

A yacht enclosure system to mitigate biosecurity risks associated with biofouling

(Developed IP Report)

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1. Introduction

Pleasure craft such as yachts and launches comprise up to 20 percent of vessel visits to New Zealand from vessels that have travelled overseas (NZCS 2008). These vessels have been shown to provide a high risk pathway for entry to New Zealand of non indigenous marine species (NIMS) as biofouling (Floerl et al. 2007)

Biosecurity New Zealand (MAFBNZ) intends to establish controls on this pathway by which vessels assessed as above an agreed risk threshold will be required to be cleaned on arrival in MAFBNZ approved facilities. To minimise the number of pleasure craft arriving with biofouling, encouragement will be given for the vessels to be cleaned before departing their last destination (such as Tonga and Fiji). MAFBNZ are investigating establishing a system whereby accredited facilities will provide certification of the most recent cleaning showing that all NIMS have been removed. A certificate from such a cleaning facility at last the point of departure would be accepted by MAFBNZ as part of the risk assessment on arrival at the New Zealand border.

MAFBNZ contracted Aquenal Pty Ltd (Aquenal) to produce a report which describes the design, operation and costs associated with a reusable floating enclosure that can fit around a range of yacht hull shapes in order to kill all biofouling organisms through anoxia or from the addition of chemicals (dosing) or a combination of these. MAFBNZ is seeking to progress the development of this type of system to the stage where a system can be easily installed at a point of departure (i.e. Tonga/Fiji) or into a port of first arrival in New Zealand (Opuia in the Bay of Islands is the major port of first arrival for pleasure craft to New Zealand).

2. Confidentiality Agreement

MAFBNZ acknowledges that Aquenal has developed the majority of the information behind this project at their expense prior to the commissioning of the project. That information is presented in the report entitled “A yacht enclosure system to mitigate biosecurity risks associated with biofouling” and is subject to a Confidentiality Deed and must be treated as detailed in that agreement.

The Intellectual property developed under Contract 10878 is presented here. A description of the enclosure system developed by Aquenal and its operation are included to provide background to this information.

The Developed IP report contains:

- The sources and costs of materials, logistic support and construction of the system in the ports listed in the Schedule.
- New Zealand waste water discharge requirements.
- The estimated operational costs and personnel requirements, time frames for various treatments depending on biofouling levels present and number of vessels which could be treated per day.

3. Background to Enclosure System Development

In 2007 Aquenal conducted a review of control measures for NIMS for the Australian Government (Aquenal 2007) and discovered that despite the proven risks of translocation of NIMS in biofouling of pleasure boat hulls (Floerl et al. 2007) there was no effective method for negating those risks. Removing the vessel from the water was the most effective method of reducing risk against sessile NIMS, however this does not eliminate risk, particularly for mobile NIMS. From the moment a vessel enters port at the end of an ocean passage opportunities exist for mobile fauna to vacate the hull and niche areas in which they have sheltered during the voyage. Small fish such as blennies, crabs, algae grazers such as tanaids and various shrimp species have been observed to travel across oceans even on relatively clean yachts (D. Shields, personal observation; Floerl et al. 2007). There is also potential for various organisms to spawn upon arrival in the receiving port due to changes in water temperature and salinity, factors which have been demonstrated to stimulate gamete release in sessile organisms (Ram et al. 1996; Southgate & Lee 1998; Apte et al. 2000; Minchin & Gollasch 2003). Observations of vessels being hauled out of the water and later scientific testing have demonstrated that when a vessel is removed from the water many mobile organisms present in hull biofouling simply fall off or swim away from the vessel into the surrounding waters (Coutts & Dodgshun 2007; Aquenal, unpublished data). Additionally, sessile species and algae are dislodged during placement of the vessel within the cradle or slings used to remove it from the water. Because slipping facilities are normally booked well in advance, there is often no available slip for days or weeks allowing further time for escape and spawning of biofouling and associated species.

Concerns of yacht owners were included as important factors in the development of Aquenal's hull enclosure system. Yacht owners do not like to put their vessels at risk or be rushed into expensive maintenance programs. However, they are likely to be amenable to measures that will reduce their sailing costs and voyage times. So the safer and cheaper a treatment system is the more likely boat owners will use it without objection. Ideally vessel owners would voluntarily use the system before commencing a voyage regardless of how clean their yachts were. Reduction in vessel biofouling at the start of a voyage reduces friction thereby enabling greater speed, reduction in voyage time and fuel costs while reducing the risk of translocating NIMS to the destination port. Additional incentive to clean biofouling from a vessel before departure for New Zealand is provided by MAFBNZ's proposal to include such measures in their border biosecurity risk assessment.

