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Human Capacity Building for Introduced Marine Pest Monitoring in Western Australia

FRDC Report – Project 2009/319
Tactical Research Fund

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2009/319 Human capacity building for introduced marine pest monitoring in Western Australia

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OBJECTIVES:

1. To identify gaps in the Western Australian skill and knowledge base for the monitoring of introduced marine pests.
2. To establish a centralised source of skills and knowledge in W.A. to facilitate the planning, evaluation, and quality control of activities relating to Introduced Marine Pest (IMP) monitoring.
3. To provide an Australian best practice example and knowledge base to facilitate the consistent, effective and efficient implementation of the National Monitoring system for IMPs.

Outcomes achieved to date

The primary outcomes achieved by this project to date are:

- The completion of a gap-synthesis for knowledge regarding marine pest monitoring in Western Australia.
- The development of the capacity of relevant staff in Western Australia to competently implement national-scope monitoring designs for introduced marine pest species.
- The development of interstate and international collaborative links to relevant research institutes, to facilitate ongoing communication and synergistic efforts in the prevention, management and eradication of introduced marine pest species.
- The collation of the main body of knowledge from a capacity building travel exercise into a format suitable for dissemination to other marine biosecurity workers.

The economic and environmental impacts of introduced marine pests (IMPs) can be sizeable. Their presence can affect many different stakeholders and sectors, as they are known to compete with native species, introduce diseases, damage fisheries and aquaculture and cause significant fouling.

There are many examples around the world of the impact that IMP incursions can have, including comb jellies in the Baltic Sea causing the collapse of multi-million dollar fisheries, and high densities of Asian clams in San Francisco Bay contributing to the extinction of native fish species.

Australia is not exempt from this global problem and has experienced several notable incursions of IMPs to date, including the Northern Pacific seastar (*Asterias amurensis*) and "wakame" seaweed (*Undaria pinnatifida*) across south-eastern Australia; *Caulerpa taxifolia* in

Adelaide; and black striped mussels (*Mytilopsis sallei*) in Darwin. With the increase in recent years of international shipping traffic, particularly in Australia's north-west, the threat of IMPs is greater than ever before. High traffic areas such as in and around ports are at increased risk of introductions where biofouling and ballast water represent significant transport vectors.

The National System for the Prevention and Management of Marine Pest Incursions is a national initiative to manage the risk of incursions of IMPs onto the Australian coastline. This system is an ambitious initiative, and assumes a substantial amount of base knowledge in its workers to maintain its rigorous standards.

The aim of this project was to build the capacity of workers in Western Australia to competently implement the port monitoring component of the National System in that jurisdiction. Furthermore, the outcomes of this capacity development were expected to hold benefits for other marine biosecurity workers in Western Australia and in other jurisdictions. To accomplish these goals, collaborative meetings and a field exercise were arranged with several institutes throughout Australia and New Zealand.

The primary areas for which knowledge was required were: 1) The physical implementation of field sampling regime, including gear design, deployment and field processing techniques. 2) Practical knowledge of molecular testing techniques for IMPs as it pertains to field sampling protocols. 3) Background to the National System, including information on the baseline studies conducted >10 years prior. The taxonomic expertise to reliably identify pest species to a level of competence required by the National System guidelines.

The first three areas identified above were significantly developed throughout this investigation. Inspection of equipment in Adelaide and participation in a field regime in New Zealand significantly enhanced the participants' knowledge of and capacity to perform field operations. Meetings with workers involved in the Australian Testing Centre for Marine Pests developed the knowledge of specific molecular testing techniques currently being developed for IMPs. The history and development of the National System were explored in Tasmania with long-term marine biosecurity workers involved in the original CRIMP baseline surveys, as well as in Adelaide with workers currently involved in NIMPCG, the working group coordinating the development and implementation of the National System.

Only the fourth knowledge gap, that of taxonomic expertise, was not completely addressed during this project. Due to the limited time spent at each research institute, it was not possible to develop the depth of taxonomic expertise to fully satisfy the needs of the National System protocols. Within this document, other problems are identified in relation to taxonomic expertise, and some possible solutions are presented. While some relevant taxonomic information was gleaned, a much more significant outcome was the establishment of links to existing networks of taxonomic expertise. These links are anticipated to allow access to a wider range of experienced taxonomists while local skills are still under development.

A further benefit this project was the establishment of collaborative and synergistic research links between Western Australian workers and those at the institutes visited. These links have already progressed into proposals for collaborative research of national relevance. The final objective, the collation and dissemination of this research, is partially achieved through the This Final report document, and will be extended through other dissemination programs.

KEYWORDS: Biosecurity, introduced marine pests, port monitoring, gap-synthesis, capacity-building.

Acknowledgements

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Acronyms and Abbreviations

ABRS:	Australian Biological Resources Study
AMC:	Australian Maritime College
ATCMP:	Australian Testing Centre for Marine Pests
CCIMPE:	Consultative Committee for Introduced Marine Pest Emergencies
CRIMP:	Centre for Research on Introduced Marine Pests
CSIRO:	Australian Commonwealth Scientific and Industrial Research Organisation
DAFF:	Department of Agriculture Fisheries and Forestry
DoC:	New Zealand Department of Conservation
DoF:	Department of Fisheries, Western Australia
FRDC:	Fisheries Research and Development Corporation
IGA:	Inter-governmental Agreement
IMP:	Introduced Marine Pest
MAF BNZ:	Ministry for Agriculture and Forestry, Biosecurity New Zealand
MDET:	Monitoring Design Excel Template
MDR:	Monitoring Design Report
MITS:	Marine Invasives Taxonomic Service
National System:	The National System for the Prevention and Management of Marine Pest Incursions
NEBRA:	National Environmental Biosecurity Response Agreement
NIMPCG:	National Introduced Marine Pests Coordination Group
NIWA:	National Institute for Water and Atmospheric Research (New Zealand)
PIRSA:	Department of Primary Industries and Resources of South Australia
PCR:	Polymerase Chain Reaction
SARDI:	South Australian Research and Development Institute
TRF:	Tactical Research Fund
UTas:	University of Tasmania
WAM:	Western Australian Museum
Quarantine W.A.:	Western Australian Quarantine and Inspection Service

1.0 Background and Need

The economic and environmental impacts of introduced marine pests (IMPs) can be sizeable. They are known to compete with native species, introduce diseases, damage fisheries and aquaculture, and exacerbate fouling.

One of the most costly examples of a pest incursion is from the Baltic Sea, where the proliferation of an introduced jelly (*Mnemiopsis leidyi*) caused a systemic collapse of fisheries in the region, worth an estimated US$500 million/year (Low, 2003). This pest is now present in both the Caspian and Black seas and continues to cause problems for the relatively small fisheries that remain.

New Zealand has also relatively recently had an outbreak of an introduced marine pest, the European fanworm (*Sabella spallanzanii)*. In 2008 this recognised pest species was discovered in Lyttelton Port, at which time the New Zealand government committed NZD$3.6M to an eradication program. More than two years later, in mid 2010, the eradication program was stood down following the discovery of additional and extensive populations of the pest in nearby areas. By the time the eradication program was scaled back, the cost of remediation efforts had reached NZD$1.3M. The focus of operations regarding *S. spallanzanii* in New Zealand has switched from eradication to monitoring and mitigation (MAF BNZ, 2010).

Within Australia, the outbreak of black striped mussels (*Mytilopsis sallei*) in Darwin Harbour during early 1999 was a poignant reminder of the potential speed and scale of pest invasions and the problems they cause. The Darwin outbreak was one of very few successful eradication programs of a marine pest. The success is attributable to the speed of response and the relatively contained outbreak. Nevertheless, the cost of the operation was around AUD$2M. Given the virulence, heavy fouling nature and physiological tolerances of the black striped mussel, it is of particular concern for the pearling industry in Northern Australia (Bax et al., 2002).

To improve Australia's ability to rapidly detect and deal with IMP incursions, the National Introduced Marine Pests Coordination Group (NIMPCG) was convened with executive support from the Commonwealth Department of Agriculture, Forestry and Fisheries (DAFF). NIMPCG has developed a national framework for the monitoring of IMPs. This framework identifies 55 target pest species and 18 high-risk locations throughout Australia as priorities for monitoring.

The knowledge within Western Australia on how to implement the monitoring under the National System framework was fragmented, and the capacity was insufficient to implement an approved design. This was despite the fact that three of the top ten high-risk locations are within this state. The locations of interest within Western Australia and their rankings are Fremantle Port (2nd), the Port of Dampier (6th) and Port Hedland (9th).

The Department of Fisheries, Western Australia's responsible body for marine biosecurity, currently has four monitoring designs approved under the National System (Fremantle, Dampier, Port Hedland and Christmas Island ports). Once these four designs have been approved, and the monitoring implemented, Western Australia will have met its initial monitoring commitments under the draft Inter-governmental Agreement on the National System for the Prevention and Management of Marine Pest Incursions.

Despite the problems with securing funding for the implementation of the approved designs, there is a need to develop the capacity of researchers in Western Australia to be able to effectively undertake these monitoring designs. Specific areas that required development were pest species recognition, sampling procedures, design and use of sampling equipment, and the development of taxonomic expertise.

Furthermore, it is important that techniques used by marine pest laboratories are as nationally standardised as possible. To this end there is a need for Western Australian researchers to establish and maintain collaborative links with other laboratories in Australia and New Zealand to ensure the use of consistent and best practice methods. This knowledge will allow local researchers to effectively monitor for IMPs and to develop national consistency.

2.0 Objectives

There were three original objectives proposed for this project.

1. To identify any gaps in the Western Australian skill and knowledge base for the monitoring of introduced marine pests.
2. To establish a centralised source of skills and knowledge for Western Australia to facilitate the planning, evaluation, and quality control of activities relating to introduced marine pest monitoring.
3. To provide an Australian best practice example and knowledge base to facilitate the consistent, effective and efficient implementation of the national monitoring system for Introduced Marine Pests.

3.0 Methods

Drs Samantha Bridgwood and Mathew Hourston are responsible for developing the nationally approved designs for the monitoring of IMPs in high-risk locations within Western Australia (Ports of Fremantle, Dampier and Port Hedland), as well as for Christmas Island. The current FRDC funded project was designed to build the capacity of these and other researchers in the area of biosecurity research generally, but also specifically to enable the effective implementation of the National System monitoring designs. The most effective means to communicate the largely practical nature of the required knowledge was through collaborative visits to interstate and international research institutes that employ current best practice to monitor for IMPs.

3.1 Gap synthesis

The basis of the gap synthesis was a consultative exercise with various taxonomic, pest monitoring and marine biosecurity personnel throughout Australia and New Zealand, including local Western Australian workers.

Initially, a representative of the Australian Government Department of Agriculture Fisheries and Forestry was contacted and asked to comment on the level of capacity required by workers to complete a nationally approved monitoring design. Some information on this topic was available through the Marine Pest Monitoring Manual, however certain details required clarification.

Representatives of various stakeholder groups and industry workers were initially contacted via email correspondence, outlining the aims and goals of the project, and asking for their input into the gap synthesis process. This initial correspondence was then followed with additional communication either verbally or via email to ascertain where those workers believed knowledge gaps existed within Western Australia, and also in which specific areas they would prefer to see developments made.

