An Australian Government Initiative

NATIONAL CONTROL PLAN

European or basket shell clam
Varicorbula gibba

THE NATIONAL SYSTEM FOR THE PREVENTION AND MANAGEMENT OF MARINE PEST INCURSIONS

This collaborative effort is supported by the Australian Government, state and Northern Territory governments, marine industries, researchers and conservation groups.

Australian Government

National Control Plan
for the European or basket shell clam
Varicorbula gibba

Prepared for the Australian Government
by Aquenal Pty Ltd

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Cover photo: CSIRO Marine & Atmospheric Research

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BACKGROUND

The National System for the Prevention and Management of Marine Pest Incursions (the National System) has been developed to deal with the marine pest problem in Australia. Under the National System, introduced marine pests that are established in Australia that are having a significant impact and are not amenable to eradication, will be addressed under the Ongoing Management and Control component. The key initiative under this component is the development and implementation of National Control Plans (NCPs), which reflect an agreed national response to reduce impacts and minimise spread of agreed pests of concern. The Australian, state and Northern Territory governments, through the National Introduced Marine Pests Coordination Group (NIMPCG), have determined that the following are agreed pests of concern, for which NCPs are required:

-Northern Pacific seastar (*Asterias amurensis*);
-European green crab (*Carcinus maenas*);
-Asian date mussel (*Musculista senhousia*);
-European fan worm (*Sabella spallanzanii*);
-Japanese seaweed (*Undaria pinnatifida*); and
-European clam (*Varicorbula gibba*).

The six NCPs for the above species are being developed in accordance with the Contents List that has been agreed by NIMPCG. The aims of the NCPs are to establish nationally agreed, species specific responses, secure their coordinated implementation across jurisdictions, and provide guidance on the development of future strategies to reduce impacts and minimise the spread of these pests.

This document outlines the NCP for the European clam *Varicorbula gibba*.

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LIST OF ACRONYMS

CCIMPE	Consultative Committee on Introduced Marine Pest Emergencies
CSIRO	Commonwealth Scientific and Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DEWHA	Department of the Environment, Water, Heritage and the Arts
EEOR	Emergency Eradication Operational Response
EMPPlan	Australian Emergency Marine Pest Plan
IMCRA	Interim Marine and Coastal Bioregionalisation for Australia
IMO	International Maritime Organisation
MPA	Marine Protected Area
NCPs	National Control Plans
NIMPCG	National Introduced Marine Pests Coordination Group
NIMPIS	National Introduced Marine Pest Information System
NMN	National Monitoring Network
R&D	Research and Development
RRM	Rapid Response Manual

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A. Vision statement and strategic overview

Vision Statement:

"To establish a nationally agreed response to *Varicorbula gibba*, secure coordinated implementation across jurisdictions, and provide guidance on the development of future strategies to reduce impacts and minimise the spread of this pest."

Strategic Overview:

The National System for the Prevention and Management of Marine Pest Incursions (the National System) has been developed to deal with the marine pest problem in Australia. The objectives of the National System are to:

1. Prevent the introduction to Australia of exotic marine species;
2. Prevent the translocation within Australia of exotic marine species;
3. Provide emergency preparedness and response capacity to respond to and where feasible eradicate, outbreaks of exotic marine species; and
4. Manage and control exotic marine species where eradication is not feasible.

The National System has three major components:

1. Prevention: Prevention systems to reduce the risk of introduction and translocation of marine pests (including management arrangements for ballast water and biofouling);
2. Emergency Response: A coordinated emergency response to new incursions and translocations; and
3. Ongoing Management and Control: Managing introduced marine pests already in Australia.

The key initiative under the Ongoing Management and Control component of the National System is the development and implementation of National Control Plans (NCPs) for the following agreed pests of concern:

-Northern Pacific seastar (*Asterias amurensis*);
-European green crab (*Carcinus maenas*);
-Asian date mussel (*Musculista senhousia*);
-European fan worm (*Sabella spallanzanii*);
-Japanese seaweed (*Undaria pinnatifida*); and
-European clam (*Varicorbula gibba*).