In response to these issues Aquenal developed a treatment system that does not require a vessel to be removed from the water. The system can quickly and simply enclose the underwater portion of a vessel and isolate it from the surrounding water to quarantine it and enable it to be treated. It uses a tough, reusable sheath that can easily be deployed and retrieved without the need for divers. Aquenal has registered the trademark name "IMProtector™" for these enclosure sheaths using the acronym for Introduced Marine Pests. In its simplest form the IMProtector™ is unfolded on shore and towed behind a dinghy to a yacht on a mooring. It requires two to three people for deployment and takes about 15 minutes to enclose and quarantine a vessel from the time of arrival at the vessel. This system is ideal for treating a number of vessels one after the other at their moorings or in their marina berths, for ports where only a few vessels require treatment, or as a mobile emergency response tool. However, it is cumbersome to launch and retrieve and cannot be stored in the water.

Yachts arriving from overseas are normally required to go to a designated quarantine berth for quarantine inspection, customs clearance and immigration formalities. The New Zealand

entry biosecurity regime proposed by MAFBNZ for this feasibility study requires enclosure and treatment of yachts which have arrived from overseas and through inspection have been found to have higher than acceptable levels of biofouling. MAFBNZ is also interested in a system which can be installed in Tonga and Fiji to treat vessels before they depart for New Zealand. These scenarios require a system which can be easily and safely deployed in a few minutes with minimal disturbance to the vessel and crew. It should also be able to treat several yachts in one day.

Aquenal has designed a system to meet these requirements. It is a permanently installed roll-up enclosure system, comprising of an IMProtector™ which is stored on a reel at the head of the quarantine berth. Both deployment and retraction will take in the order of 5 minutes each and pose minimal inconvenience or risk to the vessel and crew. Treatment and rinsing are achieved using a system of readily obtainable swimming pool pumps and filters. Treatment solutions and contaminated water are stored in plastic rainwater tanks. Contaminated water is treated and discharged back into the sea or into the local storm-water system as appropriate.

4. Background to Treatment Solutions

Deployment and quarantine aspects of biofouling control using enclosures are relatively simple compared to treatment. Treatment options vary greatly depending on level of biofouling, which biofouling species are present, time available, water temperature, in-water cleaning regulations, water discharge regulations, availability of electricity, availability of treatment chemicals and solutions, contaminated water disposal facilities and regulations, availability of slipways etc.

The simplest treatment solution is to enclose the vessel and allow the water inside the enclosing sheath to become anoxic. Over time, by-products of decaying organic matter and leaching toxins from the vessel's antifouling increase within the enclosed water. This treatment is commonly referred to as "Set-n-forget" treatment (e.g. Coutts & Forrest 2007; Pannell & Coutts 2007).

To kill biofouling species more quickly than is possible with simple anoxic treatment a regime including addition of accelerants (dosing) is required. Permanent installation adjacent to land enables the use of electric pumps, sand filters and storage tanks. Standard swimming pool pumps and filters and plastic rain water tanks are used as they are readily available and can easily be repaired or replaced as required. Treatment solutions containing accelerants can be mixed in shore-based tanks and circulated around the enclosed yacht hull then pumped back to the tanks to reduce chemical use and discharge to a minimum. If necessary the yacht hull can be rinsed with clean seawater before release and the rinse water pumped ashore to the local wastewater system or to a scavenger tank for further dilution or neutralisation prior to discharge.

5. Quarantine Aspects of Enclosure

One of the most important uses of the IMProtector™ system is to rapidly enclose and quarantine an infested vessel. Using a canister system installed in a marina berth an infested vessel can be enclosed within 15 minutes without risk of disturbing the biofouling and virtually eliminating risk of escape of biofouling associated organisms. In ports where there is no permanently installed IMProtector™ system a mobile system can be used to enclose a vessel within 30 to 60 minutes depending on how it is stored and deployed. Neither system requires the assistance of divers. To date no other system has been able to provide this level of biosecurity. The next best alternative is to remove the vessel from the water. This may take days of waiting until a space on a slipway becomes available and provides the opportunity for species to reproduce and mobile fauna to escape into the surrounding waters. Once a vessel is safely enclosed and quarantined the appropriate method of treating the infestation can be considered and implemented.

