken but it is assumed that this will involve partial replacement of the existing seawall, including submerged sections below sea level.

Project B07: Cashin Quay 1

Detailed design is yet to be undertaken. It is assumed that any required repairs will involve activities similar to projects B01, B02, B03 and B05.

4.3. Group C projects (Inner Harbour)

The eastern part of the Inner Harbour (from Wharf No.3 eastwards) will continue to be part of the Port operational area. However, the cargo handling operations will shift towards those which are less noisy and dusty (these will be moved to Cashin Quay). Cement ships, some break bulk cargo, car vessels and the larger fishing vessels are likely to use this area as would the tugs and other support vessels used by LPC.

The development of Dampier Bay with a mixed use commercial development and marina is anticipated to commence early on in the recovery. This will allow for community access to the waterfront with an emphasis on activities that have wide appeal. The proposed waterfront promenade will also facilitate better connectivity between Lyttelton township and the recreational areas at Naval Point. The first phase of the Dampier Bay development involves the construction of a modern floating pontoon marina catering for up to 200 berths. Phase 1 will also include developing the landside adjacent to the marina with car parking, marina facilities, walkways and some commercial development. This is expected to be completed in 2016 / 2017.

Project C01: No. 1 Breastwork

This project will include the partial or full demolition of the existing wharf deck and the removal of piles, and will involve the excavation, re-grading and rock armour replacement of the entire seawall and batter slope. The wharf and its associated infrastructure will then be replaced. This will involve the installation of approximately 30 pilings prior to the construction of a wharf deck.

Project C06: Oil Berth

This project will include the partial or full demolition of the existing wharf deck and the removal of piles. The current proposal involves the relocation of the wharf to 22 m seaward from the existing berth line and the construction of a new wharf to accommodate bulk fuel vessels. This will likely include the installation of approximately 48 piles and a wharf deck.

Project C08: Marina

Dampier Marina currently provides pile moorings for resident recreational vessels. This project will involve the construction of a floating pontoon marina with estimated 200–300 berths. No details on the design are available but, based on the layout of similar marinas around New Zealand, the proposed facility will involve the installation of floating 'finger wharves'. These generally consist of concrete-hulled pontoons that move up and down with the tides and that are held in place by wood, steel or concrete piles.

Projects C09 (Jetty 7), C10 (Jetty 2) and C11 (Jetty 3)

These projects will include the partial or full demolition of existing wharf decks and the removal of piles. The seawalls and batter slopes require remedial works that will likely involve the partial or full excavation and subsequent re-instatement of the existing seawalls.

Project C12: Demolition of Jetties 4, 5, 6

This project will include the full demolition and removal of these facilities. There are no plans to replace them.

4.4. Cruise Berth options

Lyttelton Port of Christchurch is considering options for developing a dedicated cruise ship terminal for the Port, and is investigating two alternative designs. Each of these would enable the Port to accommodate cruise ships of 180 m–350 m in length.

Option 1: Gladstone Pier berth

This option would require the removal of Z-Berth and associated eastern mole to provide access to Gladstone Pier for large cruise vessels, and would require dredging and deepening around Gladstone Pier and surrounding areas.

Option 2: Naval Point fixed-access berth

This option would involve the westward extension of the current swing basin and Inner Harbour approach. Visiting cruise vessels would dock to a concrete pier that extends approximately 90 m from the shoreline off Naval Point. The pier is associated with berthing and mooring dolphins along its length and will be built upon a foundation of steel or concrete piles.

5. ASSESSMENT OF MARINE BIOSECURITY RISKS

5.1. Description of biosecurity risks

There are several potential biosecurity risks associated with LPC's proposed projects, for both the construction phase and the final operational phase of the post-recovery Port facilities. Broadly speaking, these risks arise through:

- The replacement and expansion of submerged port infrastructure and the operational activities (including specialised vessel movements) involved during the construction phase.
- The potential changes in the frequency and geographic origin of shipping associated with the Port's post-recovery ability to accommodate larger and different vessel types during routine operations.

Table 1 outlines the risks identified and which of LPC's proposed projects and phases they apply to.

Table 1. Potential biosecurity risks associated with the construction and final phases of the proposed projects. CST = Cruise Ship Terminal.