Under the National System there is a process for identifying additional species for which development of NCPs may be required in the future. NCPs operate consistently with other elements of the National System, including ballast water management arrangements, biofouling guidelines, emergency management, communications and research and development. This document outlines the NCP for *Varicorbula gibba* (hereafter referred to as *Varicorbula*) and includes:

- practical management actions and cost effective approaches to improve any measures currently in place to prevent, control or manage the impacts of the this species;
- contingency plans for new incursions, linking in with existing emergency arrangements, including those under development;

- creation of links with the National System monitoring strategy and recommendations for monitoring in addition to locations in the National Monitoring Network;
- recommendations for future research and development required to underpin the NCP;
- recommendations for public awareness and education strategies in addition to those planned under the National System; and
- estimated budgets and resource requirements to implement the NCP.

Decision support frameworks (in the form of flow charts and decision trees) have been included in relevant sections of the NCP. The decision support frameworks have been adapted and developed from a previous study that developed similar frameworks for marine pest management[1]. Four decision support frameworks have been developed including: (1) an overarching framework; (2) a pest prevention strategy; (3) a contingency plan for new introductions; and (4) an impact management framework. A monitoring decision support framework was not deemed necessary, since the need for additional monitoring was highlighted in each decision support framework. The decision support frameworks also provide the opportunity to highlight key Research and Development (R&D) issues (discussed in detail in section H) which should improve the decision-making process. It should also be recognised that to be effective in the long-term the NCP should be viewed as a 'living' document that is reviewed and updated on a regular basis so that new information can be incorporated into the NCP. Development of new control technologies, for example, may influence the range of control options available to managers. Furthermore, management priorities may change with increasing knowledge of the spatial extent and impacts of *Varicorbula* within Australian environments.

The overarching decision support framework for *Varicorbula* management is shown in Figure 1. Managers should refer to individual sections of the NCP for further background information to assist the decision-making process.

It should be noted that the purpose of the NCP is to establish a nationally agreed management response to *Varicorbula*, but it is not intended to represent a comprehensive field guide. In some circumstances managers will be required to refer to additional resources under the National System to implement particular sections of the NCP (e.g. biofouling guidelines, emergency response manuals). These additional resources are clearly outlined in the appropriate sections of the NCP and are listed in Appendix I.

