To: TOS Management Committee

From: Barrie Forrest

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ADDRESSING SEA-CHEST RISKS IN THE TOS

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1. SUMMARY

This short report[1] highlights vessel sea-chests as an important marine biosecurity risk to the TOS. Recently the Ministry for Primary Industries (MPI) contracted Diving Services NZ Ltd (DSNZ) to hand-remove fanworms (*Sabella spallanzanii*) and other biofouling from two sea-chests of a ship (the *Spirit of Independence*) berthed in Nelson. In addition to fanworms, the removal work revealed the presence of many *Styela clava* and a single *Pyura doppelgangera*, among other species. Such findings reaffirm the importance of sea-chests in marine biosecurity, and the importance of focusing on risk pathways. The incidental discovery of *Pyura doppelgangera* is particularly significant, as this species is an MPI-designated pest that is not known to have established in the TOS. To address sea-chest risks, the following needs are evident, among other things:

1. Develop a cost-effective treatment: Heat treatment criteria are already well-understood and heat treatment is considered feasible. However, DSNZ suggest that a dock-side mobile chemical treatment system (based on recirculation to minimise loss to the environment) would be cheaper in terms of set-up cost, and operationally easier to implement. For any company to invest in such a development, there would need to be a clear market for the treatment service.

2. Permitting issues: For any treatment, especially one involving chemicals, there is a need to clarify and address the issue of resource consent requirements of the three TOS councils, as well as EPA permit requirements. The TOS ideally needs to get to a point where marine biosecurity treatments can be implemented without the need to consider permitting issues on every occasion (or at least without permitting issues significantly delaying action).

3. Affected industry parties and their willingness: In the case of the TOS, ships from other risk locations are the most important to treat, and these would need to be identified. For the main exacerbators, willingness to pay for treatment is likely to depend on cost. Cost will mainly depend on the type of treatment system, its capital and operational costs, and treatment frequency.

4. Inspection and treatment regime: Based on scant existing data, sea-chest treatment every 6 months or so might be sufficient to mitigate risk. Cawthron has developed a method to enable sea-chest inspections in situ, which has the potential to provide a means of quickly screening vessels to determine priorities for treatment.

[1] Note that this final document is an amended version of a draft compiled for the TOS Management Committee on 7 July 2014. This amended version incorporates feedback from MPI (Kathy Walls) on the earlier draft.

These issues are clearly relevant not only to the TOS, but also nationally. Accordingly, the Ministry for Primary Industries (MPI) recently prepared a separate summary of observations and insights from the *Spirit of Independence* work, and is considering options to address sea-chest issues broadly, including the types of issues outlined above.

2. BACKGROUND

The Top of the South (TOS) Marine Biosecurity Partnership has recognised that vessel sea-chests may be an important mechanism for the introduction of biosecurity risk species to the TOS. This issue was brought to attention recently when Diving Services New Zealand Ltd (DSNZ) inadvertently discovered the Mediterranean fanworm *Sabella spallanzanii* in a sea-chest of the merchant ship *Spirit of Independence*. The discovery resulted in the Ministry of Primary Industries (MPI) leading efforts to remove the fanworm and other biofouling.

The purpose of this document is to consider directions that the TOS Partnership could take regarding future management of sea-chests. For this purpose, this short report: describes sea-chests and their importance in marine biosecurity; discusses the *Spirit of Independence* fanworm removal and its efficacy; describes factors that contribute to sea-chest risk; provides an overview of routine fouling prevention systems used in sea-chests; and outlines ideas for a way forward in terms of treatment and management. These thoughts should be read in conjunction with recommendations and ongoing related work by MPI.

3. WHAT ARE SEA-CHESTS?

Sea-chests are cavity-like recesses built into the hulls of merchant ships and some other vessel types, including cruise ships, as well as some fishing boats, barges, tugs, drilling rigs and rig support vessels (Fig. 1A-C). Sea-chests contain intake pipes for water used for engine cooling, ballast water operations, and emergency fire-fighting. Sea-chests are typically covered with metal grilles, which prevent the entry of large debris during pumping, although this does not preclude the entry of small marine organisms. Sea-sieves or strainers are located between the sea-chests and the pumps, and are designed to retain objects > 5 mm (Fig. 1A). Sea-chests come in a variety of shapes and sizes, and their number varies with vessel size and type. Coutts & Dodgshun (2007) state that a small 500 gross weight tonne (GWT) fishing vessel may only possess a single 0.5 m^3 sea-chest while a 30,000 GWT bulk carrier could have several sea-chests > 2 m^3 in volume.