6. Compliance with Water Discharge Requirements

6.1. NEW ZEALAND

6.1.1. Background

Any water discharged from the proposed enclosure treatment system into the marine environment must meet the local council water quality guidelines. The proposed treatments outlined in this report will create, as a by-product, water that is altered from its natural state. The system has been designed to be able to quarantine this water by pumping it into a holding tank if required. This water can then be treated and tested to ensure it satisfies water quality guidelines before being discharged into the marine environment or local waste water system. Water treatment options include addition of lime to neutralise acidity, aeration to raise DO levels, filtration to remove solids and organic matter, improve clarity and hue and to remove oil and odour. There is potential for treatment using acetic acid to alter dissolved metal concentrations but the degree to which this will occur is uncertain at this stage. Treatments which produce unacceptably high levels of dissolved metals will not be used. It is expected that both anoxic treatment and treatment with acetic acid will alter the water quality of the enclosed water as listed in Table 1.

Table 1. Expected water quality stressors from proposed activity

Stressor	Method of Treatment	
	Anoxia	Acetic acid
Temperature	*	*
pH	X	X
DO	X	X
Visual Clarity	X	X
Hue	X	X
Oil/grease, scum, foam, odour	X	X
Copper	**	**
Lead	**	**
Phosphorous	**	**
Zinc	**	**
Nitrate	X	X
Ammonium	X	X
Acetic Acid		X

X indicates an alteration from natural levels

* Unlikely to have an effect

** Currently unknown. There have been no studies conducted as yet in regards to the affect of these treatments on anti-fouling paints.

6.1.2. Water quality guidelines for the Northland Region, New Zealand

The relevant local government authority for the port of Opua is the Northland Regional Council. They provided the water quality guideline presented in Table 2.

Table 2. Indicative water quality guidelines for discharging processed water into the coastal marine area (provided by Northland Regional Council, New Zealand)

Physical or chemical stressor	Guidelines on water quality
Natural Temperature	Not changed by more than 3°C
Natural pH	Not changed by more than 0.2 units
Concentration of dissolved oxygen	Not reduced below 80% saturation
Natural visual clarity	Not reduced more than 20%
Natural hue	Not changed more than 10 Munsell units
Oil/grease film, scum, foam, odour	No conspicuous oil or grease film, scums or foams, floatable or suspended materials, or emissions of objectionable odour
Total Cadmium	2 mg/m ³
Total Chromium	50 mg/m ³
Total Copper	5 mg/m ³
Total Lead	5 mg/m ³
Total Zinc	50 mg/m ³
Dissolved Reactive Phosphorous (DRP)	1-100 mg/m ³
Nitrate (NO ₃ -N)	10-60 mg/m ³
Ammonium NH ₄ -N	<5 mg/m ³

6.1.3. Relevant Legislation – Regional Coastal Plan of the Northland Region, New Zealand

Rules in the Plan relating to the planned activity are shown below. These provide information on rules in addition to the specific water standards listed in Table 2.

RULE 31.8.6 DISCHARGE

Rule	Activity	Terms/Standards/Conditions	Classification
b	The discharge of water on to the foreshore, seabed or into the waters of the coastal marine area	The discharge (i) is free from any contaminant; and (ii) does not result in permanent physical damage to the foreshore or seabed. The activity shall comply with all relevant standards listed in section 31.8.12	Permitted
c	Any stormwater discharge (other than from a boat maintenance facility, open cargo storage or handling areas, or authorize facilities).	The discharge does not result in permanent physical damage to the foreshore or seabed. The activity shall comply with all relevant standards listed in section 31.8.12	Permitted
f	The deposition of litter and other solid domestic or industrial contaminants on to the foreshore or seabed or into coastal waters.		Prohibited

