Fisheries Research Report No. 201, 2010

A Community-Based Monitoring Program for Introduced Marine Pests

Samantha D. Bridgwood, Justin I. McDonald

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

Natural Heritage Trust
Helping Communities Helping Australia

Fisheries Research Division
Western Australian Fisheries and Marine Research Laboratories
PO Box 20 NORTH BEACH, Western Australia 6920

Fish for the future

Fisheries Research Reports

Titles in the Fisheries Research Report series present technical and scientific information for use in management processes. Research Reports are subject to full internal refereeing by senior scientists of the Fisheries Research Division, and in many cases, elements of the work are published in international scientific literature.

Correct citation:

Bridgwood, S.D., McDonald, J.I. 2010. A Community-Based Monitoring Program for Introduced Marine Pests. 2010. Fisheries Research Report No. 201. Department of Fisheries, Western Australia. 48 p.

Enquiries:

WA Fisheries and Marine Research Laboratories, PO Box 20, North Beach, WA 6920
Tel: +61 8 9203 0111
Email: library@fish.wa.gov.au
Website: www.fish.wa.gov.au
ABN: 55 689 794 771

A complete list of Fisheries Research Reports is available online at **www.fish.wa.gov.au**

Cover: Photograph Eloise Dortch

ISSN: 1035 - 4549 ISBN: 1 921258 78 0

Contents

Figures

Tables

A Community-Based Monitoring Program for Introduced Marine Pests

Executive Summary

Non-indigenous marine species (NIMS) are organisms that have moved, or been moved from their natural environment to another area either by natural dispersal or anthropogenic means. While many NIMS remain inconspicuous and innocuous, they can potentially threaten human health, economic, social and cultural values or the environment, thereby becoming introduced marine pests (IMPs). Early detection of marine pest incursions is critical if there is to be an attempt at eradication. Community-based monitoring for IMPs can provide an effective early warning mechanism, complimenting other monitoring activities around the State.

Monitoring for IMPs allows community groups to develop an awareness of, and raises the profile of the natural, cultural and social values of the marine environment and how these values can be negatively impacted with non-indigenous marine species incursions. Community-based monitoring also gives a sense of ownership and achievement, i.e. realising the important role they played in protecting their 'own backyard'.

This project aims to provide the means with which community-based groups can undertake scientifically meaningful and robust monitoring for IMPs. Three, tried and robust methodologies to detect introduced marine species, are discussed: beach walks; visual survey (snorkel or diving); and settlement arrays. The long-term outcomes of such a project will be that it provides greater coverage of marine pest monitoring in Western Australia, an engaged community that can take a more active role in management of their marine systems.

Acknowledgements

The Department of Fisheries initiated a project "*Actions to implement and complement the National System for the prevention and management of introduced marine pests in Western Australia*" in October 2006. The present report is part of the project. It is funded by the Australian Government's Natural Heritage Trust, delivered in Western Australia in partnership with the State government. This component was funded through the W.A. Strategic Reserve Fund (Project No. 053085).

The Northern Territory Government (Helen Cribb), and Justin McDonald are heartily thanked for allowing the use of various photographs within this document. Various free-to-use images were accessed through the web have been acknowledged within the document.

Disclaimer

1.0 Introduction and Background

The translocation of marine organisms from their natural environment to another area is assisted by human activity, in particular by the global movement of vessels (commercial and recreational) where organisms are moved about in ballast water and as biofouling on vessel hulls. This translocation of marine organisms is a world-wide problem and second only to habitat change and loss, in reducing global biodiversity (Millennium Ecosystem Assessment 2005). Many of these displaced organisms remain inconspicuous and innocuous, however they can potentially threaten human health, economic, social and cultural values or the environment, in which case they are then referred to as introduced marine pests (IMPs) (Hewitt *et al.* 2004). It is estimated that one, in six to ten, of displaced marine organisms will become IMPs (Anonymous 2002).

Introduced marine pests can drastically alter marine environments, becoming the dominant flora and fauna of an area to the detriment of native species (Bax *et al.* 2003; Scheibling & Gagnon 2006). Amenity and recreational activities can also be threatened by IMPs, impacting on social and cultural values of the community. Economic effects can also be considerable. For example IMPs can damage important fisheries and increase labour costs associated with preventing or removing biofouling from facilities (e.g. aquaculture and port infrastructure) and equipment (e.g. nets and fishing lines). The outbreak of the black striped mussel (*Mytilopsis sallei*) in Darwin cost more than $2 million to eradicate (CRC Reef, 2004) but had the potential to severely damage the pearling industry ($225 million value of production in 1998).

While the impact of IMPs in WA is as yet unknown, the availability of tropical to temperate habitats means suitable conditions for the growth and possible survival of most IMPs can be found somewhere in the State. Currently there are a total of 60 marine species regarded as having been introduced, and presently established, in Western Australia (Huisman *et al.* 2008). All of these species are closely associated with harbours/ports, suggesting their introduction is through major nodes of human activity. Most (37 species) of the marine species introduced into Western Australia are temperate species occurring from Geraldton south (Huisman *et al.* 2008). Six are tropical species that occur from Shark Bay north whilst 17 species occur over the full extent of the Western Australian coast (Huisman *et al.* 2008). Because of the preponderance of temperate species, southern marine areas have more introduced marine species than northern areas. The greatest concentration is in the southwest corner of Western Australia, for example Fremantle (including Cockburn Sound and the lower Swan River) has 46 introduced species (Huisman *et al.* 2008). Albany (25 species), Bunbury (24 species) and Esperance (15 species) are all smaller ports with less habitat diversity and fewer numbers of introduced marine species (Huisman *et al.* 2008).

1.1 Project Need

For any biosecurity system to work efficiently the early detection of marine pest incursions is critical, particularly if there is to be any attempt at eradication. However, it is often the case with environmental monitoring programs that state agency resources and people are limited. This gap in available personnel could be partially filled by providing community groups with the skills to conduct marine pest surveillance. Such programs would then supplement existing statewide marine pest monitoring programs. Programs for community-based IMP monitoring have been successfully developed and trialled within Australia, for example in the Northern Territory (see Cribb *et al.* 2009) and Tasmania (see Sutton & Hewitt 2004).

Monitoring for IMPs will allow community groups to develop awareness and raise the profile of the natural, cultural and social values of the marine environment when it is pest-free and how these values can be negatively impacted with incursions. Community-based monitoring is flexible and encourages a range of people with a diverse set of skills to become involved in caring for their marine environment. Community-based monitoring also gives the volunteers a sense of achievement; in this case they could play an important role in keeping WA free of marine pest species. Field-based monitoring will allow participants to learn new skills and techniques while having fun and increasing the volunteers' knowledge of IMPs. Volunteers will be able to survey their local marine habitat, giving them a sense of ownership over the program. Further, biological information collected by community groups will assist the Department of Fisheries to monitor for IMPs across the State. Community-based monitoring is therefore valuable to management from both an ecological and social perspective.

2.0 Project Description and Aims

This document outlines an innovative and cost-effective introduced marine pest monitoring system to be used by community groups in Western Australia. The focus is on enhancing community skills, and knowledge through engagement of volunteers and coastal communities. Guidance as to where and when to best target monitoring efforts is also provided.

This document aims to provide the means by which community-based groups can undertake scientifically meaningful and robust monitoring for IMPs within their chosen marine area. To this end three tried and robust methodologies are described for community groups to use to detect introduced marine species.

The long-term outcome of projects using methodologies outlined in this document could include:

- greater coverage of marine pest monitoring in Western Australia;
- an engaged community that can take a more active role in making informed decisions about the future management of their marine systems; and
- an early detection tool for pest incursions.

3.0 Potential Target Species

The Australian and state/territory governments are implementing Australia's National System for the Prevention and Management of Marine Pest Incursions (the National System). It is the National Introduced Marine Pests Coordination Group (NIMPCG) that are coordinating the measures and arrangements under the National System. NIMPCG have identified 55 species (Table 1) to target when undertaking IMP monitoring around Australia. However, for the vast majority of these species significant taxonomic expertise is required. It is proposed that for a WA community-based program a reduced listing of 11 species is used. This reduced list is centred on the ideal that these species are more easily detected* and more readily recognisable* by non-taxonomic experts (Table 1).

**Likelihood of detection and identification is based on adults of the species – larvae or juveniles are unlikely to be detected or identified by groups. Training would be provided by the Biosecurity group in basic identification of these species and factors that distinguish them from similar native species.*

The 11 species identified as potential target species for community-based IMP monitoring are described in the following pages, including their key identification features and habitats they will most likely occur in. Pictures of the 11 species are also provided (Figures 1 to 11) (Note pictures are for illustrative purposes only and should not be used as the primary mechanisms of identification).

It should be noted that this document is to be used as a generic tool, it provides methodologies for IMP monitoring, however, further refinement of the pests to be targeted is possible for specific locations based on available environmental data. This data must include temperate and salinity ranges (at least one year duration, preferably three) for the marine area to be monitored. This data is then compared to the tolerance thresholds of the species to indicate which species are likely to be able to exist and reproduce in the communities' area. Tolerance threshold information for IMPs has been provided by NIMPCG to the Department of Fisheries Biosecurity group. The Biosecurity group will need to be contacted with the environmental data to undertake any refining of target species to specific regional sites.