Potential biosecurity risk	Applies to projects	Construction phase	Final (operational) phase
Increased spread of established non-indigenous species during removal of infrastructure	B01, B02, B03, B07, C01, C06, C08, C09, C10, C11, C12, CST1	✓	
Increased abundances and spread of non-indigenous species from the installation of new artificial habitat	A01, A02, A03, A08, B01, B02, B03, B05, B07, C01, C06, C08, C09, C10, C11, CST1, CST2, CST3	✓	✓*
Increased abundances and spread of non-indigenous species via dredging and spoil disposal	A08, B01, B02, B03, B05, B07, CST1, CST2, CST3, CST4	✓	
Introduction of new NIS through the involvement of specialised vessels or equipment sourced from overseas	A01, A02, A03, A08, B01, B02, B03, B05, B07, C01, C06, C08, C09, C10, C11, C12, CST1, CST2, CST3, CST4	✓*	
Increased establishment or spread of non-indigenous species via changed vessel patterns	A08, CST1, CST2, CST3, CST4		✓
Increased spread and establishment of non-indigenous species due to altered hydrodynamic conditions	A01, A02, A03, CST1		✓

* These are possible risks during construction or longer-term operations that depend on project-specific details that are not yet known.

5.2. Construction phase

5.2.1. Increased spread of established non-indigenous species during removal of infrastructure

Disturbance or dislodgement of NIS on piles, pontoons or other structures during removal can result in the release of individual organisms or fragments, as well as propagules (*e.g.* gametes or larvae) if timing coincides with a species' reproductive season (Minchin & Gollasch 2003; Coutts *et al.* 2010). A large synchronised pulse of propagule release during concentrated repair works could promote fertilisation rates (Inglis & Gust 2003) and population expansion of NIS. Additionally, the colonisation of adjacent boats and other transport vectors may be enhanced, leading to human-mediated spread beyond the immediate area. However, it is difficult to quantify the biosecurity risks arising from these activities but they are likely to be minimal. Non-indigenous species potentially affected will already be established in the port, and it is unlikely that their abundances would appreciably change as a result of the proposed activities. The potential for an increase in the risk of the domestic spread of these NIS via increased colonisation of resident vessels is unclear and will also be influenced by other environmental factors.

5.2.2. Increased abundances and spread of non-indigenous species from the installation of new artificial habitat

Artificial substrates such as pilings, pontoons and seawalls are known to provide very good habitats for biofouling assemblages and often have an over-proportional representation of NIS (Connell & Glasby 1999; Connell 2000; Glasby *et al.* 2007; Dafforn *et al.* 2009). Rip-rap walls are usually more impoverished and support less diverse assemblages but in some cases, they also feature extensive populations of fouling pests (Chapman & Underwood 2011; Forrest *et al.* 2013). During several different recruitment studies within Lyttelton Port, vacant settlement panels immersed in a range of Inner Harbour locations were frequently colonised by NIS, particularly the ascidian *Ciona intestinalis* (Inglis *et al.* 2009). In fact, maintenance activities on artificial structures and the addition of new structures tend to favour invasive and opportunistic species (Airoldi & Bulleri 2011). Thus it is likely that new submerged structures installed within the Port will provide a settlement habitat for the local NIS propagule pool.

There are differences in the 'attractiveness' to biofouling species of different construction materials typically used in ports, and this is reflected in the community composition. For example, wood is known to be a poor surface for biofouling assemblages (Harriot & Fisk 1987; McGuinness 1989) and many of the wooden piles on Cashin Quay wharves 1 and 2, for example, support relatively sparse assemblages (mainly *Undaria*, barnacles and colonial ascidians). In contrast, adjacent concrete and steel piles on wharves 3 and 4 are generally more overgrown and feature a higher diversity of biofouling organisms (pers. obs. O Floerl 2004–2008). With the exception of wharves 3 and 4, almost all of the piles around the Port are made from Australian hardwood (Inglis *et al.* 2008). The replacement piles are likely to be made from steel or concrete and the increase in availability and quality of vacant artificial habitat will likely provide an opportunity for the expansion of existing NIS populations within the Port (Carlton 1996).