4. THE IMPORTANCE OF SEA-CHESTS FOR MARINE BIOSECURITY

4.1. Background

Sea-chests are characterised by low water flows and low shear stresses compared with exterior hull surfaces on vessels. As such, they provide a relatively protected refuge for many organisms, which could include risk species. Conceivably, a ship's sea-chests may represent a biosecurity risk even where hull fouling is relatively low (e.g. as on active, fast-moving merchant ships). The fact that sea-chests may be present on a range of vessel types means that this mechanism could be a pathway for the first introduction of marine non-indigenous species to New Zealand, as well as for secondary spread among ports and other hubs of activity.

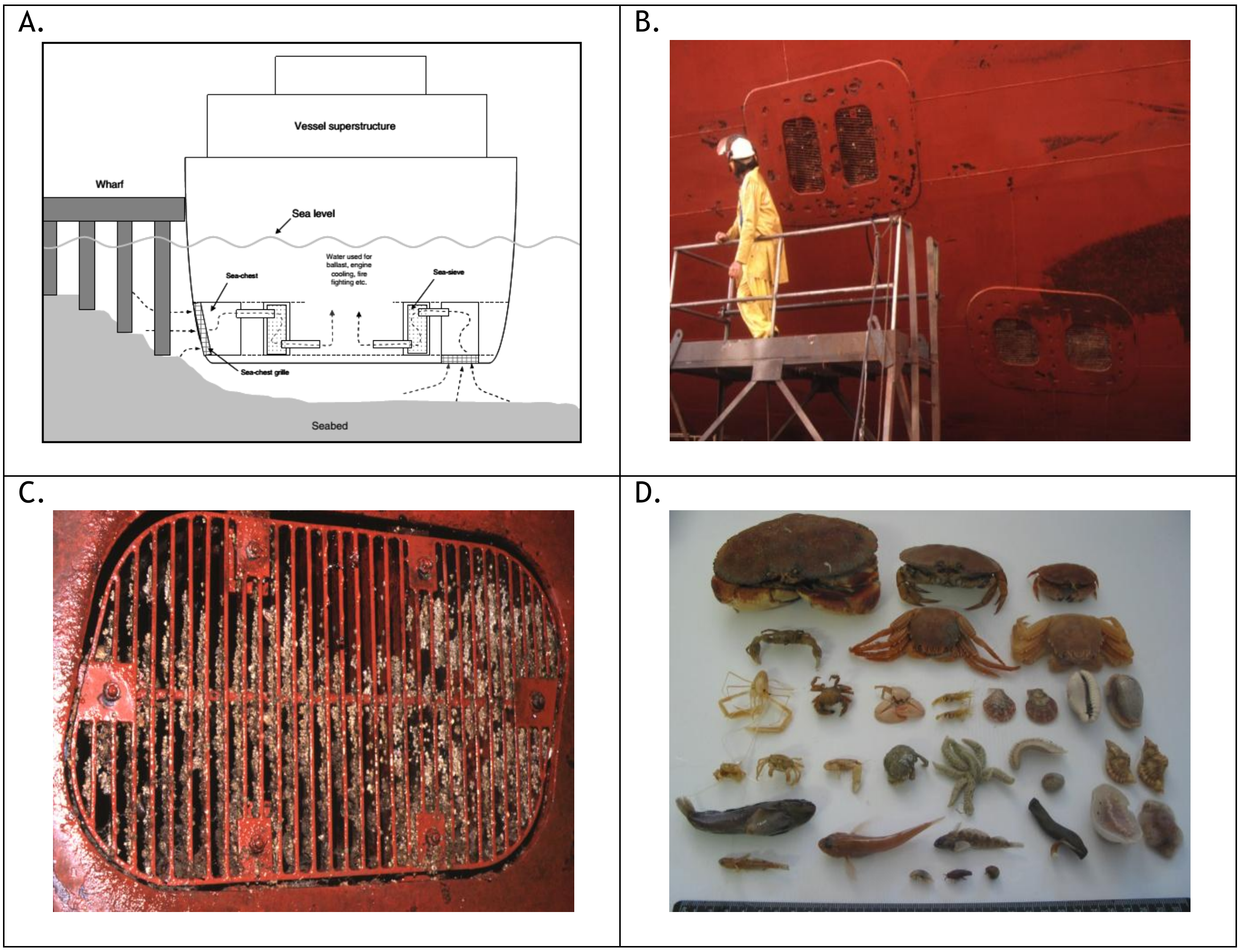

Figure 1. Vessel sea-chests. A. Schematic (Coutts & Dodgshun 2007; B-D. Fouled sea-chest grilles and examples of organisms inside sea-chests (Cawthron).

Through TOS work, it is already recognised that risk organisms can be found in sea-chests. Additionally, there have been at least two reasonably comprehensive studies of the broad suite of organisms occurring in sea-chests; one in New Zealand by Cawthron (Coutts & Dodgshun 2007) and the other in Canada (Frey et al. 2014). Both studies sampled vessels while they were in dry-dock for maintenance.

4.2. Response to fanworms found in sea-chests of the *Spirit of Independence*

Background

Diving Services NZ Ltd (DSNZ), through its involvement with maintenance work on ships, occasionally undertakes work on sea-chests (e.g. cleaning grilles, changing fouling/corrosion prevention anodes). DSNZ has previously reported the occurrence of clubbed sea squirts (*Styela clava*) in sea-chests, and in late January 2014 found the fanworm *Sabella* in a sea-chest of the *Spirit of Independence*. This is a coastal ship that visits Nelson weekly on a regular domestic schedule, which also includes visits to Auckland and Lyttelton where the fanworm is established, as well as Tauranga and New Plymouth.