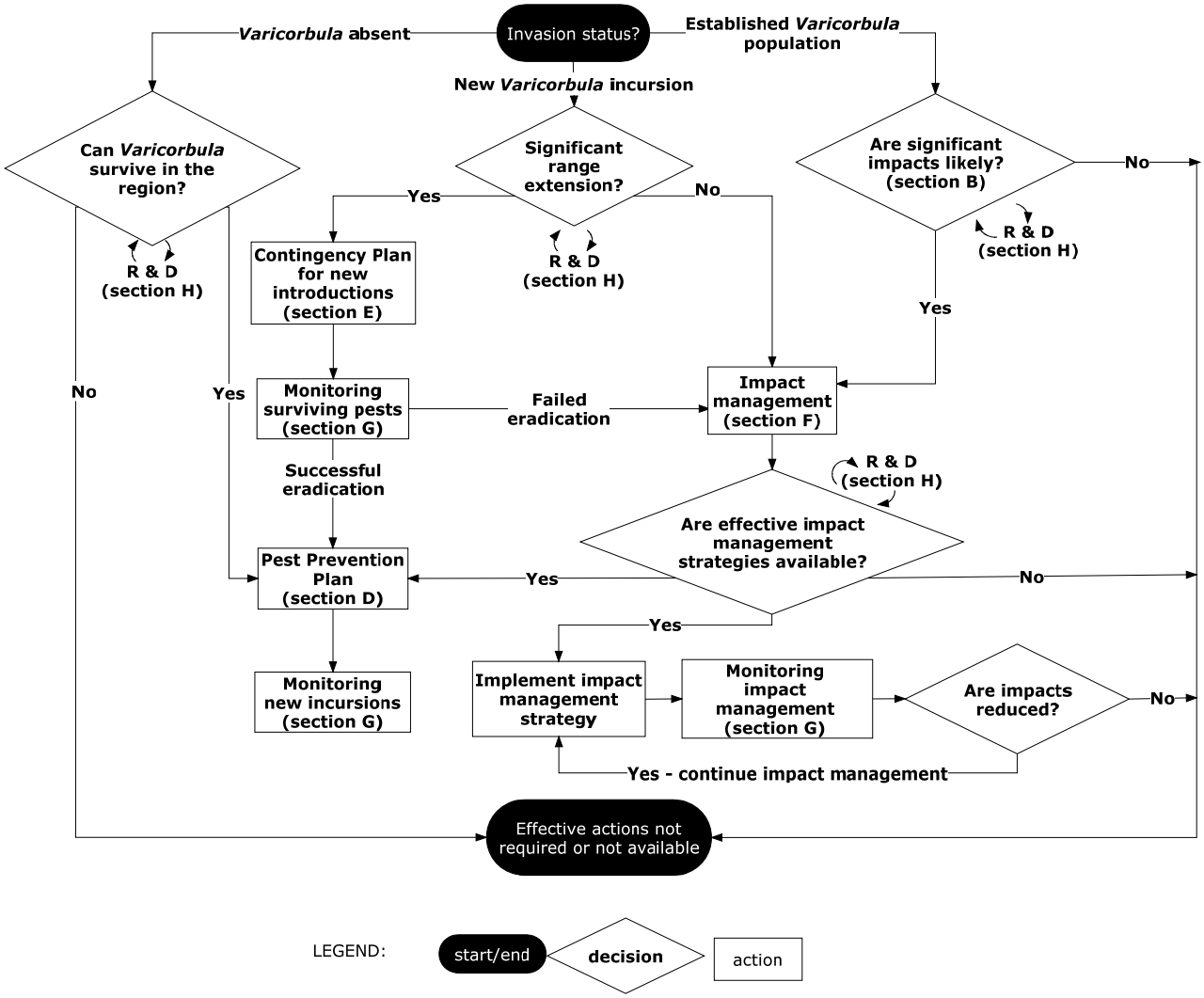

Figure 1. Overarching decision support framework for *Varicorbula* management. There is inherent uncertainty associated with some questions (e.g. Can *Varicorbula* survive in the region?) so decisions must be made on the best available information (e.g. Species range mapping data[2]). Note that if effective impact management strategies are available they will be integral to the "Impact management strategy", but they may also be considered under the "Pest prevention plan" if effective reproductive output and spread can be reduced from source populations.

It is recognised that the number of pests and the likely impacts may vary substantially between jurisdictions so it will be essential to prioritise regional management activity. The purpose of the NCPs is to establish the ongoing control strategies that provide the best options for controlling the spread or impact of these species. It is beyond the scope of the NCPs to consider specific circumstances of each jurisdiction. Each jurisdiction needs to consider the costs and benefits of the proposed actions in relation to their specific circumstances and determine the ongoing control options that are most suitable for their jurisdiction. There are several tools available to assist managers to prioritise species for management purposes, such as the recommendations outlined in the Global Invasive Species Toolkit[3] (section 5.2 "Priorities for management"). As outlined in the Toolkit[3], a number of criteria should be considered when prioritising pest species including: (1) current and potential extent of the species on or near the site; (2) current and potential impacts of the species; (3) value of the habitats/areas that the species infests or may infest; and (4) difficulty of control.