Internal consultation within the Department of Fisheries was conducted initially followed by external intrastate groups. Bodies such as the Western Australian Museum, the Pearl Producers Association, OceanWatch, Quarantine W.A., various port authorities and several private consultancies were all asked to comment on these topics. In addition to the bodies above, representatives of all the institutes that were ultimately visited during the travel phase of this project were also consulted during the gap synthesis phase.

Once the consultation had been completed, the results of the gap synthesis were used to generate a list of areas that had been identified as substantial knowledge gaps. The list of knowledge gaps was then used to determine which of each of the institutes was most able to address the needs of the workers, which were added to the final itinerary.

Before undertaking the travel component of the project, specific agendas were forwarded to the relevant institute representatives identifying the areas that were of most interest. This allowed them the opportunity to formulate responses ahead of time.

3.2 Travel

The institutes that were considered to provide the best cover of the required knowledge spanned Australia and its biosecurity partner, New Zealand. A total of five separate institutes were visited, many of which included multiple facilities and researchers.

The institutes visited were:

- The South Australia Aquatic Sciences Centre in Adelaide, which is the marine research hub for the South Australian Research and Development Institute (SARDI);
- The Department of Primary Industries and Resources South Australia (PIRSA) in Adelaide, which is South Australia's policy body for marine biosecurity,
- The Australian Maritime College, which is a subsidiary institute of the University of Tasmania, located in Launceston, Tasmania,
- The New Zealand National Institute of Water and Atmospheric Research (NIWA) was consulted on several occasions at various locations. Initial consultation was at field operations at Taranaki Harbour (New Plymouth, N.Z.); the second at the Marine Invasives Taxonomic Service (MITS, Wellington, N.Z.); and the final at the Mahanga Bay Aquaculture and Fisheries Enhancement Station (Wellington, N.Z.), and
- The New Zealand Ministry for Agriculture and Forestry, Biosecurity New Zealand (MAF BNZ), which is the policy body for both marine and terrestrial biosecurity, and administrates funding and coordination of the New Zealand port monitoring system. MAF BNZ is located in Wellington, N.Z.
- The details of the specific personnel visited at each institute, as well as their roles in relation to IMP monitoring, are given in Table 1.

Table 1. Locations, institutes and collaborative researchers visited during the course of the capacity building travel.

Adelaide, Australia, 15th-18th March 2010		
SARDI - South Australian Aquatic Sciences Centre		
	Dr Marty Deveney	Subprogram Leader, Marine Biosecurity
	Dr Nathan Bott	Research Scientist - Molecular Diagnostics
	Leonardo Mantilla	Taxonomic Research Officer - Marine Environment & Ecology
SARDI - Field compound and equipment storage		
	Jason Nichols	Operations Manager - Marine Environment and Ecology
PIRSA - Adelaide CBD		
	Dr Michael Sierp	Manager - Marine Biosecurity
	Keith Rowling	Policy Officer
Launceston, Australia, 18th-22nd March 2010		
AMC (UTas) - National Centre for Marine Conservation and Resource Sustainability		
	Prof. Chad Hewitt	Director
	Ass. Prof. Marnie Campbell	Head of Department - Conservation and Ecology
New Plymouth, New Zealand, 22nd-24th March 2010		
NIWA - Field operations for Taranaki Harbour		
	Dr Don Morrisey	Marine Ecologist - Team Leader
	Stephen Brown	Field Team Researcher
	Dan Cairney	Field Team Researcher
	Megan Carter	Field Team Researcher
	Lisa Peacock	Field Team Researcher
	Kim Seaward	Field Team Researcher
	Caroline Williams	Field Team Researcher
	Bryan Williams	DoC Researcher
	Callum Lilley	DoC Researcher
Wellington, New Zealand, 24th-26th March 2010		
MAF BNZ		
	Dr Justin McDonald	Senior Advisor - Marine Biosecurity Surveillance
	Dr Naomi Parker	Manager - Strategic Science Team
NIWA - Marine Invasives Taxonomic Service		
	Sadie Mills	Taxonomic Research Officer - MITS
NIWA - Mahanga Bay Aquaculture Research Station		
	Dr Sheryl Miller	Marine Scientist - Aquaculture and Fisheries Enhancement

Three of the proposed locations that were indicated on the initial application were not visited. This itinerary alteration was detailed in the Milestone Progress Report for this project, received by the FRDC on the 1st May 2010. As stated in that document, the list proposed in the initial application was preliminary only, and the ultimate list was to be informed and directed by the gap synthesis process conducted prior to travel.

The inclusion of SARDI in the travel itinerary was considered particularly advantageous for several reasons. The liaison with researchers at SARDI was designed to inform the project investigators about the molecular testing procedures being developed by that institute. This information was considered particularly relevant since one of the issues identified by the gap synthesis was the lack of expertise and means to effectively deal with the planktonic samples generated by port monitoring fieldwork under the National System.

Likewise, PIRSA's inclusion was considered advantageous given that South Australia was the most advanced state with regards to the implementation of port monitoring designs. Another issue identified in the gap synthesis was the inability to source funds for monitoring surveys. Since South Australia was beginning its second round of monitoring, details of the funding arrangements for that work (administered through PIRSA) were of particular interest.

The Australian Maritime College in Launceston was included on the itinerary in preference to the CSIRO facilities in Hobart. The reason for this amendment was that the research, administration and policy development for pest monitoring in Australia, previously conducted by the CRIMP program at CSIRO, had since been disbanded and the responsibility for those functions had been reallocated. Several of the researchers that previously formed the core of the knowledge base at CSIRO had since moved to the AMC in Launceston.

3.3 Dissemination

The details for the complete suite of methods for dissemination are yet to be finalised, however several means of communication are currently being prepared.

The TRF final report will be presented as an out-of-session paper to NIMPCG. This will ensure a full dissemination to all NIMPCG members and stakeholders associated with that group. Since it will be presented out of session, it is anticipated that discussion of the report port will occur at the NIMPCG meeting following its submission.

An article has been prepared for the Western Fisheries Magazine as part of an ongoing series on marine biosecurity in Western Australia. This article specifically deals with the findings of the current TRF project. It is expected to reach a sizeable local audience, and to raise the awareness of the issue of marine biosecurity with the readership. The article appeared in the magazine's October 2010 issue (Appendix 3).

The Final Report will have minor amendments made to make it suitable for general publication as a Fisheries Research Report. This report will be disseminated through an extended distribution, to those institutes and working groups for which it may be applicable or useful. This list will include, but not be limited to, all of the parties contacted during the gap-synthesis and travel components of the project, if they had already not received it as part of its dissemination through NIMPCG. The report will also be publicly available through the DoF website.

4.0 Results and Discussion

4.1 Gap synthesis

The gap synthesis phase of this project identified that capacity development in several key areas was required to effectively manage the threat of marine pest incursions through National System protocols in Western Australia. Most of the knowledge gaps could be grouped into three broad themes: taxonomic capacity, field techniques, and historical knowledge of the National System (Table 2). It should be noted that no single stakeholder identified all of the points below, instead Table 2 represents the amalgamation of the points raised by one or more of the stakeholders.

Table 2. Broad areas and key questions identifying knowledge gaps in the area of marine biosecurity research as identified by relevant workers in that field.

Taxonomic capacity
What if there are no relevant "Level 3" workers available for analysing taxonomic samples?
Who do we contact for taxonomic verification?
Why look for species that are impractical to identify?
Why target certain species when remediation of that pest is extremely impractical or even impossible?
Who do we talk to in order to develop the necessary taxonomic skills?
What is the current stage of development of molecular testing techniques for pests?
Field techniques
Are there standardised gear types/sizes?
If so, what are they?
What are the safest and most efficient ways to deploy the equipment?
What is the difference between the Australian and New Zealand systems that has allowed New Zealand to have had their research implemented for more than ten years?
What can be taken from the New Zealand system to increase the efficiency of the implementation of the current Australian National System?
The National System
What were the original intentions for funding arrangements?
When will there be jurisdictional legislation regarding pest monitoring and fouling/ballast water?

4.1.1 Taxonomic capacity

Taxonomic capacity and the ability to identify the relevant species was one of the primary concerns of the biosecurity personnel in Western Australia, and indeed among the taxonomic authorities contacted including the Western Australian Museum. It is considered that in order to implement a monitoring design with the level of rigour specified by the National System, a significant level of taxonomic capacity needs to be developed.

The *Marine Pest Monitoring Manual V2* identifies the three levels of expertise required to conduct various portions of the monitoring protocols.

Level 1: No training required

Level 2: Some training required

Level 3: Formal training or formal qualification required

The initial stage of the monitoring programs require only Level 1 and 2 researchers, however, later stages of each implementation potentially require substantial practical input from multiple Level 3 researchers. Although the *Marine Pest Monitoring Manual V2* does include a list of suitably qualified Level 3 researchers, this list was found to be somewhat out of date with many of the suggested researchers being retired and several deceased.

It was identified in the gap synthesis process that what has been coined the "taxonomic impediment", that is currently affecting the biological sciences globally, was likely to have an impact for implementation of the National System's Australia-wide monitoring strategy.

The availability of Level 3 researchers, as well as the ability to train Level 2 researchers, was considered a significant gap in the capacity of Western Australia in particular, and was also of concern for Australia in general.

Several of the stakeholders identified that the development of molecular testing techniques may alleviate some of the problems associated with the scarcity of taxonomic expertise. SARDI is currently conducting a project to develop molecular testing techniques for IMPs. Since this program is still in the developmental phase, knowledge concerning the specific capabilities and limitations of the protocols was not up to date in Western Australia. An examination of the techniques as well as the current and projected capabilities of the system was considered a useful exercise, in order to determine its current usefulness, as well as its projected influence on the National System port monitoring protocols.

4.1.2 Field equipment and techniques

This knowledge gap was identified after a thorough examination of the monitoring protocols as specified in the literature provided through the National System. Although many aspects of the field protocols are specified in great detail, many other practical elements are not. Specific dimensions of sampling equipment such as dredge and trap design, and net and mesh sizes are not detailed, and in the interests of national standardisation should be kept consistent. Likewise, the safe and efficient operation of that equipment was considered as a complimentary and necessary area for capacity building.

Since SARDI was one of the bodies involved in the development of the design protocols, an examination of the field equipment used by that institute was considered advantageous. The opportunity to observe the actual implementation of a survey for IMPs was available in New Zealand, where NIWA was conducting its field regime at Taranaki Harbour. The common origins of the Australian and New Zealand port monitoring protocols meant that the sampling regimes and equipment were similar enough to allow some comparison. This allowed the observation of the correct and safe use of equivalent sampling equipment by an experienced team of biosecurity researchers.

4.1.3 The National System

The combination of the relatively long period that NIMPCG has been running (ca. 10 years) and the relatively short turnover time for biosecurity staff at both federal level and in Western Australia, has resulted in a situation where much of the accumulated knowledge regarding the history and formation of the National System has been dispersed. This information on the origins of the system is considered a knowledge gap, and is knowledge that would be beneficial to the current researchers. Specific pieces of information that were identified in the gap synthesis under this topic included, founding tenets, original goals, and changes in focus. Information regarding the original baseline surveys was also considered relevant to the implementation of the current designs.