RULE 31.8.10 BOAT MAINTENANCE FACILITIES

Rule	Activity	Terms/Standards/Conditions	Classification
a	Boat maintenance activity	The activity does not: (i) cause contaminants to be discharged into coastal waters or deposited on the foreshore or seabed; or (ii) require, or result in, the boat occupying space in a foreshore area for longer than the period of one low tide; or (iii) impede public access to or along the coastal marine area. The activity shall comply with all relevant standards listed in section 31.8.12	Permitted
b	Boat maintenance facilities and associated use		Discretionary
C	Discharges from authorized boat maintenance facilities		Discretionary

RULE 31.8.12 GENERAL PERFORMANCE STANDARDS

The following standards shall apply to all specified permitted, controlled, restricted discretionary and discretionary activities, and to all non-complying activities, listed in the Marine 6 Management Area:

- (d) Discharges to water shall, after reasonable mixing, comply with the relevant receiving water quality standards and shall not contain any contaminants which could cause:
- (i) the production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials.
 - (ii) any conspicuous change in the colour or decrease in the visual clarity of the receiving waters.
 - (iii) any emission of objectionable odour.
 - (iv) accumulation of debris on the foreshore or seabed underlying or adjacent to the discharge point.
 - (v) any significant adverse effects on aquatic life or public health.

6.2. TONGA AND FIJI

Specific information on water discharge requirements for Tonga and Fiji were not available for this study. It is assumed that adoption of the Water quality guidelines for the Northland Region, New Zealand would meet, if not exceed, the requirements of Tonga and Fiji.

7. Domestic spread

Marine pest incursion is only the first stage of threat from NIMS. They have to become established and then spread domestically to inflict greatest harm. Enclosure treatment can be a useful tool for reducing the risk of domestic spread. Domestic spread is likely to be centred on busy ports and such locations are more likely to become infested by an invader and to accelerate spread to secondary locations (Floerl et al. 2008). Busy transport hubs should be considered a priority for the allocation of preventative and management efforts, such as regular baseline or target surveys and the development of incursion response plans that minimize the risk of spread within the transport network (Floerl et al. 2008).

The provision of an enclosure treatment system such as a permanently installed IMProtector™ in busy or infested ports would enable either government controlled or voluntary hull decontamination to be conducted quickly, safely, cheaply and easily.

8. Time required for Enclosure Treatment

8.1. BORDER CONTROL FOR HIGH RISK YACHTS

The New Zealand biosecurity regime proposed by MAFBNZ for this feasibility study is to require enclosure and treatment of yachts which have arrived from overseas and through inspection have been found to have higher than acceptable levels of biofouling. Assuming the trigger level for mandatory treatment is the presence of tertiary level biofouling, this protocol will capture only vessels which pose the highest level of risk of carrying NIMS. Until a 100 percent certain enclosure treatment has been developed and tested the only available way to eliminate the risk from these yachts is a two stage treatment involving encapsulation treatment then removal from the water and cleaning. Suitable encapsulation treatment will take 1 hour with an accelerant or 24 hours with anoxia depending on biofouling species present and local conditions. A slightly less biosecure, more rapid and less expensive option for vessels that are not extensively infested with mussels or barnacles is a 1 hour encapsulation treatment with an accelerant then follow-up physical removal of live mussels and barnacles by divers.

8.2. MAXIMISING RISK REDUCTION AT THE BORDER

Maximum border biosecurity would be achieved if all yachts arriving from overseas were immediately enclosed, inspected and their hulls given a 10 minute flush with treatment solution with an accelerant regardless of the level of biofouling. Those which carried tertiary level biofouling or any resistant taxa of concern would be treated as described in Section 8.1.

8.3. RISK REDUCTION IN FOREIGN PORTS

Rapid encapsulation treatment involving 10 minute treatment with an accelerant in ports of departure prior to leaving for New Zealand will drastically reduce the number of species likely to be transported on yacht hulls. Encouraging such proactive treatment will therefore significantly reduce the risk of translocation of NIMS to New Zealand. However, such treatment will not completely remove the risk of translocating resistant taxa such as mussels.

An underwater inspection and possible further treatment is required to completely eliminate this risk.

8.4. EMERGENCY RESPONSE

An emergency response option is to keep ready for deployment folded up mobile 15 and 20 m IMProtectors™ at ports of entry. If inspection of a newly arrived yacht finds dangerous biofouling then the yacht could be taken to a safe mooring and enclosed in an IMProtector™. Once the water had been pumped out the hull could be dosed with a treatment with an accelerant for 1 hour which would kill the majority of the biofouling and many of the resistant taxa within a few minutes. The acetic acid could then be retrieved and the yacht released if high levels of resistant organisms were not present or for immediate removal from the water if high levels were present. If haul-out facilities were not available the yacht would remain safely enclosed at the mooring until facilities became available. For low levels of resistant taxa any surviving individuals could be removed by divers.