Some of the proposed projects will replace damaged infrastructure (*e.g.* many of the Group-B projects), while others will install new habitat that was previously not there. For example, the two 350 m berths associated with the proposed container terminal (A08) will likely require the installation of new piles and seawalls. Similarly, the new marina in Dampier Bay (C08) will comprise a relatively large surface area of floating pontoons (*i.e*. ideal habitat for NIS). In contrast, the demolition of wharves 4, 5 and 6 will result in a loss of artificial habitat. Following completion of all proposed projects, the Port may comprise a larger surface area of artificial habitat than it currently does. However, the extent of this increase can currently not be determined.

Soon after construction, the newly available habitat will be prone to colonisation by the local propagule pool. It is possible that a lack of an established community on these structures could increase establishment success of new NIS arriving on domestic or international vessels (Stachowicz *et al.* 1999; Davis *et al.* 2000). The likelihood of this occurring is very difficult to predict due to the stochastic (*i.e.* probabilistic) nature of invasions and the large number of factors that determine invasion success.

Whether the provision of new artificial and vacant habitat during the construction phase leads to increased abundances of NIS will depend on the actual extent of habitat increase. Any increase in the abundances of NIS will potentially lead to an increased propagule supply if there are more reproductive individuals in the population. While many elements of the invasion process are stochastic and difficult to predict, propagule pressure (the frequency with which NIS or their propagules are introduced to a habitat, and the number that arrive with each introduction event) has been demonstrated as an important determinant of establishment success (Hedge *et al*. 2012). The possible ‘downstream’ outcomes are similar to that described in the preceding section; that is, an increased natural or human-mediated spread of NIS.

A related consideration is the importance of not inadvertently introducing NIS associated with any ‘second-hand’ materials that might be used in construction. For example, leased pontoon transfers around Waitemata Harbour possibly contributed to initial spread of the sea squirt *Styela clava* in that region (Gust *et al.* 2008). From discussions with LPC we understand that only new materials will be used. If not, mitigation measures to address this risk are described in Section 5.4.1.

5.2.3. Increased abundances and spread of non-indigenous species via dredging and spoil disposal

Some of the proposed projects are expected to require dredging of seabed sediment, and spoil transfer to the currently consented spoil disposal ground in Lyttelton Harbour. The associated biosecurity aspects to consider are the inadvertent transfer of NIS present in the dredge location to the spoil disposal grounds, and alteration and disturbance of the seabed by dredging and spoil disposal, which may increase the susceptibility of seabed habitats to colonisation by NIS. A concurrent report being prepared for LPC describes a large capital dredging proposal to deepen the outer Harbour channel, for which the biosecurity risk from dredging and spoil disposal were assessed as minor (Sneddon *et al.* 2014). This capital dredging proposal is relevant to the Port Lyttelton Recovery Plan although the extent of dredging required is yet to be determined. We expect that biosecurity issues associated with dredging will be minor, for similar reasoning put forward by Sneddon *et al*. (2014).

Key factors that mitigate risk are:

1. the likely similarity in depth and sediment textural characteristics (primarily mud sediments) between the dredged areas and disposal ground.
2. the fact that the disposal ground is relatively close to the Port, being situated adjacent to the northern shoreline of the Harbour between Gollans Bay and Godley Head.

Many marine NIS capable of living in soft-sediment habitats would be able to spread naturally to the disposal ground and the timeframe of such spread would depend on their dispersal characteristics. It is also relevant that the presumably limited extent of dredging required under this proposal will represent a small increment to the present situation, in which maintenance dredging of the existing channel has been ongoing in Lyttelton Harbour for over a century. A more in-depth discussion of these issues can be found in Sneddon *et al*. (2014).

5.2.4. Introduction of new non-indigenous species through the involvement of specialised vessels or equipment sourced from overseas

During construction activities, it is possible that LPC will source specialised vessels (such as dredges, barges) and equipment from overseas that could pose a marine biosecurity risk. Given the scope of works, such vessels are likely to operate around Lyttelton Port for a considerable period of time (weeks to months). Barges and dredge vessels are typically slow-moving and their travel history is characterised by long residency periods at previous destination ports. Because of this operational profile, they tend to accumulate higher levels of fouling biomass compared with faster moving vessels (*e.g*. container ships) that tend to stay in port for shorter periods (hours to days, usually < 1 week). Biofouling on slow-moving and towed vessels often contains marine NIS (Hopkins *et al.* 2013; Bridgwood & McDonald 2014).