Other areas in which significant knowledge gaps were identified included the specifics of funding arrangements for monitoring designs, development of any marine biosecurity legislative instruments, and some of the decision-making processes behind the development of the current system.

4.2 Travel

4.2.1 Taxonomic capacity

When the issue of the taxonomic knowledge gap was discussed with various researchers, several different recurring themes became apparent. The first, as expected, was that of the taxonomic impediment and its impacts on the implementation of the monitoring designs. The second was the list of species currently on the monitoring design watch-list. Thirdly, the usefulness of the molecular testing techniques, and finally, accessing any existing network of taxonomists.

1) The taxonomic impediment is the termed coined for the worldwide decline in the taxonomic workforce. It is recognised that the number of active taxonomists is declining as the older generation of workers are retiring without being replaced by a new cohort of younger workers in this field (Ponder *et al*., 2002). The trend is further exacerbated by the lack of training, funding and focus being invested in taxonomic research. To a degree this problem is being combated under various initiatives such as the ABRS and the Convention on Biological Diversity. Nevertheless this effect is still plainly evidenced locally in Western Australia, with experts for many taxonomic groups simply not being available.

   Within the National System framework there is a significant commitment to taxonomic rigour, leading to a sizeable processing and staff-training workload for Level 3 (specialist) researchers such as taxonomists. While this is commendable, it places a large burden on a largely aging and retiring workforce. The most expedient solution to this problem is to allow lower level (2) researchers to conduct a larger portion of the processing, with only minor amounts being delivered to specialists. This may lead to a lower level of taxonomic rigour, but would greatly facilitate the monitoring process. In an effort to combat the decreased skill level of the taxonomic workforce, it was suggested that a dedicated and accredited training scheme be implemented that is specifically designed to cater for the expanding biosecurity industry. This training would benefit not only the monitoring aspects of the National System, but would also be applicable to increasing the workforce of qualified biofouling inspectors ahead of national and jurisdictional legislation.

   While this problem had been identified prior to the travel exercise, the scope of the problem and potential solutions had not. It was anticipated that some measure of taxonomic knowledge might be gained during this exercise, however it quickly became evident that much more in-depth training was required than could be delivered on this schedule.

2) The list of target species was discussed with the majority of researchers, both in terms of the rationale for the inclusion of certain species, and the means by which they could be feasibly identified. The rationale for the inclusion of microscopic planktonic species in the target list was the most common topic of conversation, with several differing opinions being expressed. One of the major criticisms of the inclusion of, in-particular, holoplanktonic

species was that even if one of these pest species became established, there was very little that could be done in terms of eradication. The rebuttal to this assertion was that the inclusion of these species was in order to inform risk registers for ballast water movements and was designed to provide pre-emptive management rather than reactive. This benefit only becomes apparent once surveys in a significant number of interconnected high-risk ports have been completed, relative risk of translocation established, and the appropriate ballast water management legislation enacted.

The inherent taxonomic difficulty of processing planktonic samples was also discussed. There are currently few researchers capable of competently processing these samples in the volumes specified by the Monitoring Design Guidelines. This problem has already been identified by SARDI and is one of the reasons behind the development of the molecular diagnostics techniques as well as the founding of the ATCMP. The ability to test for very small and inconspicuous species in relatively low concentrations will make the routine processing of planktonic samples feasible. At the current time, the processing of planktonic samples through traditional taxonomic methods is likely to present a prohibitively difficult and/or expensive task due to the relative shortage of staff with a sufficient level of training. The problems with monitoring for planktonic species are equally applicable to monitoring for benthic cyst stages of various pest species.

3) The use of <u>molecular techniques</u> to speed up taxonomic identification is the goal of the Australian Testing Centre for Marine Pests. This is a SARDI initiative and has been formed to service the needs of the National System. Its primary function is to develop and implement molecular testing procedures to quickly, efficiently and reliably detect the presence of certain marine pest species in samples collected under the monitoring regime.

The testing procedure used by the ATCMP is real-time PCR, which not only allows relatively rapid determination of presence or absence of particular pests species, but if present, also provides a measure of abundance. Currently, the Centre has assays for nine different pest species either developed or in late stage development, including several of the CCIMPE trigger species.

These species are:

Asterias amurensis (Northern Pacific Seastar)
Carcinus maenas (European Shore Crab)
Undaria pinnafida (Wakame)
Ciona intestinalis (Vase Tunicate)
Perna canaliculus (Green lip mussel)
Perna viridis (Asian Green Mussel)
Musculista senhousia (Asian Bag Mussel)
Corbula gibba (European Clam)
Sabella spallanzanii (European Fanworm)

The nature of the testing procedure is such that bulk processing is very advantageous, in that it is as easy to test for all nine species as it is to test for one, as well as it is easier to test 100 samples than 10 samples. This means that if samples can be processed in bulk, substantial saving in terms of both time and money can be made. Preliminary estimations indicate that if samples are processed in bulk, the cost per unit would be in the order of $250, which is considerably less than the cost of traditional taxonomic identification as estimated by the MDET. Furthermore, as assays are developed for more species, they can be added into the test regime at minimal extra cost.

In addition to the nine pest species above, an assay for a species of brine shrimp has been developed for use as a positive control. The positive control measure involves the addition of DNA material from an indicator organism to each sample at various stages between collecting the sample in the field, and producing the results of the PCR test. When the positive control assay is run on the samples along with the pest assays, the researchers can determine if the sample has been treated appropriately for molecular analysis. If the positive control assay does not return the expected positive result, there has been degradation of the DNA in the sample and the assays for the pest species cannot be considered accurate.

As of March 2010, the ATCMP was not yet capable of receiving bulk samples for routine testing for all nine species. SARDI researchers report that several stages of development remain before the testing centre is capable of receiving and processing the samples produced from the implementation of a monitoring design. Those steps that remain include:

The development of a fully tested and reliable field sampling and preservation technique to keep the samples in an appropriate state for testing, This project is in its final stages and reporting is anticipated before 2011. Preliminary results indicate that an oven drying procedure at about 40°C is the best means to dry samples on filter paper, ready for transport.

Ongoing testing of the existing assays against samples from around Australia. This is required because each assay has been developed using samples from the local South Australian environment, to produce a positive result only for the pest species rather than any native species. When the assay is applied to samples from another location there is a possibility of returning a false positive if the sample includes a species for which it has not been trained. By training the assays on samples from a variety of locations, the likelihood of a false positive result is minimised. The stringent testing and training for each assay is a very important step to avoid many of the problems previously encountered using PCR assays in this manner (Burreson, 2008).

The eventual goal of the ATCMP researchers is to develop a larger suite of assays for more of the National System's target species. This is a very large task and as such does not have an expected completion date.

Accessing networks of taxonomists is still required since the molecular techniques described above are not designed to completely replace traditional taxonomic analysis, but to direct researchers to focus their efforts on a smaller number of samples by pretesting a larger bulk of samples. There is still expected to be a reliance on traditional taxonomists for the ongoing implementation of the National System. The formation of a network of expert taxonomists is therefore still an integral part of implementing a monitoring design.

4) The Marine Invasives Taxonomic Service (MITS) within NIWA is an excellent example of the type of facility needed to service a national monitoring system such as the one Australia is currently creating. The MITS provides several services to the New Zealand marine biosecurity program. Firstly, it acts as a collection point for all the specimens collected by field teams that are suspected of being a pest species. Secondly, they act as a specimen reference library for any pest species found in New Zealand, or that are on their watch list. MITS also acts as a coordination point for a network of taxonomists throughout New Zealand and around the world. Despite the on-staff researchers at MITS having a considerable amount of taxonomic expertise, they do not necessarily cover the breadth of knowledge for all taxonomic groups. To help to solve this problem, MITS has developed a strong network of external taxonomists, who are consulted when samples are received which contain certain taxa that require specialist examination.

Under the current arrangements in Australia, each jurisdiction is required to contact and contract the services of their own taxonomic experts on an ad-hoc basis, as they are needed. Since monitoring designs under the current National System have only been implemented relatively recently, there has not been a need for an Australian equivalent to New Zealand's MITS. Now that monitoring regimes have been completed in Northern Territory and South Australia, and several more monitoring designs are approved, there is more of a need for a structured and centralised taxonomic service. The possibility of engaging the taxonomic expertise of MITS was discussed, however only small amounts of material could be considered, and they would be subject to samples passing quarantine in New Zealand, which is likely to be a difficult process. Additionally, their resources are finite and their own samples would take precedence over any Australian samples.

4.2.2 Field protocols and equipment

There were two opportunities to examine the various pieces of equipment used in pest monitoring regimes. The first was in Adelaide at the SARDI field operations compound and the second at the NIWA field operations at Taranaki Harbour in New Zealand. Since SARDI had input into developing the monitoring guidelines, the design of their equipment was considered the most appropriate to use as a template for Western Australia. However, the input from the experience of the New Zealand team was also considered invaluable.

The design and usage of the benthic dredge was of particular interest during this project. The monitoring design literature concerning the use of benthic sleds required a lot of user interpretation regarding the design and operation of this piece of sampling equipment, as did the MDET specifications. This was quite evident at the SARDI field compound, where there were several prototype designs of benthic sleds and dredges for use in the pest monitoring regimes. All of the prototypes, including the most recent, were relatively large, heavy pieces of equipment, which sampled approximately 1 metre swath. Initial prototypes were extremely heavy, requiring a large boat with a lift arm and winch to operate safely (Fig. 1a). Later designs were built significantly lighter, in a similar style to that of the sleds manufactured by Wildco™, which could conceivably be operated by hand from a smaller vessel, albeit with a great deal of effort (Fig. 1b). The collection bag used in the final prototype design was a typical mesh net with an aperture of about 15mm.

In contrast to the sled used by SARDI, the NIWA sampling protocol used a much smaller sled based on the design of an "Ockelmann sled" (Ockelmann, 1964). Ockelmann sleds are typically large, having a swath in the range of 1 –1.5 m (Fig. 2a). However, the ones used by NIWA were much smaller (swath of only 0.4 m) and lighter than both a typical Ockelmann sled, and the sleds employed by SARDI (Fig. 2b). It was safely and easily operated by one person from a smaller boat, and without the used of a winch or lift arm. To account for the smaller swath of the Ockelmann sled, a greater number of tows were conducted. Also in contrast to the SARDI sled, the collection bag was a much finer nylon mesh bag, similar to a heavy duty plankton net, which had an aperture of about 2-3mm.

Since the majority of sampling during the upcoming monitoring regimes in Western Australia is likely to be conducted from vessels with varying sizes and capabilities, the downsized Ockelmann sled was considered to be the better option due to its ease of operation, even from relatively small boats. Furthermore, since several of the targeted Western Australian locations are in remote areas, compact equipment is easier to transport. As per the NIWA sampling regime, the number of replicates in the Western Australian designs has been increased to account for the smaller sample size taken by each deployment.

Figure 1. **a)** Early prototype benthic dredge employed by SARDI. **b)** Later prototype dredge employed by SARDI.