MPI made a number of subsequent attempts to encourage the vessel owner to take action, but in the absence of any progress decided to undertake a response, using the *Spirit of Independence* as a case study to help inform operational aspects of dealing with domestic vessel risks (Kathy Walls, MPI, pers. comm.). Hence, in June 2014 MPI contracted DSNZ to remove the fanworms and other biofouling, and inspect other parts of the *Spirit of Independence* hull. The majority of the cost was borne by MPI, with Nelson City Council (NCC) and the shipping company paid equal but lesser amounts.

Summary of fanworm removal

DSNZ removed worms from two sea-chests; one covered by three grilles and the other by two. There was interest in trialing a chemical treatment, but this would have required a resource consent from NCC and was not pursued. Hence, the fanworms were removed by hand, but not all could be found or removed because of difficulties accessing the bottom sea-chest. Other fouling was removed as well, to the extent practical. There were ca. 100 worms removed, of which 52 were examined by Geoff Read (MITS). Most of the worms were gravid (contained eggs). Of interest is that a range of worm sizes were noted, suggesting multiple times of sea-chest infection and/or *in situ* reproduction within the sea-chests.

Among the other fouling, *Styela clava* was common and, more significantly, there was a single *Pyura doppelgangera*. Both species are MPI-designated sea squirt pests. *Styela clava* exists in the TOS in Port Nelson, Picton and Waikawa Bay. However, *Pyura doppelgangera* is not known to occur in the TOS; currently it is only known from sites on both coasts in the far north of the North Island, and was recorded from the Opua area in December 2013 during MPI-funded Marine High Risk Site Surveillance (MHRSS). The fact that it has turned up in a sea-chest is perplexing, as the vessel has not been in the known infested localities in New Zealand. Two possible explanations are: (i) there is a reproductive population present (but not yet discovered by MHRSS) in one of the New Zealand ports visited by the *Spirit of Independence*; or (ii) the sea squirt colonised the sea-chest before the vessel came to New Zealand, which MPI indicate was in December 2012[2].