Specialised vessels also tend to have a large number of 'niche areas', which could pose a higher level of biosecurity risk than the hull proper. The term 'niche areas' refers to the 'nooks and crannies' of the hull that tend to readily accumulate biofouling or may trap sediment and water. Some niche areas do not receive antifouling treatments during dry-docking, or the antifouling coating is subjected to excessive wear. Some niche areas provide relatively sheltered environments for marine growth, for example, 'sea chests' are recesses in the hull that house pipework for taking water on-board. These can contain considerable biofouling and mobile organisms such as crabs, fish and sea stars (Coutts & Dodgshun 2007; Frey *et al.* 2014).

There have been several high-profile examples where slow-moving vessels and equipment have transported a high biomass of biofouling NIS into a new region. This, coupled with an extended residency period, resulted in a new incursion in the region. For example, the arrival of an extensively fouled barge in Picton from Tauranga caused the initial introduction of the ascidian *Didemnum vexillum* to the Marlborough Sounds region (Coutts & Forrest 2007). Similarly, an international barge with high abundances of *Sabella spallanzanii* on its hull was found moored in Waitemata Harbour and implicated as the initial source of introduction to the Auckland region (Hopkins & Forrest 2010; Read *et al.* 2011).

Other transport mechanisms (*e.g*. ballast water, residual dredge spoil) associated with specialised vessels can also pose a biosecurity risk. As with hull fouling, these risks should be managed to the extent feasible. Accordingly, if specialised vessels are expected to be brought into Lyttelton for any of the projects, especially overseas vessels, there should be careful attention to risk mitigation (see Section 5.3.2).

5.3. Operational phase

5.3.1. Increased abundances of non-indigenous species from the installation of new artificial habitat

In Sections 5.2.2, 5.2.3 and 5.3.4 we described scenarios by which construction activities could give rise to increased abundances of NIS. Some of these same factors are relevant when considering the longer term post-construction effects of the projects. In particular, NIS abundances would increase from the present situation if the amount of surface area of artificial habitat available for biofouling has increased, or the recovery work used materials that might be more suited to NIS (*e.g.* concrete vs wooden piles). Hence, the same issues arise, leading to an increased potential for natural and human-mediated spread of NIS from Lyttelton Port. These are issues that are recognised with any coastal development involving the installation of artificial habitats. As we discuss in Section 5.5, mitigation possibilities theoretically exist, but they are currently not controlled through the Regional Coastal Plan and their detailed discussion is beyond the scope of this report.

5.3.2. Increased establishment or spread of non-indigenous species via changed vessel patterns

Lyttelton Port is one of New Zealand's busiest shipping ports, with over a thousand domestic and international commercial vessel arrivals each year (LPC 2014). Between 2002 and 2005, Lyttelton Port had 654 overseas arrivals of vessels of > 99 gross tonnes from 44 different countries and representing most regions of the world (Inglis *et al.* 2008). In 2014, the Port handled 376,567 TEUs and 4.5 million tonnes of other cargo (LPC 2014). The construction of two large (350 m long) berths at the new container facility (Project A08), a dedicated cruise ship terminal and a new enlarged marina (C08) within the Inner Harbour are all likely to increase the frequency of vessel movements to and from Lyttelton Port.

At the time of writing, it was unknown to what extent the proposed projects will change the number of departures and arrivals to and from Lyttelton Port. However, an increase in volume of vessel traffic has the potential to increase the risk of spreading NIS from Lyttelton Port to domestic destinations, as well as the Port being at greater risk of receiving species from elsewhere (Floerl *et al.* 2009). If there is an increase in the frequency at which a NIS is introduced to Lyttelton Port, the likelihood that this species will eventually become locally established may increase correspondingly (Drake & Lodge 2004). In fact, increasing the frequency of introduction events has been found to be of higher relative importance to establishment success than increasing the average abundance of individuals associated with each introduction event (Hedge *et al.* 2012).