8.5. DOMESTIC SPREAD

Prior to departing for another domestic port or uncontaminated anchorage any yacht suspected to be carrying biofouling could tie up in the berth, roll out the IMProtector™, zip it up, flush the hull with an accelerant, pump out the solution, unzip and roll away the IMProtector™ and sail away. This treatment should take less than an hour and could coincide with taking on fuel, loading provisions or picking up passengers. It would result in the extermination of all biofouling organisms except some mature shellfish from the hulls of departing yachts and could greatly reduce the risk of domestic spread of NIMS.

9. Sources and costs of enclosure systems

Extensive searching for equipment and suppliers in New Zealand, Australia, Tonga and Fiji found that in general it was most cost effective to purchase equipment in its place of manufacture and ship it in containers by sea to the destination port. IMProtectors are manufactured in Ballarat, Victoria, Australia. The canister system is manufactured in Hobart, Tasmania, Australia and the cost of modular marina berths is much cheaper in Australia than in New Zealand. All other equipment and consumables can be purchased cost effectively in New Zealand. It was difficult to obtain cost and supplier information from Tonga and Fiji using internet and phone. It would be prudent to visit these countries and talk with local officials and suppliers prior to deciding whether to source supplies locally or import them.

A list of the best value for money equipment, suppliers and shipping costs is provided in Table 3. Estimated purchase and installation costs for each of the 3 deployment configurations are presented in Table 4. All costs are reasonably accurate quotes or estimates which may vary depending on final design details, local conditions and logistics at the installation site, exchange rates, labour costs and market fluctuations. However, they are sufficient to provide a good indication of the magnitude of costs that can be expected.

Table 3. List of components of the IMProtector™ system, their suppliers and costs (NZ\$ ex GST)

Item	Provider	Location	Cost NZ\$
IMProtector™ – mobile sheath 15 m x 3 m	CE Bartlett http://www.bartlett.net.au/	Ballarat, Australia	\$ 9,804.60
IMProtector™ – roll up sheath 15 m x 3 m	CE Bartlett	Ballarat, Australia	\$ 6,863.22
IMProtector™ – mobile sheath 20 m x 4 m	CE Bartlett	Ballarat, Australia	\$ 12,355.20
IMProtector™ – roll up sheath 20 m x 4 m	CE Bartlett	Ballarat, Australia	\$ 8,648.64
IMProtector™ canister	Plastic Fabrications	Hobart, Australia	\$ 37,566.36
IMProtector™ canister mounting	Engineering works	Auckland NZ	\$ 1,200.00
Pump – petrol – 4 hp 600 L/min 50 mm	http://www.buywright.co.nz/pumps.html	Auckland NZ	\$ 879.00
Pump – electric – 600 L/min – 50 mm	Waterco http://www.swimart.com.au/documents/ZZB1267_PoolPumps.pdf	Auckland NZ	\$ 1,170.80
Filter – sand – 440 kg – 500 L/min – 50 mm	Waterco http://www.swimart.com.au/documents/Micronfilterrange_ZZB1271.pdf	Auckland NZ	\$ 2,538.00
Filter – 500 L/min – 50 mm	Waterco http://www.swimart.com.au/documents/Micronfilterrange_ZZB1271.pdf	Auckland NZ	\$ 559.00
50 mm pipe per 4 m length	www.pggwrightson.co.nz		\$ 5.41
50 mm T joint	www.pggwrightson.co.nz		\$ 31.73
50 mm 90 deg angle	www.pggwrightson.co.nz		\$ 22.83
50 mm ball valve	www.pggwrightson.co.nz		\$ 61.59
50 mm flexible hose	www.pggwrightson.co.nz		\$ 3.54
50 mm strainer box	www.pggwrightson.co.nz		\$ 34.21
Tank – plastic – 425 L	Bailey water tanks	Auckland NZ	\$ 365.00
Tank – plastic – 900 L	Bailey water tanks	Auckland NZ	\$ 499.00
Tank – plastic – 1800 L	Bailey water tanks	Auckland NZ	\$ 730.00
Tank – plastic – 2100 L	Bailey water tanks	Auckland NZ	\$ 845.00
Independent marina berth	Bellingham Marine	Auckland, NZ	\$ 97,350.00
	Pacific pontoon and Pier www.pacificpontoon.com	Melbourne, Aust	\$ 42,328.00
Swing mooring for independent marina berth	Pacific pontoon and Pier www.pacificpontoon.com (inc installation)	Bay of Islands, NZ	\$ 19,500.00
Pile mooring for independent marina berth	Pacific pontoon and Pier www.pacificpontoon.com (inc installation)	Bay of Islands, NZ	\$ 12,350.00
Shipping costs Aust to NZ per m3	Australiatrade	Australia	\$ 200.87
Shipping costs Aust to NZ per 40 ft container	Australiatrade	Australia	\$ 7020.00
Shipping costs NZ to Fiji per m3	AquaAir Freight Services	Auckland, NZ	\$ 130.00
Shipping costs NZ to Tonga per m3	AquaAir Freight Services	Auckland, NZ	\$ 210.00