Table 1. Target species of introduced and potentially introduced marine species on the national monitoring program (NIMPCG 2006) and their most likely vector for introduction, i.e. ballast water or bio fouling. Species in bold are those proposed target species to be used in a community-based monitoring program.

Group and Species	Group and Species
BALLAST WATER	
Dinoflagellates	Diatoms
Alexandrium catenella	*Chaetoceros convolutus*
Alexandrium minutum	*Chaetoceros concavicornis*
Alexandrium monilatum	*Psuedo-nitzschia seriata*
Alexandrium tamarense	Ctenophorans
Dinophysis norvegica	*Beroe ovata*
Gymnodium catenatum	*Mnemiopsis leidyi*
Pfisterisia piscicida	*Acartica tonsa*
HULL FOULING	
Algae	Cnidarians
Bonnemaisonia hamifera	*Blackfordia virginica*
Caulerpa racemosa	Polychaetes
Caulerpa taxifolia	***Sabella spallanzanii***
Codium fragile fragile	*Hydroides dianthus*
Grateloupis turuturu	*Marenzellaria spp.*
Sargassum muticum	Barnacles
Unidaria pinnatifida	*Balanus eburneus*
Womersleyella setacea	*Balanus improvisus*
Bivalves	Crabs
Corbula amurensis	*Callinectes sapidus*
Ensis directus	***Carcinus maenus***
Limnoperna fortunei	*Charybdis japonica*
Mya arenaria	*Eriocheir spp.*
Varicorbula gibba	*Hemigrapsis sanguineus*
Musculista senhousia	*Hemigrapsis takanoi*
Mytilopsis sallei	*Rhithropanopeus harrisii*
Perna perna	Ascidians
Perna viridis	*Didemnum spp.*
Crassostrea gigas	Seastar
Gastropods	***Asterias amurensis***
Crepidula fornicata	Fish
Rapana venosa	*Neogobius melanostomus*
Copepods	*Siganus luridus*
Psuedodiaptomus marinius	*Siganus rivulatus*
Tortanus dextrilobatus	*Tridentiger barbatus*
	Tridentiger bifasciatus

4.0 Target Species Descriptions

4.1 Aquarium Caulerpa – *Caulerpa taxifolia*

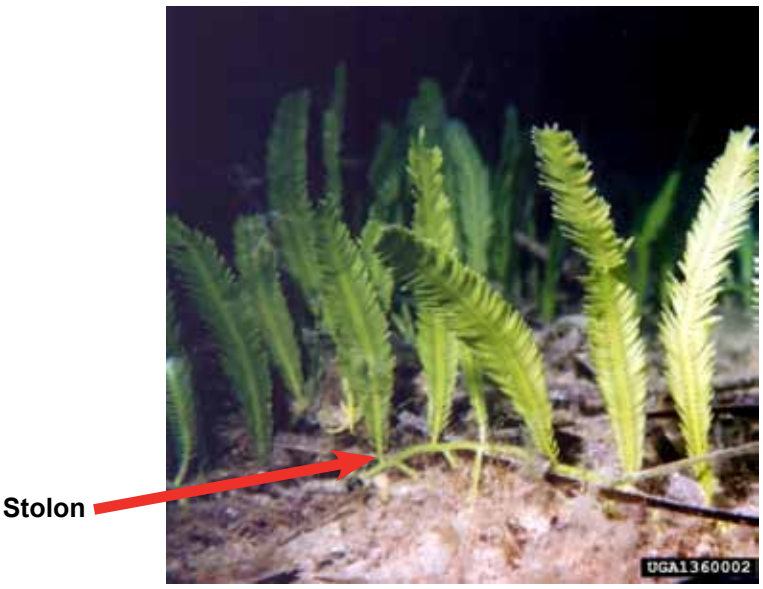

Figure 1. *Caulerpa taxifolia*. Photograph by Rachael Woodfield, Merkel & Associates, Inc. image accessed from: http://www.invasive.org/browse/detail.cfm?imgnum=1360002

Description and distinguishing features: This is a light green alga with erect leaf-like fronds, arising from stolons, which resemble networks of bright green feathers. Each "feather" is about 1 cm wide, can be up to 65 cm high with a space between 'feathers' of about 2 cm. 1) where branchlets connect to the midrib (i.e. the base) they are constricted 2) branchlets attach opposite each other on the midrib 3) branchlets curve upwards and taper at the apex. Fronds are flattened with a smooth midrib.

Habitat: This alga occurs in the subtidal particularly between 3 – 35 m however, it can occur in waters of up to 10 m depth. It can be found in exposed and sheltered estuaries, coastal lagoons and bays, rock, sand, mud and seagrass beds.

Australian distribution: This species is native to tropical WA, but can also tolerate cooler waters, thus poses a significant threat to temperate WA waters. It has been introduced to temperate locations in SA and NSW.

Concerns: This species can spread rapidly and is known to overgrow native habitat. It can affect fisheries due to the habitat alteration and cause biofouling problems by tangling up nets and ropes.

Links for further web-based Information

http://www.marinepests.gov.au/__data/assets/pdf_file/0007/852109/Caulerpa-taxifolia.pdf,

http://www.marine.csiro.au/crimp/Reports/Infosht13_Caul0700S3.pdf and

http://swr.nmfs.noaa.gov/hcd/CAULERPA.htm

http://www.invasivespeciesinfo.gov/aquatics/caulerpa.shtml

4.2 Dead Man's Fingers – *Codium fragile* ssp. *fragile* (formerly *Codium fragile* ssp. *tomentosoides)*

Figure 2. *Codium fragile* ssp. *fragiles* (juvenile). Image accessed from: myweb.dal.ca/rescheib/codium.html 11/08/09.

Description and distinguishing features: The adult of the species is a large branching medium to dark green alga which typically grows between 15 to 60 cm tall but can attain almost 1 m in length. This is a spongy looking algae with cylindrical branches that divide regularly into two. There are native species which occur in WA and look quite similar to this invasive subspecies. This species does require a higher-level of taxonomic expertise for identification than can be expected from a community group, however, due to its invasive nature and its recent detection in Albany, WA it has been included in this design

Habitat: This alga tolerates a wide range of temperatures and salinities, and can be found in estuarine and marine waters. It attaches to hard surfaces, e.g. rocks, rubble, shells, wharfs and ship hulls.

Australian distribution: This species has been introduced into VIC, TAS and SA and has recently been found in Albany, WA.

Concerns: This alga is known to smother mussels and scallops by preventing their valves from opening, fouls nets and ropes and other infrastructure (e.g. jetties) and can change the ecology of an area with flow on effects to other species and fisheries.

Links for further web-based Information

http://www.algaebase.org/search/species/detail/?species_id=46

http://www.marine.csiro.au/crimp/images/NIMPIS_PDF/6916.pdf

http://www.marine.csiro.au/crimp/Reports/Infosht14_Codium0201S3.pdf

http://www.issg.org/database/species/references.asp?si=796&fr=1&sts=&lang=EN

4.3 Wakame Seaweed – *Undaria pinnatifida*

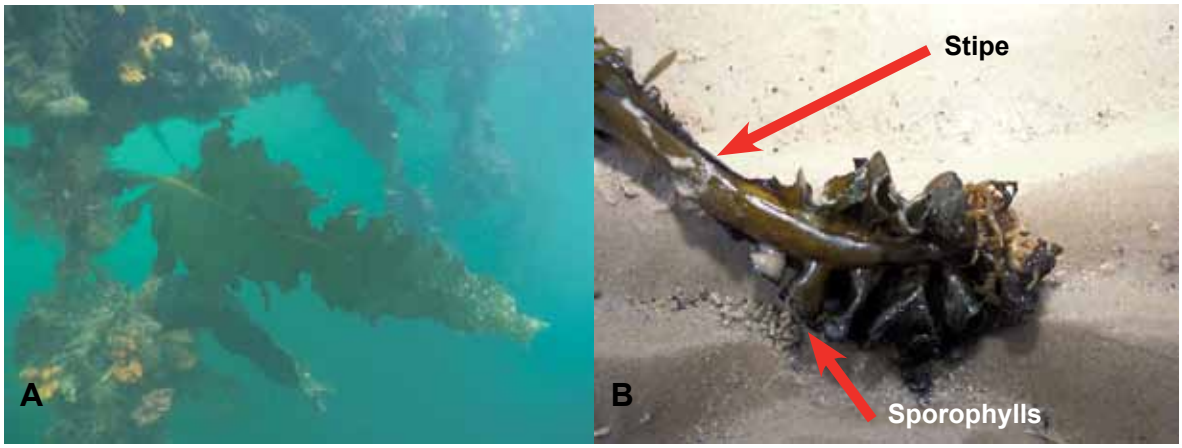

Figure 3. *Undaria pinnatifida*. Photographs by Keith Hiscock. Image accessed from http://www.marlin.ac.uk/speciesinformation.php?speciesID=4547#22/08/09.

Description and distinguishing features: Generally brown/green in colour, up to 1 - 3 m long. Mature plants are only found from early winter to late summer. They have a frilly structure (known as sporophyll) near the base of a mature plant. This alga has a strap-like midrib and fronds of thin blades which occur on only part of the midrib the furthest from the base. The midrib starts to become visible in plants > 5cm. Mature plants have a divided blade with a conspicuous midrib.

Habitat: This alga occurs in cold temperate subtidal waters up to 20 m depth. It can attach to rock, reef, stones, artificial structures (e.g. jetties) and aquaculture equipment.