Figure 2. **a)** Large Ockelmann sled employed at SARDI. **b)** Small Ockelmann sled employed by NIWA.

2) The beam trawl was one of the other pieces of sampling equipment for which additional information was required. Since NIWA did not use a beam trawl in their sampling regime, the details of the net used by SARDI was the only available template. The net used by SARDI is 1.5 m wide, the body of the net was ca. 12mm mesh and the cod-end was of a finer mesh, ca. 6mm. Using these specifications as a guide, the net that has been adopted for the current Western Australian monitoring protocols is 1.5 m wide, with a body consisting of 12mm mesh and the cod-end of 7mm mesh. Unfortunately, since SARDI was not conducting any field monitoring activities at the time of the visit to their facilities, the deployment and use of the net was unable to be observed.

Several different crab trap designs were examined at both the SARDI and NIWA facilities. While the design of the traps varied, most were reported to catch a similar range of species. Three trap designs were examined in the SARDI facility (Fig. 3), with the first being a simple net box trap, which is commercially available. This is a standard trap type and will catch most crab and fish species, as well as starfish if the opening is of sufficient size. The other two trap types were an operahouse trap, which is also commercially available, and a pipe trap, which was made by SARDI specifically for use in port monitoring. The pipe trap comprised a length of PVC pipe (100mm diameter, 600mm long) covered at one end with a removable mesh, and the other partially blocked with a funnel. The funnel had previously been cut at the narrow end to create an appropriate entrance (60 mm diameter) and at the wide end to fit the inside diameter of the pipe. For the Adelaide port monitoring design, one of each of these three trap types were baited with pilchards, joined together on a single dropline and tied to a float and/or a hard structure for deployment. This set of three traps was considered a single replicate.

Figure 3. Three trap types used by SARDI. From left to right: box, pipe and opera house traps.

The only trap type common to both SARDI and NIWA sampling operations was the box trap, NIWA used neither opera house nor pipe traps, but did employ starfish traps. The starfish traps comprised of two large metal hoops, with a coarse net forming the body of the trap. Like the SARDI design, traps were baited with pilchards, sets of three traps were deployed on a single shotline, tied to a hard structure and marked with a float. Unlike the SARDI design, each shotline held the same type of trap, i.e. all crab traps or all starfish traps.

4.2.3 Alternate sampling methods

Although the main focus of this report has been developing the capacity to implement marine pest monitoring with specific reference to the National System methodology, there were also opportunities to develop knowledge and skills relevant to marine biosecurity, that were not necessarily directly related to the National System. These discussions included alternate methodologies for pest monitoring, existing pest incursions, and the implications of pests for aquaculture.

The use of settlement plates as part of a pest monitoring regime was discussed at several of the institutes visited, in particular at the AMC in Launceston. The current monitoring guidelines for the National System do not incorporate the use of settlement plates as an approved sampling method. This is mainly because the sampling for each monitoring implementation is designed to occur within a limited timeframe, in the order of 10-14 days, and settlement plates do not accumulate identifiable individuals of fouling species in that period. Furthermore, it is only possible to detect sessile fouling species such as mussels, algae and ascidians using settlement plates. The motile and semi-motile species such as crabs detach when the plates are removed from the water.

Despite not being adopted by the National System, settlement plates are widely used for pest detection as a means of continuous monitoring. Monitoring programs using settlement plates are currently underway across Australia, along the east coast of Australia through the AMC, and in the Northern Territory through N.T. Fisheries.

Settlement plates are typically PVC or terracotta tiles, ca. 10-20cm^2 and are usually deployed in arrays, each holding 4-12 plates in different orientations and at a range of depths (Fig.4). Arrays may also hold mops to allow settlement of different organisms. Arrays are often suspended from jetties and wharves so that they are in close proximity to potential introduction vectors such as the hulls of ships. Their underlying premise is to provide a fresh, unfouled surface for marine organisms to colonise. By their very nature, significant biofouling species are among the first, and fastest growing species to colonise the fresh substrate. If viable propagules of an introduced fouling species are present in the environment, the settlements plates are designed to form an ideal substrate for them to colonise. Arrays are usually retrieved after a three-month soak on a rotating basis, i.e. after 12 weeks half of the plates in an array are retrieved and replaced with new plates, after a further six weeks, the other half are retrieved and replaced. This cycle is repeated every six weeks, allowing a three-month soak for each plate. This soak period may be made longer or shorter as desired, however the trade-off is that if plates are left too long, a fouling species may have time to form a significant population before they are detected. Conversely, if the plates are not left in the water long enough, the fouling organisms do not have time to grow to a large enough size to be reliably identified.

Under the National System's monitoring regime, each survey is to be repeated after a two-year period. This means that if an incursion event occurs soon after the completion of a port survey, it may be two years before it is identified as a problem. To combat this possibility, settlement arrays may be used as a continuous method of monitoring for a limited suite of marine pest species as a complement to the National System surveys. They are seen as a very cost effective and proactive measure to monitor the spread of marine pests, and while they do not cover as large a list of species as the National System surveys, they do provide a relatively cheap and continuous method of detecting key fouling species.

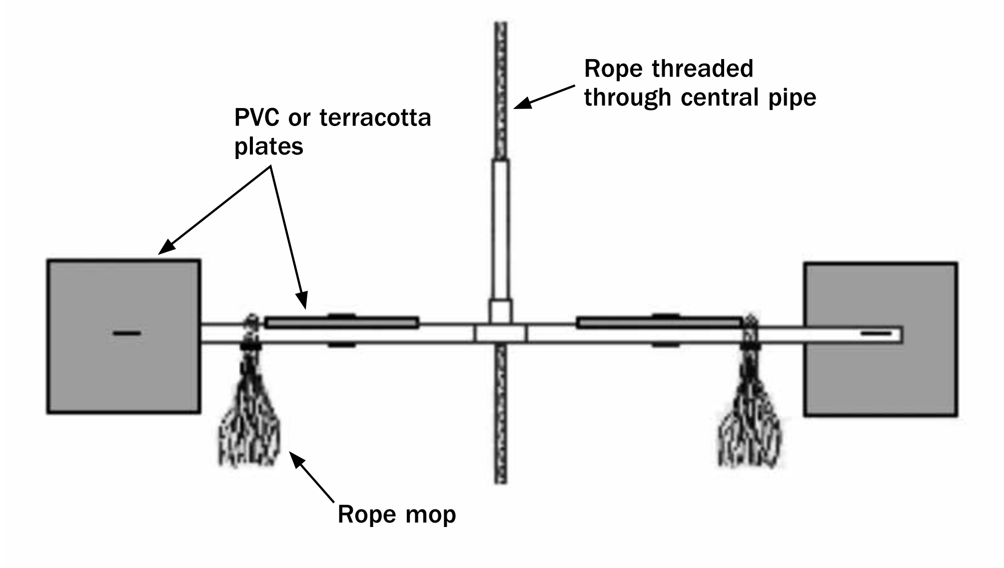

Figure 4. Illustration of one segment of a typical settlement array. Individual designs may vary with the material used for the settlement plates, inclusion of rop mops and number of array segments. Adapted from Marshall and Cribb (2004).

4.2.4 The National System

Funding Models

The draft IGA regarding the adoption of the National System specifies that the "Individual jurisdictions will determine where the funds are sourced", and proposes that "stakeholders that either contribute to the risk of a marine pest incursion or benefit from the National System should contribute to the funding of the National System". The list of stakeholders that this statement encompasses varies from location to location, and may cover a large number of entities, as is the case in Fremantle Port, or relatively few, as in Port Hedland.

Despite the implementation of the National System being approved by the signatories to the draft IGA, at this time there are no legislative instruments that compel any stakeholders to contribute to the funding of a monitoring regime. Stakeholders are also reluctant to contribute to substantial funds towards the implementation of the system on a voluntary basis. Nevertheless, both the Northern Territory and South Australian jurisdictions have sourced funds to implement several designs. In both cases, the territory/state government has provided funding to complete the implementation of a survey. There have been no further commitments of funds to ongoing port surveys by the Northern Territory Government, despite the requirement of the National System of biennial implementation of the monitoring regimes. SARDI also receives funding from external sources for other biosecurity-based projects to supplement the government funding it receives for port monitoring and to maintain its core body of researchers.

Some possible solutions to the problem of funding were suggested at the various institutions visited, some of which were considered more feasible than others. One was the development of legislative instruments at a State level to compel stakeholders to contribute to the cost of monitoring. Another was the compilation of case studies to increase the desire to provide funding, detailing the potential costs to industry and environment if monitoring did not occur. This latter solution may be equally tailored towards either stakeholder groups, as in the draft IGA suggestion, or state-level government, as in the Northern Territory or South Australian funding models.

In contrast to Australia, the New Zealand system of port surveillance has been running since 2000, was expanded in 2005, and now has ongoing port surveys at 21 ports. It was suggested that the successful implementation of the surveillance regime in New Zealand was at least partly attributable to the level at which governance of the program was located. The bodies responsible for both the policy (MAF BNZ) and the implementation (NIWA) exist at a national level, likewise, the funding for the program comes from the federal government level. This is in contrast to the Australian system, where much of the overarching policy aspect of the marine biosecurity initiative is developed (NIMPCG) and coordinated (DAFF) at a national level but the responsibility for securing funding is the responsibility of the state jurisdictions, and the actual funding of a design is suggested to come from the stakeholders.

It was speculated that under the current arrangement in Australia, there is little ownership of the system by any of the parties involved. The federal, state and stakeholder groups each seem to feel that various components of the system are the responsibility of one of the other groups, and the large geographical expanse of the continent tends to nurture the misconception that one jurisdiction's problem has little relevance to any other jurisdiction. This once again contrasts with the New Zealand arrangement, where there is a strong sense of national ownership of their system and the relevant decisions regarding both policy and funding can be made by the single organisation, MAF BNZ. Likewise, NIWA has responsibility for conducting sampling at locations around the entire coastline of New Zealand. Consequently, those workers are able to develop a sense of ownership of the entire project rather than just of their own isolated component.

Background to the National System

Prior to the development of the current National System and the formation of NIMPCG in 2001, the management and research into IMP incursions was handled by CRIMP, within CSIRO. One of the projects instigated by CRIMP was the comprehensive survey of port areas around Australia to provide baseline data for future port monitoring efforts. The port surveys were jointly funded by the CSIRO and the relevant port authorities. This was designed to link in with previously identified IMP incursions such as that in Darwin (black striped mussel) Victoria (Northern Pacific seastar) and Tasmania (Wakame seaweed). In 1997, a ballast-water risk assessment was conducted in tandem with the port surveys at the request of the ports, the completion of which coincided with the transfer of funding for the remaining surveys from a joint operation to one funded by the ports. In 2001, a federal ballast-water management protocol was implemented, but this did not apply to interstate movements for most jurisdictions.