Table 4. Cost for the three IMProtector configurations (NZ\$ ex GST)

Item	Cost
Mobile system	
15 x 6 m IMProtector	\$ 9,804.60
Shipping costs from Aust to NZ	\$ 429.87
Pump – petrol – 4 hp 600 L/min 50 mm	\$ 879.00
Filter – cartridge – 14.5 kg – 500 L/min – 50 mm	\$ 559.00
Plumbing – Flexible pipe and strainer box	\$ 51.91
Total cost	\$ 11,724.38
Canister system installed in a permanent marina berth	
15 x 6 m Roll-up IMProtector	\$ 6,863.22
Canister and reel	\$ 37,566.36
Canister mounting	\$ 1,200.00
Shipping costs for IMProtector inside canister from Aust to NZ	\$ 1,032.48
Installation costs for canister	\$ 1,500.00
Mixing tank – 900 L plastic rainwater tank	\$ 499.00
Scavenger tank – 2100 L plastic rainwater tank	\$ 845.00
Pump – electric – 600 L/min – 50 mm	\$ 1,170.80
Filter – sand – 440 kg – 500 L/min – 50 mm	\$ 2,538.00
Plumbing – 48 m pipe, 6 valves, 6 x 90 angles, 4 x T joiners, 5 m flexible pipe, strainer box	\$ 706.99
Installation costs for plumbing and electricity	\$ 2,000.00
Total cost	\$ 55,921.85
Canister system installed in an independently moored marina berth	
15 x 6 m Roll-up IMProtector	\$ 6,863.22
Canister and reel	\$ 37,566.36
Canister mounting	\$ 1,200.00
Independent marina berth	\$ 42,328.00
Swing mooring for independent marina berth	\$ 19,500.00
Pile mooring for independent marina berth	\$ 12,350.00
Shipping costs for IMProtector inside canister plus marina berth and moorings from Aust to NZ	\$ 7,020.00
Installation costs for canister	\$ 1,500.00
Mixing tank – 425 L plastic rainwater tank	\$ 365.00
Scavenger tank – 900 L plastic rainwater tank	\$ 499.00
Pump – petrol – 4 hp 600 L/min 50 mm	\$ 879.00
Filter – cartridge – 14.5 kg – 500 L/min – 50 mm	\$ 559.00
Plumbing – 24 m pipe, 6 valves, 6 x 90 angles, 4 x T joiners, 5 m flexible pipe, strainer box	\$ 696.17
Installation costs for plumbing	\$ 500.00
Total cost for system moored on piles	\$ 112,325.75
Total cost for system moored on swing mooring	\$ 119,475.75

10. Estimated operational costs of the treatment system

Consumables and suppliers for the day to day operation of the various enclosure systems were sourced, in the main, from New Zealand (Table 5). All are reasonably accurate at the time of writing but may vary with time.