The proposed projects will also result in Lyttelton Port being able to accommodate Quantum class cruise vessels and Maersk S-Class container vessels. Both vessel types have lengths of ~350 m and draft 9 m–14 m. Compared to today, this will represent an increase in the size of vessels the Port is able to service on a routine basis. The larger submerged surface area of these vessels potentially enables a greater abundance of organisms to be transported to Lyttelton Port with each visit. Generally, however, the levels of fouling on such vessels are likely to be low. Also, the ability to accommodate larger vessels may result in Lyttelton Port receiving vessels from a new set of global ports that it has not traded with previously (New Zealand Shippers' Council 2010; Floerl *et al.* 2013). This could result in the transport of novel species to Lyttelton Port. However, as stated above, the Port is already well connected to a large number of regions via present-day shipping activities (Figure 3) and, like Lyttelton, overseas ports themselves are also highly connected. Without knowledge of specific changes in vessel origins it becomes purely speculative how biosecurity risk may change. Nonetheless, it is reasonable to assume that an increase in the vessel traffic (and possibly different types of vessel), as well as a change in the geographical origin of vessels arriving in the port, has potential to pose a significant biosecurity risk to the region.

As described in Section 5.4.2, a lot of the increased traffic volume is likely to arise after 2018, when the CRMS will be mandatory. This will considerably reduce the biosecurity risks posed by biofouling on international vessels. It is currently not known whether and to what extent biosecurity risk pathways associated with domestic shipping will be managed at this time (Sinner *et al.* 2013), nor whether domestic pathways into Lyttelton Port will change. However, the issue of inter-port pathways and associated marine biosecurity risk is relevant to all regions of New Zealand. Effective domestic risk pathway management will require all regions to adopt a consistent approach for effective risk reduction.

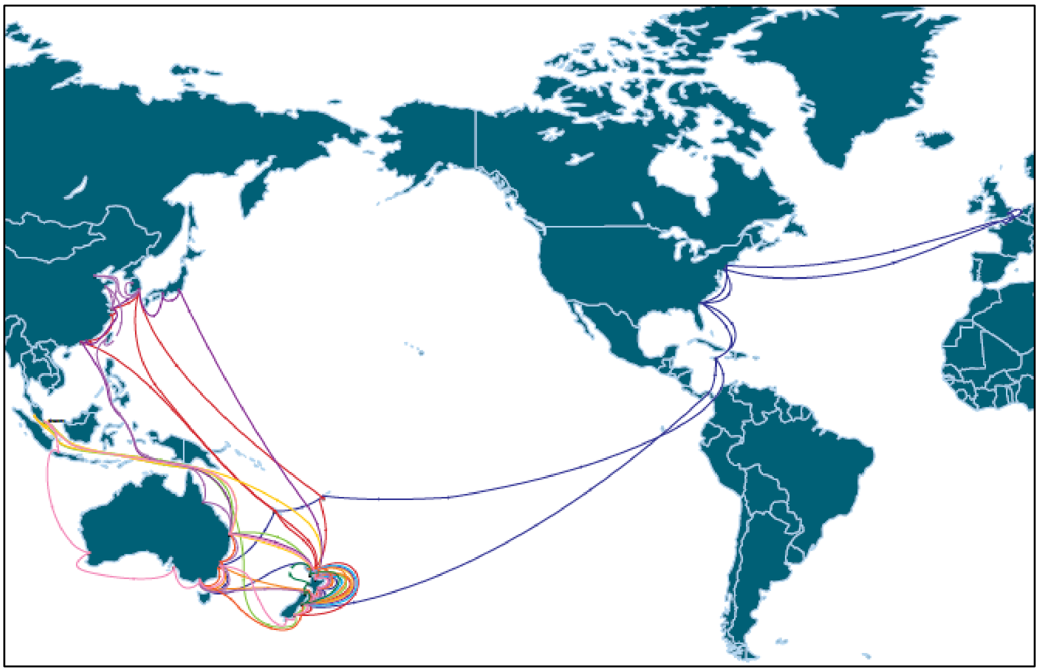

Figure 3. Direct connections of Lyttelton Port to other domestic and international ports. Source: Lyttelton Port of Christchurch Limited (2014).