After the completion of the CRIMP surveys, NIMPCG was officially formed in 2001 to develop a national system for the management of IMPs, including further mechanisms for the control of ballast water discharge and hull fouling as well as regular monitoring. For the monitoring regimes, the intention was to use the data from the CRIMP surveys as they were originally intended, as a baseline data set on which to build a targeted system. In 2005, the intergovernmental agreement, developed by NIMPCG and specifying the scope and responsibilities of the jurisdictions, was signed by the federal and jurisdictional governments (with the exception of NSW). This document also included some details of the cost-sharing arrangement for IMP emergency responses (although the arrangement has since been amended and is now covered by a different cost sharing model under the NEBRA).

5.0 Benefits

The benefits of this project are linked both directly and indirectly to commercial and recreational fisheries, as well as aquaculture ventures. The impacts of IMPs have been proven to be detrimental to many fisheries through many examples worldwide.

The aims of this project have benefits for both aquaculture and wild stock fisheries. Introduced Marine Pests (IMPs) may have significant impacts on commercial and recreational fishing activities, including competition with and ultimate displacement of native species, introduction of foreign pathogens, and infrastructure damage such as significant fouling of sea cages, nets, hulls and water conduits.

This relatively low-cost project has significantly contributed to the implementation of the monitoring program for high-risk locations under the National System. The National System is a multi-agency initiative involving most states and territories, and both public and private sectors. It is designed to provide a crucial tool for the early detection and eradication of introduced marine pests. The project was designed to facilitate and streamline the much larger national monitoring project and to identify national best practice in this field.

The monitoring program is likely to be most directly beneficial to the aquaculture industry, through the timely detection and efficient eradication of various introduced species such as fouling algae (e.g. *Undaria pinnatifida*), ascidians (*Didemnum* spp.) and mussel species (*Mytilopsis sallei, Perna perna, P. viridis* and *Musculista senhousia*). Additionally, benefits are envisaged for the majority of commercial and recreational fisheries, both directly through disease and competition minimisation and indirectly through safeguarding the ecological integrity of the Western Australian marine environment.

Since the compilation of this report, one full monitoring regime has been implemented in Western Australia, i.e. at Christmas Island. Thus, several examples of how the knowledge gained during this project has directly affected the implementation of pest monitoring in Western Australia can be cited.

Firstly, the small Ockelmann sled manufactured for NIWA was used as a template for the one used in the Christmas Island implementation. The design proved to be very efficient, and preferable to using a very large sled given the very small areas of loose sand in the Christmas Island port area.

Secondly, discussions with SARDI regarding the performance of various types of crab traps was very informative, and influenced the ultimate decision to rely on opera house traps for field work on Christmas Island.

Thirdly, the information gathered regarding the use of settlement arrays has been formulated into a monitoring regime designed to compliment that of the National System. Currently, the ports of Fremantle, Dampier and Port Hedland are participating in the trials of an early warning system for marine pests. The trial system primarily employs settlement arrays, with a relatively frequent rotation (three to four months), as well as frequent trapping and visual surveys to provide an ongoing monitoring program in between the biennial National System surveys.

6.0 Further Development

Several areas were identified throughout this exercise that could not be dealt with effectively within the time and funding constraints of the project.

The development of a level of taxonomic expertise specifically relevant to pest monitoring under the current National System is a critical first step to equipping the workers to perform the NIMPCG protocols to a high and consistent standard. This is not to say that all marine pest researchers need to be trained to the same level as specialist taxonomists, but to a moderate level in order to relieve the pressure on that specialist but small workforce. Given the expansion of the biosecurity industry, as well as the progression of monitoring plans and biofouling/ballast water legislation, it seems prudent to implement a training mechanism for its workers. Furthermore, it would be advantageous that such a training mechanism be accredited and standardised to ensure its workers meet an acceptable level of competency.

An ideal means to address the ad-hoc approach to taxonomy currently in place through the National System, whereby jurisdictions liaise directly with numerous taxonomists and institutions in an ad-hoc manner, would be the development of a centralised and experienced taxonomic service such as the MITS. The formation of a taxonomic service specifically tailored to the National System's requirements would provide an excellent resource for all jurisdictions, ensure the maintenance of a current and relevant taxonomic network and would likely streamline one of the more troublesome aspects of the current National System. Such a centre would also provide an ideal foundation for developing the accreditation scheme mentioned previously. A collaborative partnership with centres such as the ATCMP would provide further synergies, allowing faster and more efficient workflows.

The formal decision needs to be made regarding the provision of funding for the implementation of the port monitoring surveys under the National System. Despite Western Australia (and most other States and Territories) signing the draft IGA to adopt the National System, there has been no commitment of funds to undertake ongoing port monitoring. Under the draft IGA, it was stipulated that the funding for projects covered under the draft IGA is the responsibility of the various jurisdictions, but the means for recovering those funds were not specified. This lack of specificity has resulted in stagnation of the process in most jurisdictions. In order to realise the full potential of the National System, there must be some definitive decisions and commitments made by the jurisdictions.

Partially linked with the lack of funding is the relative dearth of relevant legislative instruments. As these instruments are currently in the developmental process in many jurisdictions and at a Federal level, specifically with regards to ballast water management, this future development is already in process.

7.0 Planned Outcomes

1) *Completion of a gap-synthesis for knowledge regarding marine pest monitoring in Western Australia.*

   The gap synthesis exercise was developed primarily to direct the efforts of the remainder of the project. In this capacity it was a success, since it identified several themes in which biosecurity knowledge in Western Australia needed augmentation. Broadly these were: implementation of field operations (gear design and survey logistics), taxonomic capacity (traditional as well as molecular techniques), and historical knowledge of the National System (and how it pertains to the current implementation of survey designs). These themes were used to select preferred institutes for the travel component of the project, and once at those destinations, to focus the meetings on pertinent topics.

2) *The development of the capacity of relevant staff in Western Australia to competently implement federally mandated monitoring designs for introduced marine pest species.*

   The core staff members tasked with implementing the National System port monitoring designs in Western Australia have gained significant benefits from the outputs of this project. Substantial knowledge has been gained with regards to the equipment design, implementation of the field regimes, forming links into existing taxonomic networks and the details of the ATCMP for molecular testing procedures. Additionally, understanding the historical context of NIMPCG and the National System has allowed those workers to develop strategies to source additional funding.

3) *The development of interstate and international collaborative links to relevant research institutes, to facilitate ongoing communication and synergistic efforts in the prevention, management and eradication of introduced marine pest species.*

   The collaborative links established during this project have allowed the researchers to access taxonomic networks and facilities such as those based out of SARDI, the ATCMP and MITS. These networks are expected to hold benefits for all biosecurity researchers in Western Australia as the capacity of workers further increases through continued collaborative efforts. Furthermore, the establishment of communication links has enhanced consistency and is expected to reduce parallel/redundant research.

4) *The collation of the main body of knowledge from the capacity building travel exercise into a format suitable for dissemination to other marine biosecurity workers.*

   Several means are being employed to ensure relevant information is disseminated to the various marine biosecurity worker and stakeholder groups. The target audience is anticipated to include marine biosecurity workers in Western Australia, the other Australian jurisdictions, and in New Zealand.

8.0 Conclusions

The main aim of this project, to build the capacity of workers in Western Australia in order to competently implement the monitoring component of the National System, has been met.

Subsidiary to that general aim, most of the areas for which knowledge was lacking have been addressed through the course of this project. Knowledge gaps were identified by a gap-synthesis exercise and were in the areas of:

1) The physical implementation of field sampling regimes, including gear design, deployment and field processing techniques.
2) Practical knowledge of molecular testing techniques for IMPs as it pertains to field sampling protocols.
3) Background to the National System, including information on the baseline study conducted >10 years prior.

The taxonomic expertise to reliably identify pest species to a level of competence required by the National System guidelines.

Inspection of equipment in Adelaide and participation in a field regime in New Zealand significantly enhanced the researchers' knowledge of and their capacity to perform field operations. Specific pieces of sampling equipment including nets, dredges and traps have been specially designed or chosen, based on the information gained during this project. Likewise, safety and efficiency aspects of the field regimes were noted for incorporation into the Western Australian sampling protocols.

Meetings with workers involved in the Australian Testing Centre for Marine Pests developed the knowledge of specific molecular testing techniques currently being developed for IMPs. Since the ATCMP is still in a development phase, the current and anticipated capabilities of the centre were not widely known. This project allows those capabilities, the centres timelines for future developments and availability to researchers, to be widely known.

The history and development of the National System was explored in Tasmania with long-term marine biosecurity workers involved in the original CRIMP baseline surveys, as well as in Adelaide with workers currently involved in NIMPCG, the working group coordinating the development of the National System. Knowledge of the founding tenets, and some of the problems the National System has had in the past has shed light on the current state of the management of marine biosecurity in Australia. An external view of Australia's National system was also garnered in New Zealand, which lead to further understanding of why the implementation of New Zealand's port monitoring system is further advanced than Australia's.

Only the fourth knowledge gap, that of taxonomic expertise, was not completely addressed during this project. Due to the very limited time spent at each research institute, it was not possible to develop the depth of taxonomic expertise to fully satisfy the needs of the National System protocols. While some relevant information was gleaned, a much more significant outcome was the establishment of links to existing networks of taxonomic expertise. These links are anticipated to allow access to more experienced taxonomists while local skills are still under development.

A further benefit that was developed during this project was the establishment of collaborative and synergistic research links between Western Australian workers and those at the institutes visited. Some of these links have already progressed into proposals for collaborative research of national relevance.

Future developments and potential courses of action are suggested to achieve the goal of initiating and continuing the port monitoring aspect of the National System. The most urgent of the future developments is the formalisation of the funding arrangements for monitoring. Without that critical step, the efforts of marine biosecurity workers in many Australian jurisdictions will be wasted. More importantly, biodiversity, wild fisheries, aquaculture ventures and human health will be continue to be jeopardised through the possibility of an undetected and unmanaged IMP incursion.

8.1 Recommendations

Several recommendations have been developed from the findings of this report.

1) Appropriate taxonomic and operational training, in the form of an accredited course of study, should be made available to relevant biosecurity workers in order to ensure consistency and a measure of confidence across the sector. This training would be equally applicable for workers involved in monitoring regimes and those contracted for vessel and infrastructure inspections.
2) Although the provision of an accredited training course would be of benefit to all of the jurisdictions, it may be appropriate for a single jurisdiction to take lead on the project, in a similar manner to SARDI instigating the ATCMP. An educational institution such as a university or other tertiary training institution would be a logical project partner.
3) The establishment of a centralised national taxonomic facility to service the requirements of the marine biosecurity sector should be considered, similar in structure to the New Zealand example of MITS. This facility would ideally act as:
   - A central repository for pest voucher specimens and/or samples,
   - a service for the validation of taxonomic identifications, and
   - a hub for contracting the services of specialist taxonomists.

   To progress this recommendation it would be best considered in an appropriate national forum such as at NIMPCG, with the consultation of all of the stakeholder groups.
3) A formal decision needs to be made regarding the funding model for monitoring regimes, particularly for Western Australia, but also in the other jurisdictions. Furthermore, a commitment must be made for the ongoing provision of that funding, and if appropriate, the development of relevant legislative instruments to facilitate the funding model. While this is the responsibility of the individual jurisdictions, it is likely to be of benefit if decisions are made in consultation with each of the other signatory jurisdictions.