B. Analysis of the level of threat posed by the species to national and regional environmental, social and economic values

This section of the NCP outlines the threat posed by *Varicorbula* to economic, environmental and social values should the species not be controlled. It is based upon an assessment of demonstrable and potential impacts of *Varicorbula* against the relevant CCIMPE criteria[4] (i.e. economy, environment, human health, amenity):

Economy:

Impacts in native and invaded ranges

There are no reported examples of economic impacts caused by *Varicorbula* in its native or invaded range.

Impacts in Australia

Economic impacts attributable to *Varicorbula* have not been documented or reported (refer to NIMPIS[5] for details on *Varicorbula* distribution in Australia). An experimental study in Port Phillip Bay demonstrated a negative impact of *Varicorbula* on growth rates of commercial scallops (*Pecten fumatus*[6]), thought to be caused by competition for food. Whether or not this competition could influence commercial production in the scallop fishery remains the subject of speculation. Commercial scallop fisheries along the southern coastline would potentially be impacted by the presence of *Varicorbula*, however, the strong link between habitat degradation and *Varicorbula* abundance reported elsewhere (see below) suggests that major impacts are unlikely, except where fishing activities focus on degraded or organically enriched habitats.

The presence of *Varicorbula* also has the potential to impact clam and cockle fisheries, such as those targeting *Katelysia* sp. and *Venerupis* sp. in sheltered bays on the east coast of Tasmania (combined average beach value of $AUD 234K per year, based on average earnings 2001-2005[7]).

Environment:

Impacts in native range

In its native range, *Varicorbula* is commonly found in subtidal environments, in coastal and estuarine silts and muddy gravels [8]. In locations where *Varicorbula* is prevalent, it can account for > 80% of the total benthic biomass, and reach densities exceeding 50 000 individuals[9] m^{-2} . By virtue of its sheer abundance, *Varicorbula* would potentially impact other species[8], however, direct environmental impacts are considered minimal because there is strong evidence for a link between habitat degradation and *Varicorbula* abundance [10-14].

Varicorbula is tolerant of a broad range of habitat conditions and can tolerate anthropogenic and natural disturbances, developing dense populations in habitats subject to excessive loads of organic matter[11]. The strength of evidence for the link between degradation and *Varicorbula* abundance is such that the species is regarded as a key bioindicator for benthic communities[15] and is typically considered an indicator of environmental instability caused by pollution, low oxygen content, or increased turbidity. In contrast, in undisturbed, relatively stable soft-bottom communities, the size of the *Varicorbula* populations appears to be limited by the activity of competitors and predators[11].

The ability of *Varicorbula* to thrive in disturbed habitats is thought to be due to a number of life history characteristics. It is tolerant of a wide range of environmental conditions and is particularly well adapted to tolerate anoxic conditions[8]. The ability of *Varicorbula* to close its

shell strongly, combined with physiological adaptations to low oxygen levels, conveys protection against environmental stress. *Varicorbula* is also thought to possess a number of characteristics commonly associated with 'opportunistic' or 'r-selected' species including short lifespan, fast growth, a high reproductive potential and long larval period, allowing it to exploit recently disturbed environments[11].

Recent experimental studies conducted in Sweden[8] concluded that instead of being an insidious pest species, *Varicorbula* is more likely to be an inferior competitor, present in background numbers in normoxic habitats, and only becomes dominant when a system becomes hypoxic, thereby removing competitors and allowing *Varicorbula* to flourish.

Impacts in Australia

Very high densities of *Varicorbula* have been recorded in Port Phillip Bay[16] (up to 2600 m^{-2}). Changes in benthic community structure that have occurred in Port Phillip Bay have been linked to an increase in *Varicorbula* abundance[17]. The well-described link between habitat degradation and *Varicorbula* abundance in its native range has not been thoroughly investigated in Australia, however, in Tasmania *Varicorbula* is typically associated with high organic loading and fine sediments[18]. Interestingly, in recent surveys of Port Phillip Bay (conducted in 2002), *Varicorbula* were rare or absent, despite being the dominant organism in surveys conducted in 1994-95[19]. Such 'boom and bust' cycles are commonly reported in its native range, where massive recruitment events are often followed by recovery of pre-disturbance invertebrate populations and eventual decline of *Varicorbula* abundance[11]. In Tasmania, similar fluctuations in *Varicorbula* abundance have been observed [18].