Although the sea-chests (in particular the bottom chest) were heavily fouled, DSNZ noted that the remainder of the vessel was clean. Such observations highlight the potential relative importance of sea-chests for marine biosecurity, and suggest that general exterior hull fouling may not be a good indicator of sea-chest risk.

Efficacy of removal in terms of TOS biosecurity risk

Removal of the majority of the fanworms by DSNZ would have reduced the risk of them spawning in the near future; either while the vessel was in Nelson, or while it was at other ports on its schedule. Although the fanworm exists in Nelson, it is known only from the marina, from which it is periodically removed by divers. Hence, MPI considered that the *Spirit of Independence* removal efforts would contribute to further risk reduction to Nelson and the TOS. However, MPI also recognise that the vessel's sea-chests should be cleared of all biofouling in the near future and that it is desirable for the sea-chests to be painted with an antifoulant (Kathy Walls, MPI, pers. comm.).

The *Spirit of Independence* in conceivably the tip of the iceberg in terms of the ongoing introduction of fanworms and other species to Nelson and the TOS. For example, the fanworm is likely to spread nationally, as controls on domestic pathways are currently minimal. As such, it is likely that an increasing number of infected vessels will continue to arrive in the TOS, and could introduce the worm and other species via sea-chests, hull fouling, ballast water, etc.

The incidental discovery and removal of *Styela clava* and *Pyura doppelgangera* from the *Spirit of Independence* is particularly significant; it reaffirms the importance of sea-chests in marine biosecurity, and the importance of focusing on risk pathways and treatments for all associated species. Treating risk pathways is likely to be especially important and effective for species with limited natural dispersal capacities. For example, *Pyura*

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[2] MPI enquires revealed that the vessel's last port before coming to NZ (Auckland) was in Japan, and that it was last dry-docked in Shanghai in May 2010.

doppelgangera is thought to have a very short planktonic dispersal phase, and human transport provides the most likely means of introduction to the TOS.

4.3. Cawthron and Canadian sea-chest studies

The Cawthron study by Coutts & Dodgshun (2007) described 150 different taxa (of which 149 were animals) from 53 sea-chests across 42 vessels sampled in dry-dock. A wide variety of organism groups were present overall, and in a given sea-chest between 1 and 33 organisms were recorded (mean ca. 11). Fifty-eight percent of taxa were sessile (49%) or sedentary (9%); these were mainly biofouling organisms, but some were taxa more commonly associated with soft sediments. The remaining 42% were adult life-stages of mobile species like fish, crabs and sea stars. Forty percent of organisms were indigenous to New Zealand, 15% introduced exotics, 10% non-indigenous, and 35% of uncertain geographic origin. In terms of designated risk organisms, two *Styela clava* were recorded[3].

The occurrence of adult life-stages of mobile organisms like crabs and sea stars is of particular interest in the New Zealand study. MPI has a list of 11 designated marine pests[4], or which four have not yet been recorded in New Zealand. Three of these four are mobile species (a seastar and two crab species) that have the potential to be dispersed as adult organisms in sea-chests. Coutts & Dodgshun (2007) suggest that sea-chests may be of greater importance than ballast water or hull fouling for dispersing such organisms.

The Frey et al. (2014) Canadian study sampled 82 sea-chests from 39 vessels, and similarly found a wide variety of different groups of organism. In total, 299 different taxa were recorded. Interestingly, 20% of Canadian sea-chests contained no organisms, which contrasts the New Zealand study.

It is of relevance to note that the above two studies considered only the macrofouling organisms (> 1 mm size) in sea-chests. Other studies have highlighted a potential role of sea-chests and vessel fouling as vectors for disease transmission, but this risk is not well understood.

5. FACTORS AFFECTING SEA-CHEST OCCUPANCY

5.1. Duration of in-service period

Most commercial vessels have in-service periods (i.e. duration since vessel was comprehensively surveyed, antifouled, etc) of about 5 years, but this period can be as little as ca. 2 years. During the in-service period, sea-chests may be untouched except for grille cleaning or occasional internal maintenance. However, they are unlikely to be internally cleaned of organisms (except perhaps for pipe-work) between dry-docking.