Australian distribution: This species is already known to be introduced to the south-east and east coast of TAS and to VIC. Temperate regions of WA are vulnerable to incursions of this species.

Concerns: This species can rapidly form dense forests on any available space and can overgrow natives.

Links for further web-based Information

http://www.marinepests.gov.au/__data/assets/pdf_file/0011/930089/Undaria-pinnatifida.pdf

http://adl.brs.gov.au/marinepests/index.cfm?fa=main.spDetailsDB&sp=6000016623

http://www.salemsound.org/mis/U_pinnatifida.pdf

http://www.algaebase.org/search/species/detail/?species_id=350

http://www.issg.org/database/species/ecology.asp?fr=1&si=68&sts

4.4 North Pacific Seastar – *Asterias amurensis*

Figure 4. *Asterias amurensis*. Image accessed from http://en.wikipedia.org/wiki/Northern_Pacific_seastar 20/08/09.

Description and distinguishing features: This species of seastar is generally 12-24 cm across but can get large up to 40-50 cm in diameter. The colour of the upper surface is yellowish with deeper purple and red, the underside is yellow. This seastar has 5 pointed arms with distinct upturned tips. Arms can appear thin or fat depending on availability of food. The arms join at a central disc and there are spines which are irregularly arranged down the arms with a single row of spines along the groove where the tube feet lie, these join fan-like, at the mouth.

Habitat: This seastar occurs in the lower intertidal and subtidal zones (up to 200 m deep), in protected waters on soft bottoms and rock. It can also occur on jetty piles. This seastar prefers temperate waters but can adapt to warmer waters.

Australian distribution: Known to be introduced to TAS and VIC. There is a likelihood it could be introduced/translocated to the temperate waters of WA.

Concerns: This pest is an aggressive predator and has been known to negatively impact native benthos, aquaculture and fisheries. This species is a carnivore and feeds on a variety of molluscs, crabs and barnacles.

Links for further web-based Information

http://www.marinepests.gov.au/__data/assets/pdf_file/0005/852107/Asterias-amurensis.pdf

http://www.marine.csiro.au/crimp/nimpis/spsummary.asp?txa=6131

http://www.issg.org/database/species/ecology.asp?si=82&fr=1&sts=&lang=EN

4.5 European Shore Crab – *Carcinus maenas*

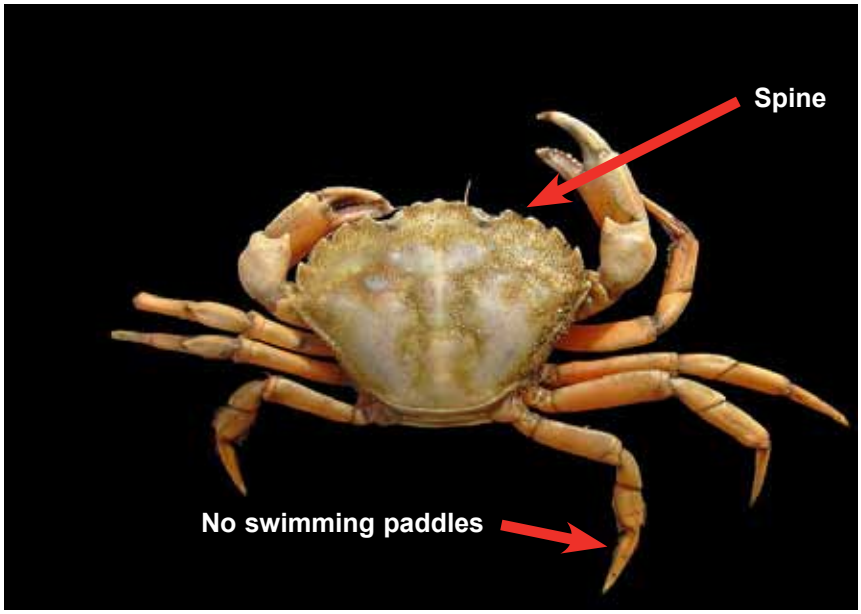

Figure 5. *Carcinus maenas*. Image accessed from: http://en.wikipedia.org/wiki/File:Carcinus_maenas.jpg 20/08/09.

Description and distinguishing features: A medium sized crab with a carapace width of between 65 – 80 mm. The upper surface of the adults shell is green and red-orange on the under surface of larger animals. Juveniles are lighter coloured. This crab has five distinct sharp spines on the outside edge of the carapace on either side of the eyes. Three blunt spines occur between the eyes. Carapace is roughly triangular in shape. The fourth walking legs have flattened ends. There are no swimming paddles.

Habitat: This crab can be found in the intertidal and shallow subtidal zones of bays and estuaries. It can inhabit both sandy and vegetated areas.

Australian distribution: This crab has been introduced into NSW, VIC, TAS and SA. Given this distribution it is possible that this pest could be introduced/translocated into WA. This species was previously reported in WA, but this has since been discounted (Wells *et al* 2010)

Concerns: This crab is a voracious predator with a broad diet. It is possible it has caused decline in commercial shellfish stocks elsewhere. It has been known to outcompete native species for food and habitat.

Links for further web-based Information

http://www.salemsound.org/mis/MISCarcinus.pdf

http://www.invasivespeciesinfo.gov/aquatics/greencrab.shtml

http://www.exoticsguide.org/species_pages/c_maenas.html

http://www.issg.org/database/species/ecology.asp?si=114&fr=1&sts=sss&lang=EN

http://www.marinepests.gov.au/__data/assets/pdf_file/0006/852108/Carcinus-maenas.pdf

http://www.marine.csiro.au/crimp/images/NIMPIS_PDF/6275.pdf

4.6 European Fan Worm – *Sabella spallanzanii*

Figure 6. *Sabella spallanzanii*. Photograph by Justin McDonald

Description and distinguishing features: A large tube worm with a crown of feeding tentacles. These tentacles vary in colour from a dull white to brightly banded with stripes of orange, purple and white. Adult worms range in size from 90 – 400 mm, the feeding crown accounting for about 45 – 60 mm. The tentacle crown is distinctively spiralled.

Habitat: Generally found in shallow, protected, subtidal areas between 1 – 30 m deep. Particularly common in harbours and embayments. This pest will colonise both hard and soft bottoms.

Australian distribution: This pest has been introduced into SA, VIC, TAS and NSW. In WA it has been found in Cockburn Sound, Fremantle, Bunbury, Albany and Esperance. Given the present distribution in temperate waters of WA it is possible this pest will be translocated to other WA areas.

Concerns: This fan worm can form dense colonies which are believed to consume vast amounts of food, outcompeting both native species and shellfish aquaculture species. It can significantly foul aquaculture structures resulting in increased costs to the industry.

Links for further web-based Information

http://www.marine.csiro.au/crimp/images/NIMPIS_PDF/6129.pdf

http://www.issg.org/database/species/ecology.asp?si=1046&fr=1&sts

http://www.marinepests.gov.au/__data/assets/pdf_file/0008/852119/Sabella-spallanzanii.pdf

http://www.biosecurity.govt.nz/pests/mediterranean-fanworm

4.7 European Clam – *Varicorbula gibba*

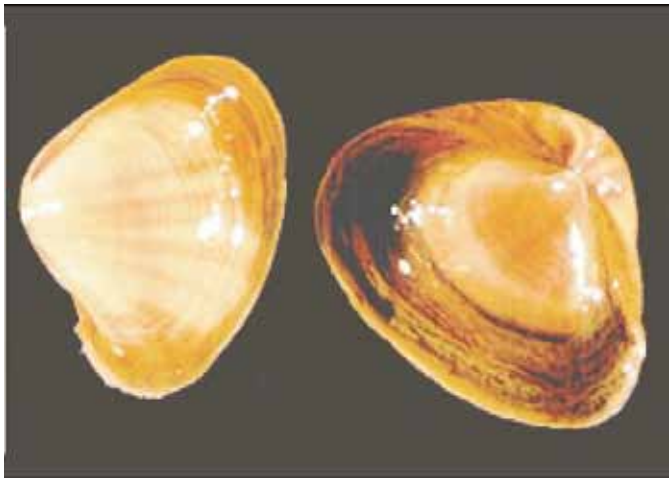

Figure 7. *Varicorbula gibba*. Image accessed from:http://www.pir.sa.gov.au/__data/assets/image/0015/22803/Euro_Clam.JPG. 26/08/09.

Description and distinguishing features: This is a small bivalve that can grow to about 15 - 20 mm. There is a single, well defined tooth in each valve. The outer shell is usually white/cream with brown patches/bands.

Habitat: This clam can occur from the intertidal zone to 150 m depth. It is often buried just below the surface in thick muddy sand and may also attach to gravel or stones. Often in large clumps with 1/3 to 2/3 of shell exposed above sediment. It survives well in polluted waters.

Australian distribution: This clam has been introduced into VIC and TAS. There is a likelihood it could be translocated/introduced to the temperate and sub-tropical waters of WA.

Concerns: This pest grows rapidly and can form large populations able to survive in a variety of environmental conditions. This clam may compete with native species for space and food.

Distinguishing features: The two shells are of unequal size, one has well developed flat and widely spaced concentric ridges, whilst the other has finer and closely set raised ridges. The clam is broadly oval coming to a triangular end.