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10.0 Appendices

Appendix 1 – Staff List

Principle Investigator

Mathew Hourston

Co-investigator

Samantha Bridgwood

Administrative

Selina Cranley

Appendix 2 – Meeting Minutes

Government of **Western Australia**
Department of **Fisheries**

Human capacity building for Introduced Marine Pest Port Monitoring
Meeting Minutes

Date :	Tuesday 16/03/2010
Location:	South Australia Aquatic Sciences Centre, West Beach, Adelaide. S.A.
Attendees:	**DoF:** S. Bridgwood, M. Hourston **SARDI:** M. Deveney
Topic of Meeting:	General nature of marine biosecurity work at SARDI

General structure of the marine biosecurity team at SARDI.

- About an 8-person team (give-or-take) to conduct the practical and analytical component of the port monitoring designs.
- Practical skill sets available to biosecurity within SARDI include a survey design specialist, taxonomists, commercial divers and molecular biologists.
- In addition to the implementation of the port monitoring, some hull inspections are conducted.

General information on SARDI.

- Funding arrangements.
  - Biosecurity partially sustained by state funding, with supplementary external / joint funding for some projects (FRDC, ARC linkage etc).
- Place within government and private sectors.
  - 20 years ago the research components for the former South Australian Department of Primary Industries were spun-off to form SARDI.
  - SARDI now operates as an independent research institution with a significant proportion of its revenue derived from the SA Government, but with a decreasing proportion of directly attributed State funds.
  - Allows a streamlined system for the provision of State funding to the actual implementation of field operations.
  - The PIRSA/SARDI split allows better delineation of tasks and responsibilities, facilitating better communication and cooperative efforts.
- Links with PIRSA.

Specific discussion of the *Caulerpa taxifolia* outbreak.

- Outbreak of *C. taxifolia* in the “West Lakes” area. A semi-enclosed coastal inlet. Archaic outflow of the Torrens River.

- First detected in 2002
- Unknown point source of *C. taxifolia*.
- Several treatments considered, copper sulphate (too toxic), hypersalinity (too costly), glyphosate (ineffective for this alga), hyposalinity (eventual treatment).
- Winter discharge of the Torrens River diverted to the lakes. Barrages across the marine entrance decreased the salinity and killed all *C. taxifolia* in West Lakes.
- *C. taxifolia* now widespread in the outer estuarine and harbour area.
- No evidence that it out competes seagrass, despite data to the contrary from Europe.
- Causes blockages for the water intake for the power stations.
- Several exacerbating factors. creates the perfect environment.
  - Soda Ash factory discharges ammoniated liquor (free nitrogen).
  - Power plant discharges warm water.
- *C. taxifolia* also changes its own environment to better suits its own growth. Thick mats of rhizomes make a strong reducing environment, releasing free nitrogen, encouraging growth of *C. taxifolia* and inhibiting growth of other plants.
- *C. taxifolia* is now "managed", as it is not practical to attempt eradication.
- Controlled in critical areas with black plastic sheets pegged down and chlorine pumped underneath. Commercial contractors employed for this task.
- Areal cover and distribution monitored with annual surveys.
- Funding for this work is joint state/private sources.

Discussion of the National System.

- Discussion of South Australia's State funding commitment to the National System.
- SARDI's role in the development of the practical aspects of the National System.
- Identification of the fundamental differences between South Australia's funding model and the other States/Territories: SARDI is funded by PIRSA for surveys.
- Identification of inherent practical difficulties in Western Australia's implementation of the National System.
  - Very large ports.
  - Large amounts of sampling under the National System's design standards.
  - Two of the three high risk ports are in remote regional areas (Dampier and Port Headland).
  - Inflated costs associated with working in regional areas may blow-out budgets.
  - Problems with transportation of viable samples from regional areas to processing laboratories.
- Speculation regarding the reconsideration of the National System's current funding model.
  - The viability of the current model.
  - Speculated alternate models.
  - Viable other sources of funding.
- Current work on the National System in South Australia.

- The field team is about to conduct round two of the port monitoring sampling regime in the Port of Adelaide.
- The next version of the monitoring protocols is being trailed (MDET v2).
- SARDI is integral in developing the techniques and procedures for the National System. SARDI also field-tests the proposed sampling regimes in Adelaide.
- The development of the subsequent versions of the national system's sampling protocols is an iterative procedure and the field protocols are adapted in the field to address problems with implementation.

Government of **Western Australia**
Department of **Fisheries**

Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	Tuesday 16/03/2010
Location:	South Australia Aquatic Sciences Centre, West Beach, Adelaide. S.A.
Attendees:	**DoF:** S. Bridgwood, M. Hourston **SARDI:** M. Deveney, N. Bott
Topic of Meeting:	Australian Testing Centre for Marine Pests (ATCMP) Development of genetic probes

Mechanics of the genetic testing structure.

- Uses a real-time PCR technique.
- The test is quantitative, and will give an assessment of the biomass of any pest species detected.
- As more probes are developed, they may be added to a test without considerable extra cost. Since testing for 10 species requires almost the same time and effort as for 20 or 30 species.
- A positive control system involves the addition of indicator organisms at various stages (as known sources of specific DNA). This allows the samples to be tested for correct processing/handling. i.e. if a positive control is not detected, the sample has been degraded. This measure decreases the chance of a false negative.
  - Several positive controls may be included to identify stages at which samples are being degraded.
  - A brine shrimp real-time PCR assay has been developed and incorporated into the sampling system for use as a control.

Tests developed.

- There are currently 9 assays, either developed or in late-stage development.
  - *Asterias amurensis, Carcinus maenus, Undaria pinnafida, Ciona intestinalis, Perna calaniculus, Musculista senhousia, Corbula gibba, Sabella spallanzanii,* and *Perna viridis.*
- Most assays correspond to the CCIMPE trigger list.
- Testing a single sample refers to applying however many assays are available to the one sample
- The ATCMP is not currently capable of receiving bulk samples to test for the CCIMPE trigger species (as of 16/03/10)
- Assays are not currently completely developed. Once developed, commercial design and production of reagents must be completed before routine bulk use.

Water Sampling procedure still in development.

Commercial readiness is anticipated for early 2011.

Benefits and limitations of the use of real-time PCR assays.

- + Rapid, if needed, a 48 hr turnaround is possible.
- + Relatively cheap compared to bulk processing of samples using traditional taxonomy.
- – Not available yet, some tests are commercially ready but facilities are not yet set up for receiving samples in volume.
- – Assays are validated using field samples from one region and as many closely related taxa as possible in laboratory tests. Assays may show reduced specificity when used to analyse samples from elsewhere, that have different local fauna. Tests may show reduced specificity if a species is present that has not been previously validated against, or is not present in previously validated field samples.
- – Reliant on the maintenance of the sample in correct conditions to preserve the DNA for testing. This is also a consideration for morphological taxonomic analysis although practical preservation methodology is well established.

Assays are not designed to be a replacement for traditional taxonomic techniques, they will serve to rapidly test bulk numbers of samples, and allow taxonomists to target their efforts on "positive samples".

The Australian Testing Centre for Marine Pests (ATCMP).

- Laboratory at SARDI's Diagnostics facility at the Waite Campus Soil Health Agricultural testing centre facility.
- Well set up laboratory capable of bulk processing the volume of samples produced by the National Monitoring System once the assays are properly developed.
- Laboratory is set up for bulk processing, enhancing economies of scale. The lab is substantially automated, and it is easier to process 100 samples than 10 samples.
- Most of the effort is in the developmental stages of the primers and probes.
- Given the assumption of bulk samples, estimated testing per sample is ca. $250 (as at March, 2010).
- "Bulk samples" may include a bulk run Australia-wide and over the course of a year. This is considerably cheaper than the per-sample cost of traditional morphological taxonomic analysis.
- The ATCMP laboratory is an AQIS Quarantine Approved premise (QAP) and is able to receive translocated samples of pests.
- There still several conditions to satisfy to transport pest material to the ATCMP so start the approvals process early.

Continue development of the existing assays through field validations.

Continue development of assays for further species.

Development of a protocol for field / remote sampling to produce samples which are useable for the above assays.

- The problem of degraded and unreliably processed field samples was identified.
- Samples may degrade quickly and become unusable for molecular analyses.
- Several solutions were suggested.
  - Freeze drying is likely to be the best but it is not really a field technique.
  - Needs to be stable temperature environment for whole transport time.
  - Storage on ice is another good temporary measure but not really suitable for transport over long distances due to melting ice, liquid water and weight.
  - Looking into an air-drying protocol and adding of preservatives that will minimise DNA degradation.
- Development of a working protocol is anticipated in late 2010.
- Using preservation techniques, considered safe for transport and oven-drying methods (40°C) are currently favoured since it allows bulk samples to be transported easily.
- Paper filters can be stored in tubes, for ease of storage and ease of processing for DNA extraction utilising the SARDI RDTS DNA extraction service.

Potential collaborative research between SARDI and DoF.

- Questions regarding DoFs capability to perhaps develop a new or help validate an existing PCR assay.
- Collection of plankton samples from Christmas Island with dual purpose.
  - Possible field testing of various sample preservation techniques.
  - Gathering diverse samples for the reliable codification of probes in different environments.

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Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	Tuesday 16/03/2010
Location:	South Australia Aquatic Sciences Centre, West Beach, Adelaide. S.A.
Attendees:	**DoF:** S. Bridgwood, M. Hourston **SARDI:** L. Mantilla
Topic of Meeting:	Morphological taxonomic capacity at SARDI

Maintenance of a small taxonomic staff at SARDI 2-3 people.

Non-exclusive to biosecurity research, designed to service the entire Marine section of the Institute.

Samples.

- Samples come into the lab at various stages from raw bulk community samples in sediment through to clean, single specimens.
- Depending on the aim of the project, time/funds allocation and state of sample various levels of taxonomic discrimination are used.
- Pest samples are usually taken to species level where possible due to the specificity required for pest monitoring.
- Marked preference for clean specimens isolated from original matrix for taxonomic purposes as it reduces specialist laboratory time spent on non-specialist work. Also reduces transport effort and cost.

Specimen archive.

- Some wet and dry specimens are available in the laboratory as a reference collection.
- Most reference specimens are stored as a digital photo archive.

Availability of taxonomic services.

- They are happy to receive isolated specimens and send specimen photos to coarsely identify some pest species (not as a routine exercise).
- Photo identification is not a taxonomic authority, to be use as a preliminary identification before detailed specialist identification.
- May be some capacity to send samples for morphological identification, depending on the species in question and number of samples.

Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	Tuesday 16/03/2010
Location:	SARDI Field operations compound
Attendees:	**DoF** : S. Bridgwood, M. Hourston
	SARDI : J. Nichols
Topic of Meeting:	Field sampling Equipment, practical aspects of Port Monitoring implementation

Field operations, gear specifications and boats.

Showed us the sampling gear used in the Adelaide field operations, the same or similar to that used in the development of MDET.