The Cawthron and Canadian studies referred to above revealed that longer in-service periods were associated with an increased number and/or diversity of organisms. However, the in-service duration before organisms first appear in sea-chests is unclear. In the New Zealand study the shortest in-service period sampled was 7 months, and in that instance eight taxa were recorded.

By contrast, in the Canadian study only three vessels with in-service periods < 12 months were sampled (0.5, 2.3 and 3.8 months) and their sea-chests had no organisms present. Although organisms were present at 12 months, the diversity and abundance of taxa greatly increased at 24 months. However, there were exceptions in which a few vessels

[3] Of interest is that the Coutts & Dodgshun sea-chest sampling was undertaken over 2000-2004, at least one year before *Styela clava* was first recorded to have established in New Zealand.
[4] MPI's marine pest list is available here: New Zealand's Marine Pest Identification Guide

with in-service periods of > 3 years similarly had no organisms in their sea-chests, but the reasons are not discussed by the study authors. The Canadian study notes that vessel size and residence time in port did not explain sea-chest occupancy patterns.

5.2. Sea-chest treatment systems

Many sea-chests have some form of marine growth prevention system, involving the release of toxicants. Commonly used methods include antifouling coatings, cathodic protection systems (e.g. Cathelco) and chlorine based treatments (e.g. Chloropac). The general consensus is that these methods are not completely effective, at least not for the full in-service period (Coutts & Dodgshun 2007; Grandison et al. 2011). Coutts & Dodgshun (2007) found that sea-chests with such treatment systems contained fewer organisms on average that untreated sea-chests; however, treatments failed to completely eliminate organisms. Furthermore, treatment systems did not significantly affect the occurrence of mobile organisms. These authors suggest that anti-fouling paints in sea-chests are unable to perform as well as they do on uniform areas of the hull because they are subjected to extremes in water-flow that compromise their effectiveness. They note that paints may prematurely wear due to excessive water-flow or, alternatively, paints in static areas with insufficient water flow may have low anti-foulant activity. DSNZ note in addition that it can be difficult to apply a good quality coating to all parts of a sea-chest because of access issues and paint coating application difficulties.

5.3. Other mechanisms and related information needs

Coutts & Dodgshun (2007) suggested that, unlike the settlement of sessile fouling organisms on vessel hulls, organisms have the potentially to be involuntarily 'vacuumed' into sea-chests from neighbouring wharf piles, the surrounding water column and even the seabed. If that was the case, sea-chest risk could immediately arise on resumption of operations after dry-docking. However, DSNZ consider that the suction pressure would be insufficient to draw in any large organisms. Ideally, the mechanisms and rate of sea-chest fouling, and existing treatment efficacy, would be the subject of further research in New Zealand, in order to more accurately inform management (i.e. regarding cleaning or treatment frequency necessary to mitigate risk). In the absence of such information, the simplest way forward is to identify current gaps in sea-chest management and the steps that would be required to reduce actual or potential risk.

6. SEA-CHEST MANAGEMENT OPTIONS AND NEEDS FOR THE TOS

6.1. International and national context

For national border management of hull fouling, MPI has released a Craft Risk Management Standard (CRMS) for 'Biofouling on Vessels Arriving to New Zealand'. This standard is inclusive of sea-chests (which are included in the definition of niche areas). The CRMS is voluntary at present, and will become mandatory in 2018; in the interim, MPI intend to take action against heavily fouled vessels. The CRMS requires that vessels coming to New Zealand arrive with a 'clean hull' which is defined in relation to thresholds of 'allowable biofouling'. These thresholds are defined according to the duration of a vessel's visit as follows:

1. Long stay vessels (in New Zealand for 21 days or longer)
Allowable biofouling across all hull areas is restricted to a slime layer and goose barnacles.

2. Short stay vessels (remaining in New Zealand for 20 days or less)
Allowable biofouling in niche areas (i.e. including sea-chests) includes some algal growth; scattered (maximum of 5%) coverage of one organism type of either tubeworms, bryozoans

or barnacles; and incidental (maximum of 1%) coverage of a second organism type of either tubeworms, bryozoans or barnacles.