Links for further web-based Information

http://www.marinepests.gov.au/__data/assets/pdf_file/0008/930086/Varicorbula-gibba.pdf

http://www.marine.csiro.au/crimp/nimpis/spIdentification.asp?txa=6147

http://www.marine.csiro.au/crimp/images/NIMPIS_PDF/6147.pdf

http://data.gbif.org/species/13782581

4.8 European Oyster – *Crassostrea gigas*

Figure 8. *Crassostrea gigas*. Image accessed from http://en.wikipedia.org/wiki/Crassostrea accessed 26/08/09.

Description and distinguishing features: This oyster has a white elongated shell of an average size of 150 - 200 mm. The shape of the oyster depends on the type of bottom on which it grows and how densely crowded the population is. As a rule, on hard surfaces it will be more round with extensive fluting and on soft surfaces more ovate and smooth. The two valves are uneven in size and shape, one valve is concave the other deeper and cup shaped.

Habitat: This pest prefers sheltered waters, such as estuaries, and can be found in the intertidal to shallow subtidal zones. This oyster will attach to most hard surfaces, however, they can also be found in muddy or sandy areas.

Australian distribution: This oyster has been introduced into NSW, TAS, VIC and SA. Given this species current distribution it is likely that it could be translocated/introduced to WA temperate waters.

Concerns: This oyster can outnumber and exclude other native species, limiting space and food availability. They become an "eyesore" and can pose a hazard to beach walkers along the coast by creating large oyster reefs.

Links for further web-based Information

http://www.marine.csiro.au/crimp/nimpis/spSummary.asp?txa=6130

http://www.dpi.nsw.gov.au/fisheries/pests-diseases/marine-pests/species/pacific-oyster

http://www.invasivespecies.net/database/species/ecology.asp?si=797&fr=1&sts

http://en.wikipedia.org/wiki/Pacific_oyster

http://www.psmfc.org/habitat/edu_oyster_fact.html

4.9 Asian Date Mussel – *Musculista senhousia*

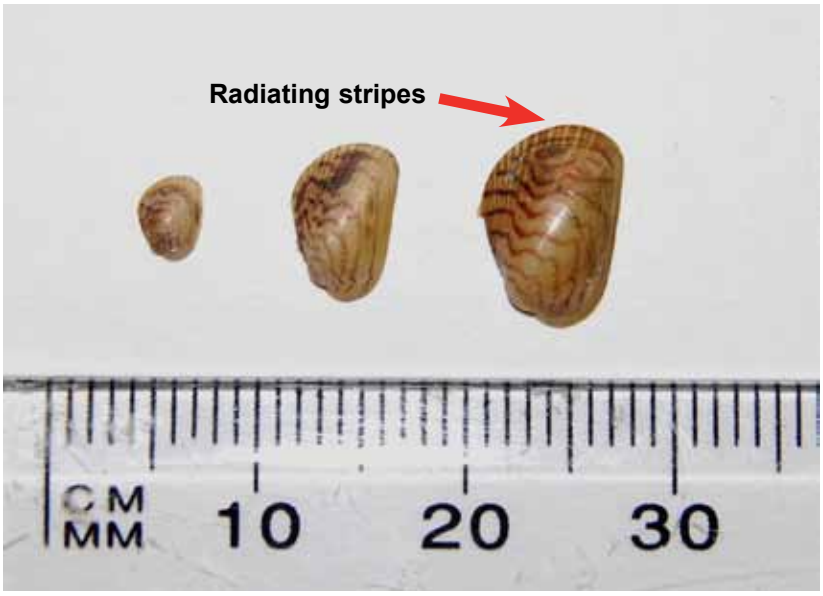

Figure 9. *Musculista senhousia*. Photograph Northern Territory Government (Helen Cribb).

Description and distinguishing features: The shells of this mussel are small, 10 to 25 mm long and up to 12 mm wide. The shell is smooth, thin and olive green to brown with dark radial or zigzag markings. The shell is olive green, easily crushed and has 15 -16 radiating stripes, the central stripe is the thickest. There are 6 – 10 teeth close to where the shells join.

Habitat: This mussel lives in the intertidal and shallow subtidal (up to 20 m depth) zones of bays and estuaries, preferring soft sediment, but will also foul artificial hard surfaces.

Australian distribution: It is known to have been introduced to VIC, TAS and SA. In WA it has been documented as present in Cockburn Sound, the lower Swan River and Fremantle. McDonald and Wells (2009) identify that many of these populations appear to have been reduced considerably, such that they are not detectible in many locations. However given that this species apparently had a large geographical distribution there is a risk of any remnant population being translocated/introduced to other temperate and tropical WA sites.

Concerns: These mussels can smother the surface when they occur in large numbers. This is due to a cocoon they construct from byssal threads that project from the anterior end of the shell. If shells are numerous and close together these cocoons coalesce and form a dense mat.

Links for further web-based Information

http://www.marinepests.gov.au/__data/assets/pdf_file/0007/930085/Musculista-senhousia.pdf

http://www.exoticsguide.org/species_pages/m_senhousia.html

http://www.issg.org/database/species/ecology.asp?si=1031&fr=1&sts

http://adl.brs.gov.au/marinepests/index.cfm?fa=main.spDetailsDB&sp=6000009514

4.10 Black Striped Mussel – *Mytilopsis sallei*

Figure 10. *Mytilopsis sallei*. Photograph Northern Territory Government (Helen Cribb).

Description and distinguishing features: This mussel is finger-nail-sized and black striped. The maximum size is 25 mm. Shells are unequal in size, smooth, small and easily crushed. The mussels form dense clusters. There may be dark zigzag lines on the shell.

Habitat: This mussel occurs in subtropical to topical, estuarine to marine waters of shallow depth. This mussel will attach to most hard surfaces, artificial and natural.

Australian distribution: This mussel was originally detected in Darwin (NT), but has since been eradicated. There are no other known populations currently in Australia. However, it is believed to have the potential to invade tropical to warm temperate waters of Australia.

Concerns: This mussel has the potential to foul any hard surface including mad-made (e.g. nets, wharves and aquaculture infrastructure).

Links for further web-based Information

http://www.marine.csiro.au/crimp/Reports/Infosht10_Mytil0201S3.pdf

http://www.marinepests.gov.au/__data/assets/pdf_file/0005/852116/Mytilopsis-sallei.pdf

http://www.issg.org/database/species/ecology.asp?fr=1&si=1047&sts=

http://www.dpi.nsw.gov.au/fisheries/pests-diseases/marine-pests/species/black-striped-mussel

http://www.scienceimage.csiro.au/index.cfm?event=site.browse.results&keywords=%20Mytilopsis%20sallei

4.11 Asian Green Mussel – *Perna viridis*

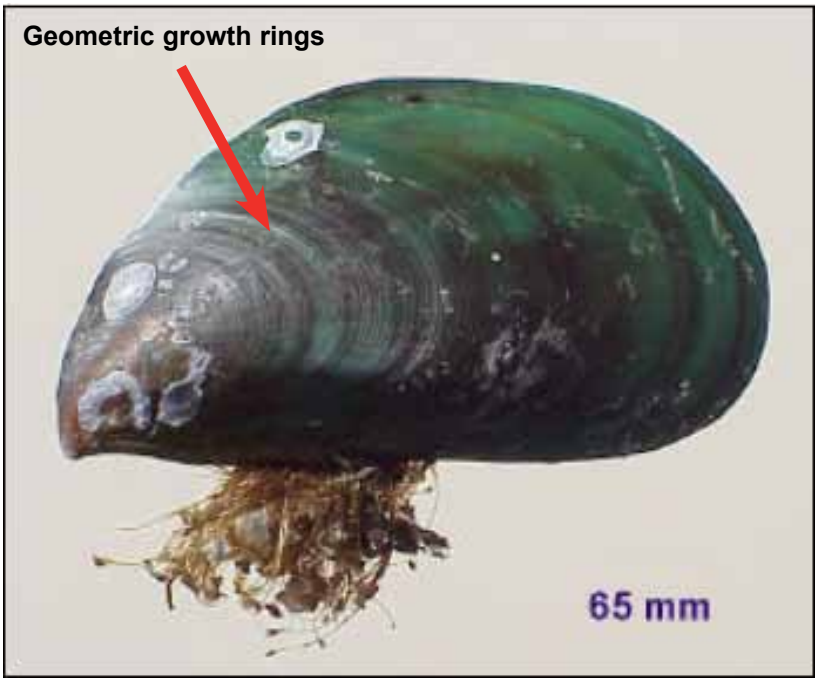

Figure 11. *Perna viridis*. Image accessed from http://en.wikipedia.org/wiki/File:Pviridiscolor.PNG 20/08/09.

Description and distinguishing features: This is a large mussel of between 80 to 160 mm length. The shell tapers to a sharp downturned beak. The interior of the shell is shiny and pale bluish-green. The beak has interlocking teeth, one tooth on one valve and two on the other. The juvenile mussel has a bright green shell, whereas the older mussels are more dark green to brown. The exterior of the shell is smooth with concentric growth lines.

Habitat: The mussel will grow on hard surfaces (e.g. wharves, aquaculture infrastructure, moorings etc.). It will grow in the intertidal (low tide mark) to subtidal zones of depths to 42 m. This mussel can tolerate lower estuarine to marine waters.

Australian distribution: Currently the only known population in Australia, is in Cairns however, its large tolerance thresholds for both salinity and temperature has lead to the belief that all of WA is at risk.