Human health & Amenity:

There are no reported or anticipated human health issues or public amenity concerns associated with establishment of *Varicorbula* populations.

C. The business case that led to the decision to establish a National Control Plan for the species

The business case that led to the decision to establish a NCP for *Varicorbula* has finalised in 2006[20]. The business case summarises the likely threat and impacts of *Varicorbula* and provides an outline of the likely benefits and costs of implementing the NCPs.

Business case

NIMPCG considers that there is a business case for the development and implementation of a NCP for *Varicorbula*, given that the implementation of the NCP will provide significantly improved coordination and management through nationally agreed responses.

The key information that informed NIMPCG is below:

Actual and potential impacts of Varicorbula

Varicorbula has been assessed by NIMPCG as having significant current and potential future impacts on Australia's marine environment, social uses of the marine environment and the economy. A summary of impacts known from existing infestations, which will occur at new sites if they are invaded, is as follows:

Varicorbula gibba is a fast-growing clam that has wide habitat tolerances and causes loss of aquaculture, recreational and commercial harvest. It dominates and out-competes native species. It is present in four out of 60 Australian marine bioregions (as defined in the Interim Marine and Coastal Bioregionalisation for Australia – IMCRA[21]).

Potential for further introductions and spread of Varicorbula

Varicorbula can be transported in ballast water.

CSIRO has assessed the invasion potential of 53 introduced marine species, on the basis of ballast water volumes discharged into Australian harbours and ports, and the hull surface area of vessels that enter ports (which increases biofouling potential). *Varicorbula* has significant potential to invade additional places in IMCRA bioregions where the species are already present, as well as bioregions that have not yet been invaded.

Varicorbula has the potential to survive and complete its life cycle at places with suitable water depths along the southern Australian coast for at least some part of the year. Many other environmental factors affect the ability of *Varicorbula* to establish pest populations. On the basis of water temperature it has the potential to invade 55 bioregions (currently present in four).

Benefits of National Control Plans

NIMPCG considers that the implementation of a NCP for *Varicorbula* and the associated implementation of ballast water controls, inclusion of the species on the trigger species list under the Emergency management element, and inclusion as a target species for the National Monitoring Network will substantially reduce its spread in the short term.

In the long-term, a research and development program for *Varicorbula* designed to address the strategic needs of the NCP has the potential to provide more effective vector controls and means of addressing existing populations.

Costs of National Control Plans

Control measure	**National System Component**	**Annual Cost**
Operation of Ballast Water Framework	Prevention	$2.91 m
Ballast Water Exchanges and delays to shipping	Prevention	$6.99 m
National Monitoring network	Supporting arrangements	$0.96 m
Emergency management arrangements	Emergency management	$0.17m
Emergency responses - cost shared	Emergency management	Case-by case
Research and development	Supporting arrangements	Case-by case
Total (six species)		[At least]
$10.96m		

Cost-Benefit Analysis

Cost-Benefit analysis for the implementation of NCPs cannot be precise as the losses to production values and the marine environment that would occur in the absence of control measures cannot be estimated. However consultants have estimated that, taking into account only the potential benefits to fisheries and aquaculture at only three sites where each of the species may have impacts, the benefit to cost ratio for a NCP for the six species ranges between 0 and 2.8. For *Varicorbula*, the benefit to cost ratio was 2.8 where eradication of the species was not considered possible and 2.4 where eradication of some incursions was considered possible. When the potential benefits for the marine environment are included, these ratios of benefits to cost will be exceeded.

Consultation

Consultation on the objectives and measures to be contained in NCPs and the business case for the initial six NCPs was conducted through NIMPCG.