Table 5. List of consumables and their suppliers and overhead costs of the IMProtector™ system (NZ\$ ex GST)

Item	Provider	Location	Cost NZ\$
Acetic acid per 20 L	Chemiplas NZ www.chemiplas.co.nz	Auckland, NZ	\$ 46.20
Vinegar per 200 L	www.anzdistillery.co.nz/index.htm	Auckland, NZ	\$ 378.00
Pool chlorine per 10 kg	poynters online shop, www.poynters.co.nz/shop_poolgard.html	NZ	\$ 79.00
Sodium Hypochlorite 20L	online poolshop, www.onlinepoolshop.com.au/listProduct/Chemicals/	Perth, Australia	\$ 52.00
Lime per 40 kg bag	AB Lime Ltd, http://www.ablime.co.nz/contactsII.cfm	Winton, NZ	\$ 3.40
Disposal costs	Opuwa sewage system		\$ –
Marina berth rental p.a. – 15 m vessel NZ	Opuwa Marina	Bay of Islands, NZ	\$ 8,770.80
Marina berth rental p.a. – 20 m vessel NZ	Opuwa Marina	Bay of Islands, NZ	\$ 14,936.40
Marina berth rental p.a. – 15 m vessel Fiji	Vuda Pt Marina	Viti Levu Fiji	\$ 3,741.46
Marina berth rental p.a. – 20 m vessel Fiji	Vuda Pt Marina	Viti Levu Fiji	\$ 4,962.07
Shipping costs Aust to NZ per m ³	Australiatrade	National	\$ 200.87
Shipping costs Aust to NZ per 40 ft container	Australiatrade	National	\$ 7020.00
Shipping costs NZ to Fiji per m ³	AquaAir Freight Services	Auckland, NZ	\$ 130.00
Shipping costs NZ to Tonga per m ³	AquaAir Freight Services	Auckland, NZ	\$ 210.00

Annual operational costs for the 3 configurations have been calculated for Opuwa harbour in New Zealand (Table 6). They include overhead costs of depreciation and labour of two technicians for 50 percent of a typical annual salary. Costs such as administration, boat hire and insurance have not been included as they cannot be estimated with any degree of accuracy. Depreciation is based on the manufacturer's estimate that the IMProtector™ systems should last for 5 years and the marina berth for at least 10 years. Shipping and installation costs have been included in depreciation calculations.

The additional cost of treating each yacht only includes the cost of bulk vinegar as labour is covered in overheads. Smaller costs such as fuel or electricity for the pumps and lime to neutralise the acetic acid have not been calculated.

Operational costs have not been calculated for Tonga and Fiji due to the difficulty of obtaining information over the internet or phone. However, if the rental charges for a marina berth in Fiji are an indicator, they can be expected to be considerably lower than in New Zealand.

Table 6. Estimates of operational costs of the IMProtector™ system (NZ\$ ex GST)

Item	Cost
Mobile system	
Depreciation – 20% p.a. of set-up cost	\$ 2,344.88
Labour costs for two technicians at 50%	\$ 45,000.00
Total annual overhead costs	\$ 47,344.88
Treatment solution – 100 L per yacht	\$ 189.00
Cost of consumables per yacht	\$ 189.00
Canister system installed in a permanent marina berth	
Depreciation – 20% p.a. of set-up cost for IMProtector, canister, pump and filter, not including tanks, plumbing or electricity installation	\$ 10,374.17
Labour costs for two technicians at 50%	\$ 45,000.00
Marina berth rental per year for 15 m vessel Opuā, NZ	\$ 8,770.80
Total annual overhead costs	\$ 64,144.97
Vinegar (9.9% acetic acid) – 100 L per yacht	\$ 189.00
Cost of consumables per yacht	\$ 189.00
Canister system installed in an independently moored marina berth	
Depreciation – 20% p.a. of set-up cost for IMProtect, canister, pump and filter, not including tanks, plumbing or electricity installation	\$ 9,920.01
Depreciation – 10% p.a. of set-up cost for independent marina berth including swing mooring system	\$ 6,884.80
Labour costs for two technicians at 50%	\$ 45,000.00
Total annual overhead costs	\$ 61,804.81
Depreciation – 20% p.a. of set-up cost for IMProtect, canister, pump and filter, not including tanks, plumbing or electricity installation	\$ 9,920.01
Depreciation – 10% p.a. of set-up cost for independent marina berth including pile mooring system	\$ 6,169.80
Labour costs for two technicians at 50%	\$ –
Total annual overhead costs	\$ 16,089.81
Vinegar (9.9% acetic acid) – 100 L per yacht	\$ 105.00
Cost of consumables per yacht	\$ 105.00

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