Concerns: This mussel is fast growing and can outcompete other native mussel species, forming dense colonies.

Links for further web-based Information

http://www.marinepests.gov.au/__data/assets/pdf_file/0006/852117/Perna-viridis.pdf

http://www.marine.csiro.au/crimp/Reports/Perna_viridis_sheet.pdf

http://www.issg.org/database/species/ecology.asp?si=731&fr=1&sts=

http://en.wikipedia.org/wiki/Perna_viridis

5.0 Methods

Below is a description of three complimentary monitoring techniques which a community-based group could easily and effectively undertake in their chosen survey location. Ports, commercial harbours and sailing clubs are the areas where community groups should focus their surveys, as these are the most likely vectors for IMP introduction and translocation (see Introduction and Background for further detail). Within these areas possible targets for surveys would include jetties, wharves, beaches and rocky shores/walls. Operational areas of ports should be avoided due to safety hazards and the potential to interfere with port activities.

As collection of specimens to verify identification is fundamental to this program the following instructions pertain to all methods outlined. All material collected should be allocated a unique code, this can be recorded on waterproof paper using pencil. As a guide unique identification (ID) codes should at least consist of: date of collection; where the specimen was collected (site name and GPS coordinates if known); the method used (e.g. visual survey); the transect number it was found on (if there are more than 1) or settlement plate assemblage number; and collectors initials. Additional information may also be required including: depth of array (for the settlement plates); and reference to any images taken (i.e. photo numbers). For example:

On the 12th October 2009 the Shoalwater Islands community group undertook a visual survey (VS) (snorkelling) along the Penguin Island Jetty (PIJ). As a result of this survey one voucher specimen was collected by John Brown (JB). The unique ID could be as follows: 121009-PIJ-VS-2-JB. As John also took a few photographs of the specimen additional information would include the photograph numbers, e.g. 121009-PIJ-VS-2-JB-IMG6-10. This information will need to be kept with the specimen collected, preferably inside the zip lock bag.

5.1 Visual Surveys

Visual surveys are well recognized as efficient in terms of time, budgetary constraints and, primarily, because they are the most useful technique for targeting such a broad range of species in potentially different habitats. Visual surveys in the water can be done by either divers or snorkellers depending on the capabilities of the volunteers. For both options volunteers need to ensure safety protocols are followed including diving/snorkelling in buddy-pairs. Volunteers will need to be mindful of the depth and visibility of the waters they wish to survey. If the water is too deep, or turbid, snorkellers will be unable to adequately view the substratum, in this case divers would be the better choice, or else shallower water should be targeted.

A transect is, usually, a straight line of known distance, preferably marked at the start by either a permanent marker (or permanent fixture e.g. first pylon on left side of jetty) or recorded Global Positioning System (GPS) mark. Transects need to cover a known distance and direction (e.g. due north) so that they can be replicated each time the area is surveyed thus providing continuity of the area covered and data collected. Transects can be used effectively along beaches or in the water along jetties, or other mad-made structures such as pontoons. Whilst swimming these transects, volunteers need to look for and record the presence or absence (total numbers can also be recorded) of any target species encountered. Any species thought to be a target species should be photographed for later identification (see Collection and Preservation section). The location of the suspected pest along the transect should be recorded so that an expert can return to the same area to verify its presence or absence.

5.2 Beach Walks

Inter-tidal and beach surveys should be undertaken by a minimum of two people. In such cases, individuals should traverse an area examining rocks, structures, beach and shallows for the presence of the target species (either alive or dead). Wrack (e.g. washed up seaweed and animals), debris and rock walls should be examined in detail to determine if any target species are present, even dead material present in wrack could provide an indicator that it is or was present in the vicinity (i.e. may still be living sub-tidally).

As for visual surveys the intertidal or beach surveys are best conducted using transects of known length and direction, with start and end points recorded/marked. Volunteers will need to record presence or absence (total numbers can also be recorded) and position of the suspected pest along the transect. Suspected, alive pests should be photographed (top, bottom and side view photos if possible) whereas dead material can be placed into zip lock bags and put on ice for later identification, ensure these are given an ID code. If identification is doubtful the collected specimens can be preserved (see Collection and Preservation section) and provided to experts for verification, however, this will depend on the degree of degradation. Again knowing the location of the suspected, alive or dead pest will allow future verification by an expert. As with visual surveys vouchers specimens can also be collected and preserved for taxonomic verification (see Collection and Preservation section).

Other things to note and record on the data sheet whilst undertaking beach walks are the general weather conditions and storms or strong wind events that have occurred recently and may have contributed to material being washed up onto the beach. Also a map of the location, along with a general description and accompanying photographs of the area being surveyed should be recorded.

5.3 Settlement Plates

Settlement plates are an established methodology to examine recruitment of marine organisms and have been used for marine pest monitoring in Albany and Esperance, in previous CRIMP surveys and also as part of long term monitoring for introduced marine species in Darwin harbour. Settlement plates not only work as an early warning system for the detection of IMPs but provide a valuable record of other organisms in the marine survey area.

These arrays are simple structures designed to act as extra surfaces for organisms, such as the pest species listed in Table 1, to settle on. Ideally they should be placed in an area where they will be protected from vessel traffic and strong wave action. These arrays can get quite heavy if large amounts of material settle onto the plates. As such they should be attached to something sturdy when deployed, for example underneath a jetty, from a mooring or pontoon.

Settlement array assembly and deployment

The settlement plate system consists of three sections of PVC pipe (0.5 m length x 20 mm diameter), joined at a T-junction, on which two 10 x 10 cm PVC plates are fixed in a horizontal position and two fixed in a vertical position (Figure 12). Thus each individual system contains four plates. Arrays also have rope collectors (looped rope with 10cm of frayed ends) to provide a different type of habitat for settlement (Figure 12). Additional systems can be added for different water depths by threading rope through the middle of the vertical piece of PVC pipe and tying of successive systems at the required depths, this is explained in detail below.

The length of rope required is based on the depth of the area to be surveyed and allowing extra length for tying off the assemblage when deploying. To avoid excessive weight no more than three consecutive arrays should be deployed as one assemblage. At one end of the length of rope a weight (dive weight) is attached (Figure 13). This weight marks the end of the assemblage and is necessary to ensure a vertical orientation is maintained within the water column once the assemblage is deployed. A knot is tied just above the weight and the length of rope is then fed up through this bottom array. The knot below the bottom array will prevent the array from slipping. Approximately one metre above the bottom arrays' horizontal crossbar another knot is tied, and the roped then passed up through the next array (Figure 13). In this way each successive array is held in place and prevented from slipping down the rope.

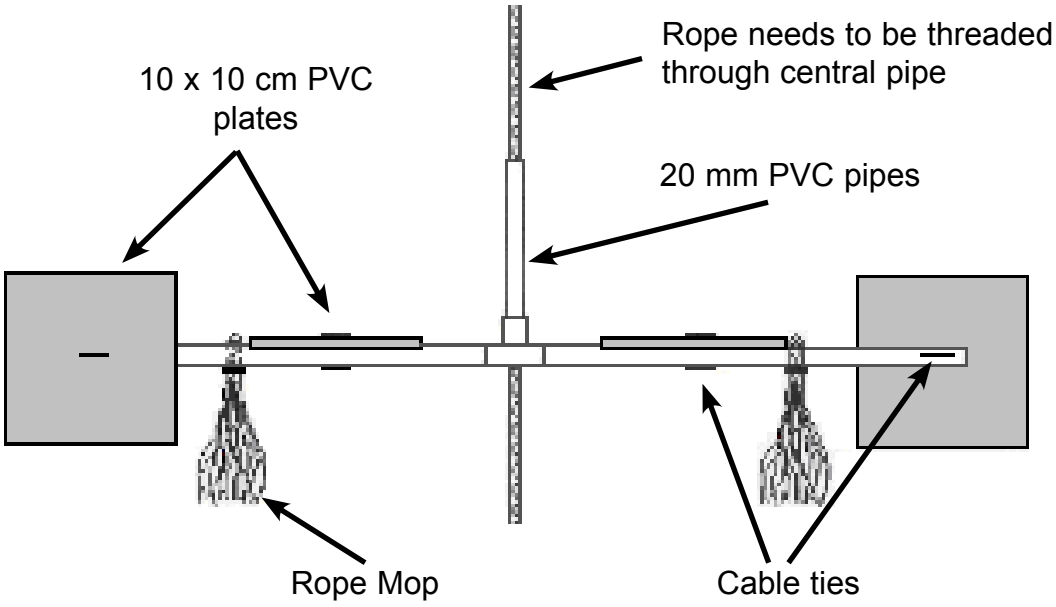

Figure 12. Illustration of the settlement plate arrays showing one vertical and one horizontal plate attached to each of the two arms of the system. Adapted from Marshall and Cribb (2004).

These steps are repeated until the assemblage is the desired length, or a maximum of three arrays are attached (Figure 14). It is essential that the first array is at least 1 m below the waters surface, this will reduce the chance of material starting to settle onto the array being disturbed by wave action (Figure 13). This configuration means the arrays are deployed at regular intervals from 1 m below the surface. The assemblage needs to be attached to a suitable structure which will not be adversely affected by the increase in weight of the assemblage over time, through fouling.