5.3.3. Increased spread and establishment of non-indigenous species due to altered hydrodynamic conditions

Some of the proposed projects are predicted to have an effect on local hydrodynamics. For example, Group A projects A01–A03 (with added breakwater option) would result in a 50% decrease in tidal current velocities around parts of the new container terminal and Cashin Quay, to about 0.05 m/s (Goring 2014). The ability of planktonic propagules to settle in low or high current velocities differs between marine taxa. However, in both natural environments and coastal port and marina systems, higher rates of biofouling development have been observed in areas of low current flow. This has been evident particularly where water masses are entrained by eddy systems (see Floerl & Inglis 2002, and references therein). Theoretically, a decrease in current velocities around the new container terminal might favour increased rates of recruitment of biofouling organisms, including NIS propagules released from visiting vessels. However, due to the variation in settlement preferences and behaviour between marine taxa it is not possible to deduct reliable estimates of risk for this scenario.

Conversely, the removal of Z-Berth associated with Option 1 of the new cruise ship terminal (Gladstone Pier Berth) would approximately double wave action and tidal currents within parts of the Inner Harbour (Goring 2014). Rates of recruitment of marine invertebrates within Lyttelton Port are spatially variable but can be considerable (Floerl 2009). The increase in tidal current within the Inner Harbour and the increased width of the approach to the Inner Harbour could result in an increased exchange of water and increased export of planktonic propagules (including those of NIS) from the Port to adjacent natural habitats. However, even a doubling of tidal currents within the Inner Harbour would result in relatively low flow velocities (~0.1 m/s, Goring 2014), and the presence of any effect on propagule export to adjacent natural environments would probably be of little significance in the context of the dispersal potential of most marine organisms.

5.4. Biosecurity mitigation options and recommendations

5.4.1. Overview

Based on the assessment above, the key marine biosecurity risks to consider from a mitigation perspective are those arising from altered movements of international vessel traffic during the construction and operational phases. We also describe approaches to infrastructure design that LPC could consider to mitigate possible long-term risks from the creation of new habitat; however, **these are ideas for further investigation rather than recommendations for mitigation.**

The other sources of biosecurity risk discussed above and summarised in Table 1 are either of minimal significance or in some cases cannot be practically mitigated. One exception relates to the materials used in construction. LPC advised that new materials (*e.g.* new piles, pontoons) will be used, but in the event that 'second hand' materials are sourced from outside the region, they should be appropriately treated to ensure that they are free of biofouling before they are re-deployed. Some of the biosecurity risks associated with removal and construction work can theoretically be mitigated by timing these activities outside the reproductive seasons of risk species (Airoldi & Bulleri 2011). However, we considered that this was not practical in this instance given that known risk species in Lyttelton are reproductively active at different times of year, and in some cases year-round (*e.g*. *Undaria*).

5.4.2. Mitigating construction risk of introduction of new non-indigenous species through the involvement of specialised vessels or equipment sourced from overseas

After 2018, biosecurity risks posed by overseas vessels (including specialised vessels) are likely to be largely mitigated by the new CRMS for biofouling and the existing IHS for ballast water (see Section 3.2). Prior to 2018, we recommend that any specialised vessels sourced from overseas to support the repair and construction works (such as barges, dredges, crane vessels, pile-driving vessels, and other types) should comply with the CRMS and be required to prepare and submit a marine biosecurity management plan (MBMP) to MPI for approval. Depending on the maintenance and voyage history of the vessels, MBMPs can involve risk profiling, hull inspections and treatment of biofouling or internal systems to minimise biosecurity risk. This mitigation measure has been discussed with LPC and is targeted at specialised vessels involved in construction activities related to the Lyttelton Port Recovery Plan. It is not targeted at regular commercial vessel traffic occurring during this period. The IHS for ballast water is currently in place and will address corresponding risks. This approach is consistent with the recommendations made for LPC's capital dredging proposal (Sneddon *et al*. 2014).

5.4.3. Mitigating operational risk of increased establishment or spread of non-indigenous species via changed vessel patterns

From 2018, biosecurity risks posed by overseas vessels will be addressed by the mandatory CRMS (addressing biofouling) and the existing IHS for ballast water (see Section 5.4.2). To minimise the risk of domestically spreading NIS, LPC should work closely with regional biosecurity initiatives (see Section 3). This could include promoting good biosecurity practices with both commercial and domestic shipping companies and ensuring that the new Inner Harbour marina actively promotes hull hygiene to customers.