Grabs - Two types of:

- Habbs corer.
  - Large structure, corer inside a rigid metal frame.
  - Spring loaded corer.
  - Corer punches deep into sediment when the catch is released.
  - Expensive and probably overkill for pest monitoring purposes.
  - Needs a bit of space, bigger boat.
- Eckmann grab
  - Appropriate for pest monitoring use.
  - Two spring loaded scoops. Bear-trap style.
  - Good for silty and sandy sediments.
  - Captures about the top 5 cm of the sediment.
  - Easily deployed from a smaller boat.
- Cores.
  - Diver cores, low-tech and simple to use.
  - PVC pipe of desired diameter, cut to desired length, rubber bung in each end once in the water.
  - PVC edge shaved to an angle to cut sediment. Simply pushed into sediment, replace top bung. Pull out and replace bottom bung.
  - Cores placed in milk-crate carrier, milk crate secured with lid, elastic strap and heavy-duty clip. ca. 16 cores per crate.
- Traps

- Series of three connected trap types on the one deployment.
- All traps baited with pilchards.
- Capable of sampling for crabs, small fish pests.
  - Anchored with a cement block.
  - Opera house trap.
  - PVC tube trap (500mm L, 110mm D, with a funnel insert to 60mm D).
  - Bicey trap (rectangular net trap).
  - Easily deployed from a smaller boat.

Dredge/ benthic sled.

- Several prototypes in the shed.
- Final prototype, (Luck dragon).
  - Huge and heavy.
  - 1.5m wide and several hundred Kg.
  - Very cumbersome.
  - Needs a large boat with a proper winch + lift arm to operate safely.

Plankton tows.

- Several sets of bongo nets.
- Zoo- and phytoplankton tows are different lengths so cant have bongos with the two types of mesh. Must be separate.
- Notes on deployment including tow speed, boat deployment, timed distance and retrieval technique.

Boats.

- Several SARDI boats.
- Pest sampling used an 8m boat.
- Most equipment can be deployed from a 5m boat, except the dredge, which is far too large and cumbersome.

Diving.

- Usually use full face, comms masks for ease of communication.
- Diver scrapes taken with a 2-person team. One holding the quadrat and catch bag, the other doing the scraping.

Scooters not often used, as they are very situational and usually get in the way.

Settlement arrays.

- National system does not use any settlement arrays, therefore none to see in Adelaide gear store.

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Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	Tuesday 16/03/2010
Location:	PIRSA Head Office. Grenfell St Adelaide. S.A.
Attendees:	**DoF:** S. Bridgwood, M. Hourston
	PIRSA: M. Sierp, K. Rowling
Topic of Meeting:	PIRSAs role in the national system and the implementation in Adelaide.

Funding for PIRSA and SARDI's biosecurity interests.

- Recurrent cabinet funding obtained by PIRSA 3-4 years ago for biosecurity.
  - 95% goes to SARDI with a small amount kept in PIRSA for a few positions.
  - at 3 year review time, recurrent funds administered after budget / project reporting and justification of expenditure. i.e. a full funding application is not required.
- Marine Innovations SA funding.
  - State government funds.
  - once again, whatever comes in through PIRSA, primarily goes to SARDI.
- Empire Security Funds.
  - Primarily a source of funding used for emergency response events.

Evolution of the SARDI and PIRSA.

- Reiteration of discussion with M. Deveney.
  - Used to be the one agency.
  - Split 14 years ago.
  - SARDI is still a government institution, allowing PIRSA to contract them to do research. This is an efficient and economic alternative to directly hiring consultants.

Genetic Probes.

- The DNA probes being developed in SARDI are not going to be serviceable until at least the end of 2010. PIRSA considers "serviceable" as all seven probes reliably codified and the ability to process bulk samples, potentially sourced from other jurisdictions.
- Discussion of collaboration with other states (including W.A.) on the development and codification of other genetic probes.
- Discussion of the value of samples from other jurisdictions in the codification process of existing probes.
  - Samples include both known pest samples such as *Perna* from Northern Territory as

well as the potential for plankton community samples to test for false positives to native species

Discussion on NIMPCG.

- M. Sierp has been a member of NIMPCG from very early on in the developmental process.
- Large turn over of members on both the NIMPCG and the MDAP pools of people.
- Large turn over tends to result in the loss of accumulated and corporate knowledge.
- The foundation of NIMPCG was at the request and using the funds of the ports to develop a system for management of pests in ballast water, and risk register /ranking system for ports for ballast water vector pests.
- Foundation was 13 years ago and focus seems to have changed.
- Ballast water management system still not completely developed, this may contribute to the reticence of ports to further funding.

CCIMPE trigger species, emergency response protocols.

- Original model under the marine IGA was a cost sharing agreement for marine pest incursion response, pro-rata on the population of a jurisdiction and the coastal area.
- Some jurisdictions found the arrangement inequitable.
- New cost sharing agreement under the NEBRA (National Environmental Biosecurity Response Agreement)
- Still pro-rata contribution but under a different model
- CCIMPE trigger species will garner a quick response, other introduced marine pests including those on the list of 55 will need to go through a more detailed application process.

Port monitoring funding discussion.

- Noted that there had been a funding working-group within NIMPCG but that it was not currently convened.
- The recurrent and widespread issue of funding was not likely to be solved by NIMPCG. Both providing the funding and compelling any bodies to provide funds are outside the boundaries of their responsibilities.
- NIMPCGs responsibility is the administration of the funds for and emergency responses from the CCIMPE trigger.
- Cost recovery a possibility but equitability is a problem.
  - Inappropriate to cost recover from some stakeholders and not others.
  - To cost-recover from all stakeholders would be a logistically unviable route, since the cost of administering the system would likely cost more than the administered sum.
  - A case study of the potential costs to industry caused by a biosecurity breach may be useful information in attempting future funding negotiations with larger stakeholders.
  - Noted that the reticence thus far of the stakeholders was partly due to the value of the system is in its whole national network, and there was little value to the stakeholders of a single port being surveyed. Their argument for national funding.
- Suggestion that State funding may be a solution, similar to the situation currently employed in South Australia.

- The reason that the state-funded approach had succeeded in South Australia is at least partly due to the large political sway of the aquaculture industry.

Disparity of Australian and New Zealand sampling protocols.

- Given the disparity of the sampling protocols and the lack of BNZ labelling on new protocol documents, is there a distance developing/developed between DAFF and MAF BNZ? Response was that there were no problems and BNZ was still a crucial part of the development of the monitoring protocols and guidelines. Lack of BNZ labelling was an error of omission.

Discussion of the varying lists and the seeming lack of communication between linked departments and bodies.

  - 7 spp CCIMPE.
  - 50 spp ballast water.
  - 35 spp ballast water.
  - 50 spp port monitoring.
  - 55 spp port monitoring.
  - >10 spp NZ port monitoring.

- Reason being that the lists are adaptive according to:
  - new research,
  - fresh outbreaks of species previously unknown as pests,
  - reassessment of the risk.

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Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	Tuesday 19/03/2010
Location:	Australian Maritime College, Launceston, Tas
Attendees:	**DoF:** S. Bridgwood, M. Hourston
	University of Tasmania: C. Hewitt, M. Campbell
Subject of Meeting:	General discussion of Pest Monitoring, History of NIMPCG and CRIMP, CRIMP surveys

Directors of the initial CRIMP port surveys throughout Australia

- Field team consisted of at least 7 and up to 20 on a rotating basis
- CRIMP surveys
  - used as the baseline data for port monitoring
  - the genesis of the National System
  - designed to be repeated and built on in latter implementations
  - Initially joint funded by port authorities and CSIRO. (50/50)
  - Changed to 100% port funded in 1997
- By 1997 the ballast water risk assessment conducted.
  - One of the original tasks for the founding of NIMPCG.

Current national system monitoring

- Routine incorporation of planktonic sampling is impractical without reliable and codified genetic probes.
- Visual surveys
  - Diver training is critical and must be done thoroughly to ensure consistency and confidence.
  - Use training pictures, specimens
  - Ideally need to test on misidentification rates of workers which are often surprisingly high
- Importance of designers (us) to get in the water to get an idea of conditions, likelihood of pest detection, QA & QC.
- Highly advised for us to get commercially qualified
- Noted that current National System monitoring is quite wasteful of effort.
  - Sampling can be quantitative but only qualitative is required.
  - No consideration of the native species already caught by the sampling.

   - Consider value-adding to the National System monitoring by recording the quantitative info for both native and introduced species.
- Reply-Currently money is hard to find for the basic implementation, never mind value-adding.

Commercial divers

- Noted considerable cost of employing commercial divers
- Indicated that UTas may be able to field a team
- Recommended UTas dive officer, both as Diver and Trainer for Commercial Divers

New Zealand monitoring

- Proponent of the NZ system
- C. Hewitt worked in MAFBNZ for several years. (replaced by N. Parker).
- Noted that NZ's system has been in operation for 10 years while Australia is still yet to have a single full national implementation under the current National System.
- NZ system is more similar to the original CRIMP designs

Potential for collaboration

- Temporal comparison of fauna in Freo harbour
   - Would require a full faunal survey of Freo harbour as per CRIMP survey,
   - Not just a pest survey as per National System
- Settlement arrays
   - Big bang for buck.
   - Needs to be a targeted list of species since they only catch fouling spp. This is one of the reasons they are not included in the current National System
   - Not necessary to have a 3 month soak. Note that a 2 month is often enough for fast growing species, even 1 month if you really know the life cycle progression and you are practiced.
   - Talk of a collaborative project. Latitudinal gradients in settlement patterns of fouling species. Already partially running on the east coast, potential to set it up along the west coast as well.

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Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	22-24/03/2010
Location:	Port Taranaki, N.Z. Field area.
Attendees:	**DoF**: S. Bridgwood, M. Hourston
	NIWA: D. Morrisey et al.
Subject of Meeting:	Port Taranaki Port Monitoring Implementation.
	Practical field sampling.

Differences between NZ and Australia Port monitoring implementation. Why is the New Zealand system progressing while the Australian is not?

- The New Zealand system is based on sampling for a restricted list of target pest species at many ports, while the Australian system is based around a large number of species at a few ports.
  - It is faster, easier and cheaper to get a single port completed, and a tangible product finished under the NZ system.
- The majority of the New Zealand's list of primary target species are readily identifiable in the field least to a stage to determine if further investigation is needed, this facilitates the rapid processing of samples without molecular techniques or routine need for specialist taxonomists. Much of the identification is field-based, although any suspect kept for further identification.
- Note that species of secondary importance may be excluded from the target list if they present too much of a problem to identify, i.e. *Didemnum*
- The reduced species list allows some of the more costly sampling methodology to be excluded , i.e. plankton sampling, beam trawls and cyst cores.
- New Zealand has an established Marine Invasives Taxonomic Service (MITS) through NIWA, this acts as a hub for all relevant specialist taxonomic services, with the network of specialists already in place. Fewer target species also means fewer specialist taxonomists are required.

Field sampling techniques.

- Dredge/benthic sled (Ockelmann sled)
  - Similar concept as the very large dredges at SARDI but much smaller (0.4m wide).
  - Photos taken to use as a reference for building our own sled
  - Very easy to handle, even by 1 person.
  - Easy to deploy from a smaller boat as no davit or lift arm required.

- Increased number of replicates to account for the smaller swath width (compared to SARDI dredge).
- Easy to manoeuvre in harbour situations.