D. A Pest Prevention Plan, which will refer to:

-National System ballast water management arrangements, where relevant to the species;

-National System best practice guidelines for management of biofouling; and

-any other prevention strategies that are targeted specifically at the species or should be considered for the future.

Ballast water:

A generalised pest prevention framework outlining the range of pest prevention strategies applicable to *Varicorbula*, including existing arrangements, is shown in Figure 2. Reducing the risk of ballast water-mediated translocation of *Varicorbula* within Australia will be addressed by new ballast water arrangements currently under development. NIMPCG has agreed that ships carrying high risk ballast water on domestic voyages may be required to exchange ballast water at least 12 nm from the Australian coast (with the exception of the Great Barrier Reef and Torres Strait which are still under consideration). It is expected that ballast water exchange in the Australian domestic ballast water arrangements will be consistent with International Maritime Organisation (IMO) regulations. This involves at least 95 % volumetric exchange conducted in water at least 200 m deep. The legislation for the Australian domestic ballast water arrangements is currently in the process of being developed and it is expected to come into affect by July 2009. *Varicorbula* has been nominated as one of the species for which ballast water management between Australian ports will be required.

Biofouling:

Varicorbula may also be considered a translocation risk via biofouling. *Varicorbula* is unlikely to attach directly to artificial structures such as vessel hulls, however, it had previously been found in the sea chest of a commercial ship[22]. Sea chests often contain sediments that have been uplifted when the material is suspended in the water column (e.g. during periods of bad weather) or become entrained when a vessel settles close to or onto the sediment layer in a harbour during low tide[23]. Consequently, niche areas such as sea chests presents significant risk of *Varicorbula* translocation and it is particularly important that protocols outlined in the best practice management guidelines (e.g. for Petroleum industry) are effective in reducing translocation risk. The specific details of best practice management biofouling guidelines for various sectors have not been officially released at the time of writing, but are expected to be finalised in early 2008. Practices that can reduce translocation risk and may be incorporated into guidelines to prevent transfer of *Varicorbula* via sea chests include application of antifouling and regular use of steam blow out pipes[24]. Another possible means of reducing translocation risk lies with improved vessel design that minimises internal niche spaces and facilitates ease of access for in-water and drydock inspection, maintenance and painting.