Finally the position where the assemblage is deployed needs to be marked so they can be found again. If possible arrays should be checked every few weeks just to make sure they are still there (especially after any bad weather). The assemblages should be deployed for 3 – 4 months before being recovered. Once recovered and the material removed (see following section) the PVC plates can be scraped clean and reused, the rope mops, however, will need to be replaced.

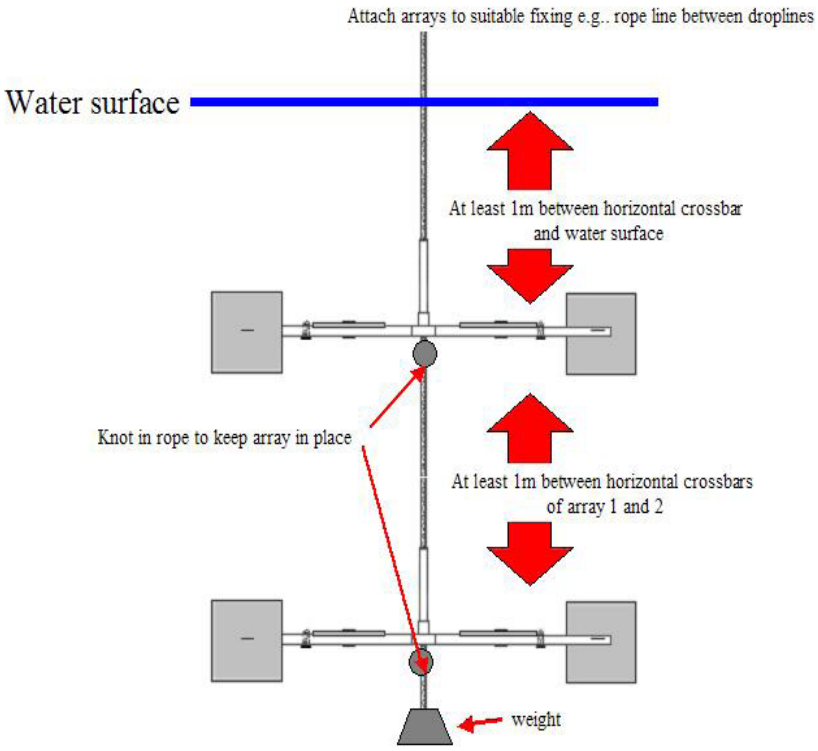

Figure 13. Schematic of the settlement plate system showing two arrays connected via a single rope line. This free hanging assemblage requires a weight at the bottom.

Figure 14. Arrays *in-situ* – showing rope collectors and multiple arrays connected by rope to sample at different depths.

Sorting and identifying specimens from the settlement plates

Photographs of the intact plates and rope mops should be taken prior to removing any material (see Collection and Preservation section). Collected material should initially be sorted into broad taxonomic groups (e.g. sea squirts, barnacles, sponges etc.) prior to more detailed taxonomic identification, if desired. During this initial sorting the material is examined for the 11 pest target species. If any pest species are detected you should notify the Biosecurity group at the Department of Fisheries (DoF) as soon as possible (see contact details Appendix 1).

All material collected will need to be allocated a unique code as previously described, however, in addition the depth of the array (if there is more than one) should be incorporated into the ID code. Potential pest species will need to be preserved to enable verification by a taxonomist.

Many of the samples collected are likely to be from taxonomic groups not represented on the target list (e.g. sponges). As such rather than ignoring this potentially valuable data, the community group may elect to classify these samples into broader morpho-species groupings (e.g. blue branching sponge 1). A representative of each of these morpho-species should be preserved as a voucher specimen (see Collection and Preservation section). In doing this the community group are able to build up a biological library of the morpho-species present in their study location. These voucher specimens can also be verified by a taxonomist at a later date.

There may also be specimens which may potentially be target pest species, however, they are of unresolved identity *i.e.* where identification was not possible due to insufficient expertise, damaged samples, larval phase etc. The community group should preserve these specimens (see Collection and Preservation section) and contact the DoF Biosecurity group for assistance with identification.

5.4 Collection and Preservation

Photographs are the recording method of choice as it will reduce the potential for the killing of native look-a-likes, damaging a sample or spreading the species by fragmentation. For the visual surveys, where possible, multiple photographs of the suspected pest should be taken at different angles, e.g. top, bottom and side views. Digital cameras are recommended, however, you will need to determine the focal distance of your camera to assess whether close-up (macro) shots are viable. When taking photographs of the settlement plates initially take one photograph of the whole plate then, depending on the capabilities of your camera, take one photograph of each quarter of the plate. For all photographs taken of the settlement plates and rope mops ensure the ID label is visible in the images.

Care should be taken when collecting algal specimens as many are known to spread via fragmentation (i.e. are able to grow complete plants from small fragments). They should NEVER be torn or cut up and discarded back into the water. All specimens will need to be given unique ID codes as previously described. Voucher specimens (i.e. one or two specimens) can also be collected. The collection of voucher specimens allows for the identification of pests to be verified by a taxonomist. Voucher specimens require preservation, as such the community-based group will need formal education from an experienced person on this process. This guidance can be provided by the Biosecurity group from the Department of Fisheries (see Appendix 1 for contact details). However, some brief notes on how best to temporarily preserve specimens is presented below.

Freezing

Place collected specimens into separate a zip lock bags with appropriate ID labels. These specimens can then be frozen until you are able to have them identified. It should be noted however, that the freezing process can make accurate identification more difficult or impossible due to the potential damage of tissue and cells. For this reason the following two methods would be the more preferred methods.

Chemical Fixing

Only a responsible adult should handle any of the following chemicals. Care needs to be taken when handling chemicals, ensuring none comes in contact with skin or eyes. Gloves should be worn at all times and chemicals should only be used in well ventilated areas, i.e. outside.

Two chemical options are available, formalin and ethanol. Both are good options for preserving specimens, however, both require further dilution prior to use. For formalin the mix needs to be 1 part formalin to 9 parts seawater. For example to mix up one litre of dilute formalin (10 % concentration) add 900 mls of seawater to a container of 100 ml of formalin. For ethanol mix 7 parts of ethanol to 3 parts of freshwater. Polypropylene containers with screw lids (and O-rings) can be used to store these pre-made chemical mixtures. Store these containers in a cool, dark area until required.

Wearing gloves place the voucher specimen into an appropriately sized container, along with the ID label, and fill the container with either one of the two preservatives. The preservative used also needs to be recorded on the label. Store the voucher specimen in a cool, dark area until contact is made with the Biosecurity group and transport of the specimen is organised.

Drying

This method is appropriate for algal specimens. Initially the specimen should be fixed in either ethanol or formalin mix as outlined above. The fixing preserves the colour of the specimen. Once the specimen has been fixed (overnight will do) the specimen needs to be rinsed under tap water to remove any other debris e.g. sand or shells. Carefully layout the whole specimen (ensuring the fronds are separated and not folded) on heavy weighted paper (such as herbarium paper or waterproof acid free paper). If the holdfast is too thick it may need to be removed from the plant, split in half and then dried separately. Ensure all sheets are appropriately labelled. On top of the specimen place some crumpled waxed paper, then 2 or 3 layers of cheesecloth (or chux super wipes) and finally some paper towel. Subsequent specimens, on their own sheet of paper, can be added using the same procedure as above. Put all the layers of specimens (don't go too thick) between two pieces of corrugated cardboard and strap together. Place a heavy item such as a brick on top and keep in a warm, dry place. Change the paper towel as required. This drying process make take up to a week or more. Once completely dried the algal specimen should be stuck to the sheet, if not, stick it in place with a few drops of superglue. Store the dried specimen on its sheet in a transparent sleeve. Ensure the ID labels are still intact.

6.0 Reporting

To ensure the information collected by a community group can contribute to any State IMP monitoring there needs to be a formal reporting process in place. This document needs to be user-friendly, but also informative for managers. This document should include template sheets for use in the field, for use when processing the samples and an overall project description template in which the community group can include their findings. Information in the project description template should include but not be limited to:

- Name of the community group involved
- Choice of the monitoring area – with a description of why the area was chosen and a map showing its locality and possibly photographs.
- A list of the pest species being targeted
- A list of the methods used
- A brief description of the results of the program
- A list of the pest species found
- A list of other species found (or a list of morpho-species)
- Conclusions from the program
- Draft templates of the Project Description document and field and processing-based worksheets are provided in Appendix 2.

7.0 References

Anonymous. (2002). Nationally Listed Threatened Species and Ecological Communities under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. Accessed online http://www.environment.gov.au/biodiversity/threatened/publications/recovery/guidelines/pubs/recovery-2002.pdf.

Bax, N., Williamson, A., Aguero, M., Gonzalez, E & Geeves, W. (2003). Marine invasive alien species: a threat to global biodiversity. Marine Policy. 27: 313-323.

Cribb, H. N., Dowden-parker, T. J. & Beatty, A. (2009). Coordinated Marine Pest Monitoring by Remote Coastal Communities. Fishery Report No. 100. NT Department of Regional Development, Primary Industry, Fisheries and Resources.

CRC Reef. (2004). Introduced species in tropical waters: current state of knowledge, March 2004. Published by CRC Reef Research Centre Ltd.

Department of Agriculture, Fisheries and Forestry. (2006). Marine Pest Monitoring Manual. Version 1. Department of Agriculture Fisheries and Forestry, Canberra. 126 pp.