5.4.4. Consideration of infrastructure design to address long-term risks from the creation of new habitat

Preventing the establishment of NIS on new structures at the Port is a challenging undertaking; however, there are several options that LPC could consider. One of these is whether new infrastructure can be designed using materials that are less prone to excessive biofouling, or designed in a way that minimises the surface area for biofouling. As an example, in wharf construction a concrete wall may present less surface area for fouling than a pile wharf, and have the added benefit of enabling greater efficacy for marine surveillance or pest management.

There are a number of other approaches to mitigation for biofouling and NIS on artificial structures that are currently the subject of ongoing or proposed research at Cawthron and elsewhere. These include biocontrol (Atalah *et al.* 2013b; Atalah *et al.* 2014), novel antifouling surfaces (Cahill *et al.* 2013) and mechanical treatment approaches (Bullard *et al.* 2010). For example, recent trials on biocontrol using native grazers and predators have shown that these species can be effective at reducing biofouling development or even reduce the biomass of existing assemblages. This shows potential for reducing biosecurity risk. However, despite promising progress and ideas, there are currently no solutions for control of biofouling and NIS on artificial structures that have been developed and applied at an operational scale. **The ideas presented in this section therefore represent relevant opportunities for LPC rather than recommendations for mitigation related to the proposed projects.**

5.5. Other considerations and suggestions

When the CRMS becomes mandatory in 2018, international vessels not meeting the strict hull hygiene requirements will require local options for treatment and mitigation. Therefore, we recommend that LPC considers a dedicated biosecurity 'treatment berth' or at least an operational framework that will support swift and effective risk management (including inspections and treatment) of visiting, non-CRMS-compliant international vessels that might be on tight time budgets (CRMS requires treatment within 24 hours of arrival). Such a framework would include considerations or planning for suitable treatment locations for a range of vessel sizes (*e.g.* access to a travel lift, slipway, dry-dock, wharf-side), access for treatment equipment (power and water supply, waste reception facilities) and identification of how LPC could support effective treatment operations via infrastructure or operations.

It might be worthwhile for LPC to consider developing a marine biosecurity strategy that includes the proposed remediation of earthquake damage, as well as the ongoing development of biosecurity risk mitigation initiatives. The purpose of such a strategy would be to ensure that efforts were well planned, streamlined and work towards common goals, including those of regional and central government (*e.g.* new structures could be explicitly included in MPI's Marine High-Risk Site Surveillance Programme). The development of the strategy would benefit from input by local stakeholders (including iwi) so that shared goals can be identified (*e.g.* the protection of mahinga kai in the region) and a range of approaches to reach these goals considered. Development of a marine biosecurity strategy is consistent with the recommendations of the Cultural Impact Assessment associated with the proposed projects (Jolly *et al*. 2014). Like any strategy document, it would require regular updating to ensure that it remained relevant. Ideally, other ports in New Zealand would develop similar plans (if they have not already done so) and that there would be consistency and coordination between companies and/or regions.

The measures mentioned above have been discussed with LPC and it has been affirmed that they represent practical and strategic recommendations, not suggested requirements.

6. CONCLUSIONS

Lyttelton Port of Christchurch is proposing a series of projects to address damage to port infrastructure caused by the Canterbury earthquakes and to reconfigure and enhance part of the Port's operations. A number of marine biosecurity risks associated with construction activities and future port operations have been identified. The most significant risks are associated with the introduction of new NIS via international vessel movements during both the construction and operational phases. These risks will largely be mitigated by border standards for biofouling, ballast water and sediments. However, in the event that any specialised vessels (such as barges, dredges, crane vessels, pile-driving vessels, and other types) are sourced from overseas during the construction period, prior to the voluntary CRMS becoming mandatory (in 2018), we recommend the following (or similar):

> *The vessel owner / operator prepares and submits a Marine Biosecurity Management Plan (MBMP) to MPI for approval that describes the measures that will be implemented to mitigate risk from biofouling, ballast water and sediments, in accordance with relevant border standards.*

This recommendation does not apply to other vessel traffic associated with the Port. Several additional approaches to managing biosecurity risks at the Port have been briefly discussed (Sections 5.4.4 and 5.5); however, they represent 'opportunities' for LPC rather than immediate options or recommendations for mitigation.

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