Under the CRMS, one of the following 'acceptable measures' must be applied to meet the 'clean hull' requirement:

a) Cleaning before visit to New Zealand (or immediately on arrival in a facility, or by a system, approved by MPI). All biofouling must be removed from all parts of the hull and this must be carried out less than 30 days before arrival to New Zealand or within 24 hours after time of arrival.

b) Continual maintenance using best practice including: application of appropriate antifoul coatings; operation of marine growth prevention systems on sea-chests; and in-water inspections with biofouling removal as required. Following the IMO Biofouling Guidelines is recognised as an example of best practice.

c) Application of Approved Treatments. Treatments are approved and listed under the Approved Biosecurity Treatments MPI-STD- ABTRT.

As an alternative to the acceptable measures above, a vessel operator may submit, for MPI approval, a Craft Risk Management Plan, which includes steps that will be taken to reduce risk to the equivalent degree as meeting the requirements of the standard. Note that sediments in sea-chests are addressed separately in an Import Health Standard for ballast water, and this issue is not discussed here.

Based on Sections 4 and 5, it is conceivable that sea-chests on many vessels will not meet the CRMS standard once their in-service period becomes advanced. Presumably, efforts will be undertaken by the shipping industry and others to address this issue so that they can comply with the CRMS. To my knowledge the only pre-border examples where sea-chest risks have been specifically mitigated have been prior to transfers of drilling rigs to New Zealand (over the last 5 years or so). In relation to the domestic scene, the *Spirit of Independence* is the only example I am aware of in which risks from sea-chests have been managed.

6.2. Improved sea-chest treatment and management in the TOS

As noted above, it would be logical to develop management approaches that focus on risk pathways and all of their associated species. For sea-chests, there are a number of possible directions that could be taken, assuming the TOS Partnership accepts that there is a risk worth addressing.

I suggest that the TOS, together with MPI, work towards an approach that involves routine, cost-effective treatment of sea-chests on vessels visiting the TOS (ideally nation-wide) from other ports or high risk localities. The issue is not technically difficult to resolve, but will require some initial investment, among other things, as well as a willingness by the relevant industry players to adopt a treatment regime. Some possible steps and related needs are outlined below. These steps need to be considered simultaneously, as they are inter-related.

1. Develop a cost-effective treatment: Heat treatment has been considered by Cawthron (Piola & Hopkins 2012) and DSNZ, and treatment criteria are well-understood. Some vessels already have the capacity to discharge hot water into their sea-chests. DSNZ consider heat treatment feasible, but suggest that a dock-side mobile chemical treatment system (based on recirculation to minimise loss to the environment) would be cheaper in terms of set-up cost, and operationally easier to implement. For any company to invest in such a development, there would need to be a clear market for the treatment service.

2. Permitting issues: For any treatment, especially one involving chemicals, there is a need to clarify and address the issue of resource consent requirements of the three TOS councils, as well as EPA permit requirements. The TOS ideally needs to get to a point where marine biosecurity treatments can be implemented without the need to consider permitting issues on every occasion (or at least without permitting issues significantly delaying action).

3. Affected industry parties and their willingness: In the case of the TOS, it is ships from other risk locations that are most important to treat, and these would need to be identified. For the main exacerbators, willingness to pay for treatment is likely to depend on cost. Cost will mainly depend on the type of treatment system, its capital and operational costs, and treatment frequency.

4. Inspection and treatment regime: Based on scant existing data, sea-chest treatment every 6 months or so might be sufficient to mitigate risk. Cawthron has developed an endoscope (linked to a monitor screen) to enable sea-chest inspections in-water, which would provide a possible means of quickly screening vessels to prioritise them for treatment. However, in-water trials of the Cawthron system have not yet been undertaken.

MPI recently prepared a separate summary of observations and insights from the *Spirit of Independence* work, and is considering options to address sea-chest issues broadly, including the types of issues outlined above.

7. ACKNOWLEDGMENTS

I am grateful to Bruce Lines (Diving Services New Zealand), Don Morrissey (NIWA) and Kathy Walls (MPI) for information and insights they have shared. I also thank Kathy Walls for her review comments on this document.

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