Huisman, J.M., Jones, D.S., Wells, F.E. & Burton, T. (2008). Introduced marine biota in Western Australian Waters. Records of the Western Australian Museum. 24: 323-366.

Marshall, A. J. & Cribb, H. N. (2004). Monitoring for marine pests in Raffles Bay, Coburg Peninsula. Third Report. Department of Business, Industry and Resource and Development, Northern Territory.

McDonald, J. I. & Wells, F. E. (2009) The apparent demise of the Asian date mussel Musculista senhousia in Western Australia: or using acts of god as an eradication tool. Biological Invasions, online access.

Millennium Ecosystem Assessment. (2005). Ecosystems and human well-being: Biodiversity synthesis. World Resources Institute, Washington DC.

Scheibling, R. E. & Gagnon, P. (2006). Competitive interactions between the invasive green alga Codium fragile ssp. tomentosoides and native canopy-forming seaweeds in Nova Scotia (Canada). Marine Ecology Progress Series. 325: 1-14.

Sutton, C. A. & Hewitt, C. L. (2004). Detection Kits for Community-based Monitoring of Introduced Marine Pests. Revised final report to National Heritage Trust/Coasts and Clean Seas, CSIRO Marine Research, CRIMP, Hobart, Tasmania. Available at http://crimp.marine.csiro.au/Reports/CDKreport.pdf.

Wells, F. E., McDonald, J. I. & Huisman, J. M. (2009). Introduced Marine Species in Western Australia. Fisheries Occasional Publications No. 57. Department of Fisheries, Perth, Western Australia. 102 pp.

Wells, F. E., McDonald, J. I. & Travers, M. J. (2010). Absence of the European shore crab, Carcinus maenas, from the Fremantle marine area, Western Australia. Records of the Western Australian Museum.

8.0 Appendices

Appendix 1 Contact Details

Biosecurity group at the Department of Fisheries, WA

Research Scientist:

Samantha Bridgwood

Postal Address:

PO Box 20,

North Beach 6920

Physical Address:

Western Australian Fisheries and Marine Research Laboratories

39 Northside Drive

Hillarys

Phone: 08 9203 0111

Fax: 08 9203 0199

Appendix 2 Report Template

Community-Based Introduced Marine Pest Monitoring Report

<insert name of monitoring location here >

<insert name of community group here>

<insert date here>

35

About this Template

<This template has been developed to assist in the reporting of marine pest monitoring surveys undertaken by community groups. The use of this template for reporting of monitoring surveys is recommended, not mandatory.

Throughout the template, annotations in italics have been made to assist in completing the report. These should be deleted when completing the report (including this section).>

Table of Contents

Primary Monitoring Contact

Name:
Organisation:
Phone:
Email:

3

Choice of Monitoring Area

<Include information such as: where the area is, a brief general description of the area, why your group chose this particular area, a general map of the area and if possible a map showing where you sampled. You could also include photographs.>

Target Species

<List the pest species that your monitoring program targeted. If the group also looked at morpho-species include the descriptions here e.g. stalked colonial ascidian 1>

Methods Used

<Include a brief site description in this section, e.g. where the beach was located, if it is a popular beach, rocky or sandy, is there a boat ramp, jetty, approximate length of the beach and width etc. Give a description of the methods used. For each method include information such as: GPS location and/or marker locations for transects and array deployments; types of markers used e.g. starpickets; the number of transects or array assemblages; the length of transects and compass direction; the number of arrays on an array assemblage; the date of the field-work; the number of people involved. Also note any difficulties encountered using the methods of choice).>

<Below is a description of three complimentary monitoring techniques which a community-based group could easily and effectively undertake in their chosen survey area. Describe each method you used under the appropriate headings. As collection of specimens to verify identification is fundamental to this program the following instruction pertain to all methods outline. All material collected should be allocated a unique code, this can be recorded on

waterproof paper using pencil. As a guide unique identification (ID) codes should at least consist of: date of collection; where the specimen was collected (site name and GPS coordinates if known); the method used (e.g. visual survey); the transect number it was found on (if there are more than 1) or settlement plate assemblage number; and collectors initials. Additional information may also be required including: depth of array (for the settlement plates); and reference to any images taken (i.e. photo numbers). For example :>

> *<On the 12th October 2009 the Shoalwater Islands community group undertook a visual survey (VS) (snorkelling) along the Penguin Island Jetty (PIJ). As a result of this survey one voucher specimen was collected by John Brown (JB). The unique ID could be as follows: 121009-PIJ-VS-2-JB. As John also took a few photographs of the specimen additional information would include the photograph numbers, e.g. 121009-PIJ-VS-2-JB-IMG6-10. This information will need to be kept with the specimen collected, preferably inside the zip lock bag.>*

<Survey locations need to target areas adjacent to where vectors such as shipping, commercial fishing operations and open water sailing vessels are present, i.e. ports, commercial harbours and sailing clubs, as these are the most likely vectors for IMP introduction and translocation (see Introduction and Background for further detail). Operational areas of ports should be avoided due to safety hazards and the potential to interfere with port activities.>

Visual Surveys

<Visual surveys are well recognized as efficient in terms of time, budgetary constraints and, primarily, because they are the most useful technique for targeting such a broad range of species in potentially different habitats. Visual surveys in the water can be done by either divers or snorkellers depending on the capabilities of the volunteers. For both options volunteers need to ensure safety protocols are followed including diving/snorkelling in buddy-pairs. Volunteers will need to be mindful of the depth and visibility of the waters they wish to survey. If the water is too deep, or turbid, snorkellers will be unable to adequately view the substratum, in this case divers would be the better choice, or else shallower water should be targeted.>

<A transect is, usually, a straight line of known distance, preferably marked at the start by either a permanent marker (or permanent fixture e.g. first pylon on left side of jetty) or recorded Global Positioning System (GPS) mark. Transects need to cover a known distance and direction (e.g. due north) so that they can be replicated each time the area is surveyed thus providing continuity of the area covered. Transects can be used effectively along beaches or in the water along jetties, or other man-made structures such as pontoons. Whilst swimming these transects, volunteers need to look for and record the presence or absence (total numbers can also be recorded) of target species encountered. Any species thought to be a target species should be photographed for later identification. Where possible, photographs of the suspected pest should be taken at different angles, e.g. top, bottom and side views. The location of the suspected pest along the transect should be recorded so that an expert can return to the same area to verify its presence or absence. Photographs are the collection method of choice as it will reduce the potential for the killing of native look-a-likes, however, voucher specimens (i.e. one or two specimens) can also be collected. These will need to be given unique ID codes as previously described. Voucher specimens require preservation; as such the community-based group will need formal education from an experienced person on this process. This guidance can be provided by the Biosecurity group from the Department of Fisheries (see Appendix 1 for contact details). The collection of voucher specimens allows for the identification of pests to be verified by a taxonomist.>

Beach Walks

<Inter-tidal and beach surveys should be undertaken by a minimum of two people. In such cases, individuals should traverse an area examining rocks, structures, beach and shallows for the presence of the target species (either alive or dead). Wrack, debris and rock walls should be examined in detail to determine if any target species are present, this could provide an indicator that it is or was present in the vicinity (i.e. may still be living sub-tidally). As for visual surveys the intertidal and beach surveys are best conducted using transects of known length and direction, with start and end points recorded/marked. Volunteers will need to record presence or absence (total numbers can also be recorded) and position of the suspected pest along the transect. Suspected, alive pests should be photographed (top, bottom and side view photos if possible) whereas dead material can be placed into zip lock bags and put on ice for later identification, ensure these are given and ID code. If identification is doubtful the collected specimens can be frozen and provided to experts for verification, however, this will depend on the degree of degradation. Again knowing the location of the suspected, alive or dead pest will allow future verification by an expert. As with visual surveys vouchers specimens can also be collected and preserved for taxonomic verification. These will need to be given unique ID codes as previously described.>

<Other things to note and record on the data sheet whilst undertaking beach walks are the general weather conditions and storms or strong wind events that have occurred recently and may have contributed to material being washed up onto the beach. Also a map of the location, along with a general description and accompanying photographs of the area being surveyed should be recorded.>

Settlement Plates

<Settlement plates are an established methodology to examine recruitment of marine organisms and have been used for marine pest monitoring in Albany and Esperance, in previous CRIMP surveys and also as part of long term monitoring for introduced marine species in Darwin harbour. Settlement plates not only work as an early warning system for the detection of IMPs but also provide a valuable record of other organisms in the communities marine survey area.>

<These arrays are simple structures designed to act as extra surfaces for organisms, such as the pest species listed in Table 1, to settle on. Ideally they should be placed in an area where they will be protected from vessel traffic and strong wave action. These arrays can get quite heavy if large amounts of material settle onto the plates. As such they should be attached to something sturdy when deployed, for example underneath a jetty, from a mooring or pontoon.>

<The settlement plate system consists of three sections of PVC pipe (0.5 m length x 20 mm diametre), joined at a T-junction, on which two 10 x 10 cm PVC plates are fixed in a horizontal position and two fixed in a vertical position (Figure 1). Thus each individual system contains four plates. Arrays also have rope collectors (looped rope with 10cm of frayed ends) to provide a different type of habitat for settlement (Figure 1). Additional systems can be added for different water depths by threading rope through the middle of the vertical piece of PVC pipe and tying of successive systems at the required depths, this is explained in detail below.>