- Traps (crab/fish)
  - Very similar design to those in SARDI.
  - Three baited traps on the one drop-line, all box traps.
  - Crab Condos, not used in the Aus National System
- Starfish Traps.
  - Additional methodology for sampling for Asterias.
- Diver Searches
  - Several rotating diver teams to maximise surface intervals but achieve fast results
  - similar technique to Aus national system
- Shore Searches.

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Human capacity building for Introduced Marine Pest Port Monitoring
Meeting Minutes

Date :	Tuesday 25/03/2010
Location:	NIWA Aquaculture and Fisheries Enhancement Station
	Wellington. N.Z.
Attendees:	**DoF:** S. Bridgwood, M. Hourston
	NIWA: S. Miller,
	MAF BNZ: J. McDonald
Topic of Meeting:	Implications of Invasive Marine Pests for Aquaculture.

Brief on the aquaculture and fishery enhancement operations at NIWA.

Discussion of the specific problem of *Undaria pinnatifida* in New Zealand with respect to Aquaculture operations.

- Undaria fouling a big problem, in particular for Mussel aquaculture.
- Heavy fouling causing poor mussel yields.
- Heavy fouling on the lines also making harvesting logistics very difficult.
    - Since *Undaria* is actually a marketable commodity (as Wakame in cooking) some proposals to harvest and sell it both to recoup lost income, and to remove the alga from the environment.
    - Since *Undaria* is a declared pest in NZ, farming, harvesting and selling it is not allowed, not even in areas where it is already an established pest.
    - Note that there is currently a proposal under review to allow harvesting and marketing of Wakame in New Zealand.
- *Undaria* fouling is also a problem on inshore sea cages.

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Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	Tuesday 25/03/2010
Location:	NIWA Marine Invasives taxonomic Service (MITS)
	Wellington. N.Z.
Attendees:	**DoF:** S. Bridgwood, M. Hourston
	NIWA: S. Mills,
	MAF BNZ: J. McDonald
Topic of Meeting:	MITS capacity and workflows.

Discussion of the capabilities of the MITS facilities

Note that taxonomy centre is the centralised repository and taxonomic service for all of NIWAs activities, MITS is a part of this division

Tour of the wet storage room

- Noting that not all specimens came from NZ waters.
- Some voucher specimens have been sent over from overseas as reference material for taxonomic comparisons
- Noted that there is often a lot of difficulty importing a known pest specimen even though it is non-viable material. Lots of negotiation.

Taxonomic capabilities

- Not all of the taxonomic work is carried out in-house, they can only hold a limited amount of knowledge with the staff they have.
- Discussion of network of taxonomists that NIWA has developed. They have specialist contacts for all of the potential pest species and also many other taxonomic groups that may become pests.
- Links are maintained with taxonomists for potential pest species even if those species are not currently in the target list

Database system to track shelf specimens and specimens on loan to external taxonomists

- Program is called "Specify"

Human capacity building for Introduced Marine Pest Port Monitoring Meeting Minutes

Date :	Tuesday 25/03/2010
Location:	MAF BNZ. Pastoral House, 25 The Terrace, Wellington. N.Z.
Attendees:	**DoF:** S. Bridgwood, M. Hourston
	MAF BNZ: Naomi Parker
Topic of Meeting:	MAF policy/structure and integration with the Australian National System

Structure of the NZ biosecurity system.

- MAF (Ministry of Agriculture and Forestry) is the federal level body with jurisdiction over biosecurity.
  - Central body that receives funding for biosecurity through the government.
  - Primary policy body that liases with NIMPCG.
  - BNZ (Biosecurity New Zealand) is a division within MAF which deals with all national biosecurity matters, including marine.
- NIWA (National Institute for Water and Atmospheric Research) is a crown research institute, similar to Australia's CSIRO.
- MAF contracts NIWA to perform the logistics of the Biosecurity port monitoring.
- NIWA tenders to MAF on a three-year basis.

Differences between NZ and Australia in marine biosecurity. Why is the New Zealand system progressing while the Australian implementation is stagnating?

- Biosecurity has a much higher profile in NZ, particularly in terms of a sense of national ownership of and responsibility to the problem.
- The much greater size of Australia versus New Zealand makes a big difference. Australia is so big that problems relevant to the northern jurisdictions are not necessarily a problem to southern jurisdictions. The continent covers several bioregions with non-contiguous coastline or common direct shipping routes (e.g. Darwin - Adelaide, Perth - Brisbane, Melbourne - Dampier, etc.).
- This causes a lack of focus on the entire problem, only the parts relevant to each jurisdiction. Thus, in relative terms a national sense of ownership of the whole problem may be lacking.
- In contrast, all of NZ is very connected and not nearly as disparate. Greater connectivity at a national level has resulted in better cooperation among relevant jurisdictions.
- In New Zealand, the policy, funding and implementation are led by a single government department (MAF). This makes the entire problem of biosecurity the jurisdiction of a single

body. Likewise, the provision of research services are predominantly covered by a single body (NIWA).

- In Australia, policy is governed at a national level (DAFF, NIMPCG), the implementation by a state level (the state jurisdictions) and the funding supposedly by stakeholders (which may be local, state, national, and international, and are non-government). This causes differences in priorities and opinions, particularly in relation to funding.
- The disparity of views among federal, state and private stakeholder bodies in terms of perceived risk, sources of funding and division of responsibility has caused a breakdown of cooperation and communication. This has in turn caused the current situation whereby only a small portion of the national port monitoring system has been implemented after many years of development.

Appendix 3 – Western Fisheries Article

SCIENCE FOR SUSTAINABILITY

Marine pest know-how

By Mathew Hourston

The National System for the Prevention and management of Marine Pest Incursions is a scheme to manage the transport of marine pest species, both into Australia from overseas and around different locations within Australia. One of the major components of this system is to monitor ports for any new outbreaks of pests.

Implementation of marine pest port monitoring in Western Australia requires a lot of time, money and knowledge.

The Department of Fisheries was awarded funding from the Fisheries Research and Development Corporation (FRDC) to build the capacity of its staff and other WA biosecurity workers, to effectively implement a port monitoring design.

The best way to get practical knowledge is to get out there and do it. After careful consideration of the state's needs, a 12-day intensive tour of biosecurity research hotspots was planned for two Department staff, Mathew Hourston and Sam Bridgwood. The places highest on the list were Adelaide, where two government bodies have been instrumental in the development of the sampling protocols, Tasmania, with their extensive biosecurity knowledge, and New Zealand, where very similar pest monitoring in ports has been conducted for several years. To gain maximum benefit from the trip, several more meetings along the way were also organised.

The first spot on the itinerary was Adelaide, to visit the South Australian Research and Development Institute (SARDI) and the Department of Primary Industries and Resources South Australia (PIRSA). They have both been key players in the development of port monitoring protocols and are in the process of creating new tools to keep Australia's shores as free of pests as possible.

South Australia is keenly interested in keeping out unwanted pests because of its very active aquaculture industry, which would suffer greatly should certain pest species take hold. The potential for pest incursions and the trouble they could cause was brought home in Adelaide in 2002 with the outbreak of an invasive strain of algae (*Caulerpa taxifolia*), which filled up one of the metropolitan coastal lakes. Although the *Caulerpa* was successfully eradicated from those lakes, it has since invaded the harbour area and continues to cause problems, particularly for Adelaide's power plants where it clogs up the cooling water intake pipes.

SARDI is also the home of the next generation of pest monitoring tools. They are developing genetic tests that once fully developed will be able to rapidly, easily and reliably test for many of the really nasty pest species, simply by taking a

Wakame seaweed *(Undaria pinnatifida)* fouling on mussel aquaculture lines in the Marlborough Sounds, New Zealand. Photo: S. Miller, NIWA

sample of micro-organisms from the water in suspect ports. Although these tests still require some time and research before they reach their full potential, they will eventually make the job of identifying pests that much easier.

Once updated on the ins and outs of genetic testing for pests, the trip included a visit to SARDI's field compound to examine their sampling gear. Here were a huge array of boats, nets, sleds, dredges, corers and traps, each designed to sample a different part of a port that could harbour a pest. Many pieces of equipment were prototypes that would be invaluable in WA ports.

After only a couple of days in Adelaide the next destination was Tasmania. At the Australian Maritime College, an outpost of the University of Tasmania in Launceston, pioneer researchers in the development of aquatic biosecurity in Australia provided a great deal of information and ideas, prompting much thought through their perspective of the national system.

Large prototype dredge at the SARDI field compound, Adelaide. Photo: Mathew Hourston

From Tasmania, the next port of call was across Bass Strait and the Tasman Sea, to New Plymouth on the western coast of New Zealand's north island, joining a seasoned crew of pest researchers from New Zealand's National Institute for Water and Atmospheric Research (NIWA). Having routinely been sampling their ports for pests for several years, the Kiwis really seem to have their act together. Although they do share a common origin, and include many of the same sampling techniques, their sampling system is slightly different from Australia's. For example, they have fewer target pest species but take a lot more samples when looking for them.

During the couple of days with the ten-person NIWA team at Taranaki Harbour, they helped fine tune many of the diverse practical skills required, such as designing and deploying the dredges and traps. They also provided a heads-up by relating a number of issues they encountered during monitoring. There was also a great deal of notes and photos of their sampling gear taken that, after several years of service, were tried and tested designs.

The final stop was Wellington, the capital city of New Zealand, to talk with more representatives of NIWA and also the New Zealand biosecurity policy body, the Ministry for Agriculture and Forestry, Biosecurity New Zealand (MAF BNZ). The primary topic of discussion with MAF BNZ was the differences between the Australian and New Zealand systems, and what could be taken from their system to make WA's more efficient while staying within our national guidelines.

With only two more visits to make, the final stretch of the fact-finding mission was underway. The friendly staff at the Mahanga Bay Aquaculture and Fisheries Enhancement Station in Wellington Harbour, another NIWA operation, provided an aquaculture perspective on the problems of invasive marine pests. One of the most troublesome pests for aquaculture that has made its way into New Zealand waters is the seaweed *Undaria pinnatifida*. Although a pest in various parts of the world, *Undaria* is actually Wakame, commonly used in Japanese cooking. This fleshy brown alga is extremely proficient at fouling mussel farms and other submerged structures like jetty pylons. It is so prolific in some places, like the Marlborough Sounds, that some mussel farms actually look more like Wakame farms.

A tour of NIWA's Marine Invasives Taxonomic Service (MITS) was an excellent learning experience and a great way to round out the trip. MITS is a centralised repository for all samples suspected of being pests and their collection of pickled sea creatures is very impressive. Whenever one of NIWA's sampling teams finds a species that looks like it is one of their targets, or is showing signs of causing lots of fouling, a sample is taken and sent off to MITS. The resident taxonomists then take that sample and decide if a new pest species has been discovered. Sometimes not even the MITS taxonomists are sure which species has been sent to them, and when that happens they call on their network of specialists to help them, sending specimens to experts all around the world.

Establishing direct personal contact for this taxonomic network was one of the most sigificant results of the trip.

With that final meeting complete, the whirlwind tour was over and we find ourselves better prepared to undertake port monitoring in Western Australia. ■