The length of rope required is based on the depth of the area to be surveyed and allowing extra length for tying off the assemblage when deploying. To avoid excessive weight no more than 4 consecutive arrays should be deployed as one assemblage. At one end of the length of rope a weight (dive weight) is attached (Figure 2) . This weight is necessary to ensure a vertical orientation is maintained within the water column once the assemblage is deployed. A knot is tied just above the weight and the length of rope is then fed up through this bottom array. The knot below the bottom array will prevent the array from slipping. Approximately one metre above the bottom arrays' horizontal crossbar another knot is tied, and the roped then passed up through the next array (Figure 2). In this way each successive array is held in place and prevented from slipping down the rope.>

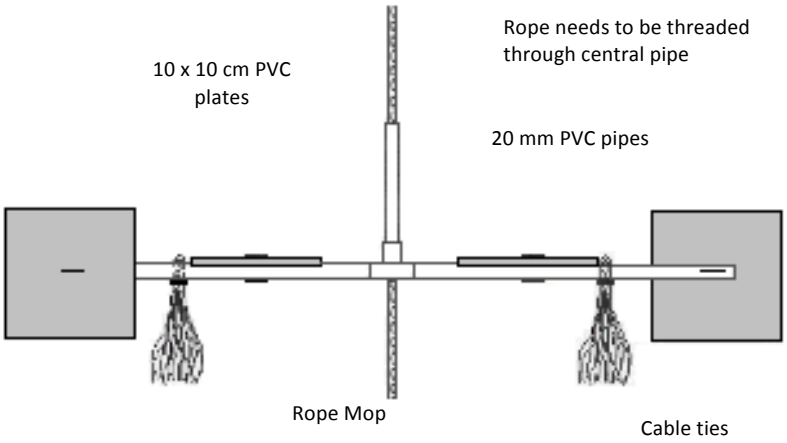

Figure 1: Illustration of the settlement plate system showing one vertical and one horizontal plate attached to each of the two arms of the system. Adapted from Marshall and Cribb (2004).

<These steps are repeated until the assemblage is the desired length, or a maximum of 4 arrays are attached. It is essential that the first array is at least 1 m below the waters surface, this will reduce the chance of material starting to settle onto the array being disturbed by wave action (Figure 2). This configuration means the arrays are deployed at regular metre intervals from 1 m below the surface. The assemblage needs to be attached to a suitable structure which will not be adversely affected by the increase in weight of the assemblage over time, through fouling.>

<Finally the position where the assemblage is deployed needs to be marked so they can be found again easily. If possible arrays should be checked every few weeks just to make sure they are still there (especially after any bad weather). The assemblages should be deployed for 3 – 4 months before being recovered. Once recovered and the material removed (see following section) the PVC plates can be scraped clean and reused, the rope mops, however, will need to be replaced.>

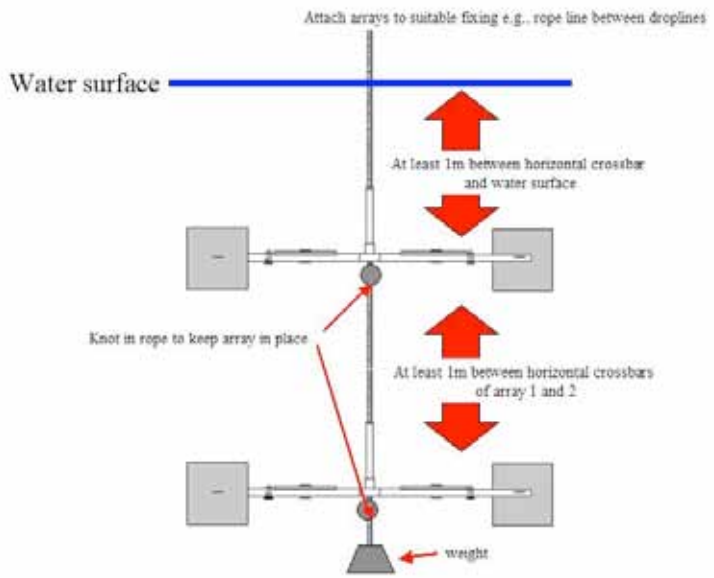

Figure 2: Schematic of the settlement plate system showing two arrays connected via a single rope line. This free hanging assemblage requires a weight at the bottom.

Results

<Record in here the results of the survey. This can be further separated into results for each survey technique used. Include in here information on the pest and suspected pests, the group has encountered including location information, how many, photographs of pests, whether the specimen was verified and by whom and if voucher specimens were collected. If the group has included work on morpho-species report this here also, in similar fashion, to the pests.>

Beach Walks

Visual Survey

Settlement Plates

Conclusions

<Give a brief run down on what you have found (e.g. overall we found one pest species, Asterias amurensis), any difficulties encountered, any other interesting facts>

12

Appendices

The following pages contain examples of field and processing sheets for Beach Walks, Visual Survey and Settlement Plates.

Beach Walk - Field Sheet

Name:		**Organisation:**	**Contact details:**	
Location name:		**Date:**	**Time:**	
GPS or marker:		**Transect number:**	**Length:**	**Compass Direction:**
Weather conditions circle more than one if applicable):	sunny cloudy rainy calm sea waves	low tide high tide	windy	light-no breeze

if you can take multiple photographs of the location and create a mud map of the area. Remember to label specimens with unique IDs.

Pest species	**Voucher (Y/N)**	**# Observed (running tally)**	**Photograph numbers**
Caulerpa taxifolia			
Codium fragile ssp. fragile			
Undaria pinnatifida			
Asterias amurensis			
Carcinus maenas			
Sabella spallanzanii			
Varicorbula gibba			
Crassostrea gigas			
Musculista senhousia			
Mytilopsis sallei			
Perna viridis			

Use this section if unsure of the species. The ones not identified as an IMP listed above will become your morpho groups.

Unknown species (make up a descriptive name, use this name for all specimens you think are the same)	**Voucher (Y/N)**	**Description e.g. approx size, colour etc.**	**# Observed (running tally)**	**Photograph numbers**
e.g. blue ascidian	*Y*	*blue, each is 2 cm, clustered in groups*	*////*	*1,2,3 5,6,7*

Visual Survey Field Sheet

Name:	**Organisation:**		**Contact details:**	
Location name:	**Date:**		**Time:**	
GPS or marker:	**Transect number:**		**Length:**	**Compass Direction:**
Depth (m):	**Visibility (m):**			
Weather conditions (circle more than one if applicable):	sunny cloudy rainy calm sea waves low tide high tide windy light-no breeze			

Pest species	**Voucher (Y/N)**	**# Observed (running tally)**	**Photograph numbers**
Caulerpa taxifolia			
Codium fragile ssp. fragile			
Undaria pinnatifida			
Asterias amurensis			
Carcinus maenas			
Sabella spallanzanii			
Varicorbula gibba			
Crassostrea gigas			
Musculista senhousia			
Mytilopsis sallei			
Perna viridis			

Unknown species (make up a descriptive name, use this name for all specimens you think are the same)	**Voucher (Y/N)**	**Description e.g. approx size, colour,**	**# Observed (running tally)**	**Photograph numbers**
e.g. brown mussel	*Y*	*brown/olive, 5 * 10 mm, shell halves even size*	*////*	*1,2,3 5,6,7*

Beach Walk / Visual Survey - Processing Sheet for Unknown Species			
Circle the appropriate one			
Name:	**Organisation:**	**Contact details:**	
Location name:	**Date:**	**Time:**	
GPS or marker:	**Transect number:**	**Length:**	**Compass Direction:**
Depth (m):	**Visibility (m):**		
Review your unknown species specimens/photographs. If they are an IMP record against the species name. Remember to label specimens with unique IDs.			

Pest species	**Running tally**
Caulerpa taxifolia	
Codium fragile ssp. fragile	
Undaria pinnatifida	
Asterias amurensis	
Carcinus maenas	
Sabella spallanzanii	
Varicorbula gibba	
Crassostrea gigas	
Musculista senhousia	
Mytilopsis sallei	
Perna viridis	

Settlement Plates - Field Sheet

Name: **Organisation:** **Contact Details**

If you can, take multiple photographs of the location and create a mud map of your sites

Location name	Array number	GPS or marker	No. of arrays in assemblage	Deployment date	Retrieval date	Notes

Settlement Plates - Processing Sheet		
Name:	**Organisation:**	**Contact details:**
Location name:	**Array number**	**GPS or marker:**
Deployment date	**Retrieval date**	**Length:**

Take multiple close-up photographs of the plates prior to removing anything, checking to make sure the entire plate fills the frame and that the photos aren't blurry. Also take close-up photos of the specimens as you remove them. Do this by floating the specimen in a small amount of sea water in a white tray. Remember to label specimens with unique IDs.

Pest species	**Voucher (Y/N)**	**# Observed (running tally)**	**Photograph numbers**
Caulerpa taxifolia			
Codium fragile ssp. fragile			
Undaria pinnatifida			
Asterias amurensis			
Carcinus maenas			
Sabella spallanzanii			
Varicorbula gibba			
Crassostrea gigas			
Musculista senhousia			
Mytilopsis sallei			
Perna viridis			

Unknown species (make up a descriptive name)	**Voucher (Y/N)**	**# Observed (running tally)**	**Photograph numbers**
e.g. blue ascidian	*Y*	*////*	*1,2,3*