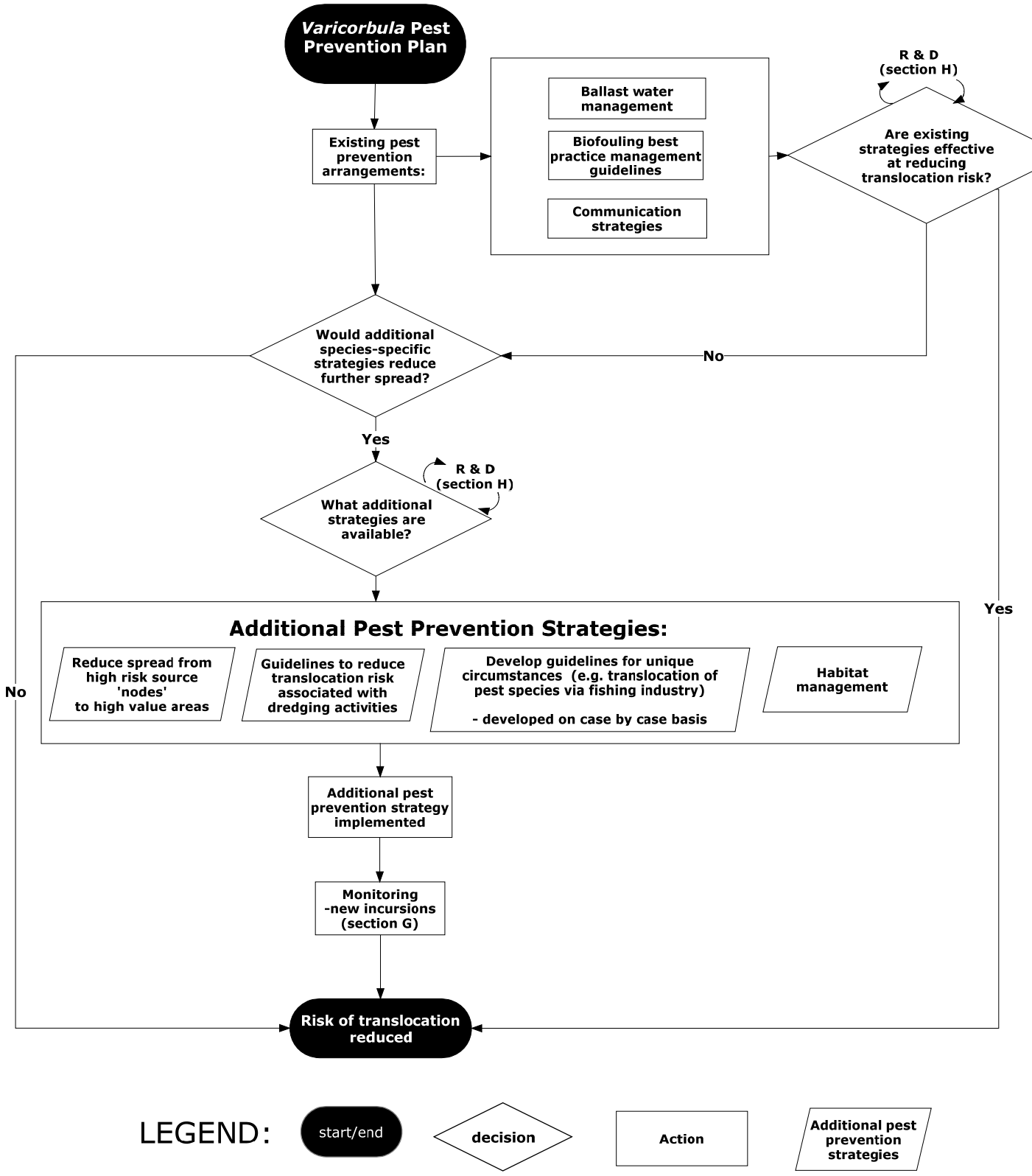

Figure 2. Pest prevention plan and decision support framework applicable to *Varicorbula*.

Additional Pest Prevention Strategies:

- Transfer of *Varicorbula* from high risk nodes (e.g. infested ports, marinas) to high value areas (e.g. MPAs, important aquaculture regions) may warrant additional pest prevention measures. For example, sterilisation of sea chests and internal seawater systems might be recommended immediately prior to departure for vessels travelling to high value areas (e.g. MPAs, important aquaculture regions). Effective public awareness and communication campaigns will be an integral component of this strategy.
- Dredging operations for port maintenance and capital works could serve as a vector for *Varicorbula*. Dredging activity could lead to localised re-distribution of *Varicorbula*, but more importantly, further spread could occur if spoil is lost overboard while en-route to the disposal site. Existing regulations controlling dumping of dredge spoil (e.g. *Sea Dumping Act 1981*[25]) may at least partly reduce the spread via this vector. Dredging activity during ballasting operations could also increase the risk of the uptake of larvae in ballast tanks and it would be preferable if ballasting operations are not carried out whilst dredging is under way. Therefore, guidelines for dredging operators should be considered as an additional strategy to reduce the risk of *Varicorbula* translocation, especially for high risk source 'nodes'.
- Other pest prevention strategies may arise on a case-by-case basis. A good example of an additional pest prevention strategy is the recent development of protocols designed to prevent translocation of *Asterias amurensis* by scallop fishermen on the east coast of Tasmania[26]. Fishermen have been provided with a clear set of guidelines that outline cleaning procedures to prevent translocation between fishing grounds, along with instructions on how to store *A. amurensis* that has been caught in their fishing gear (e.g. non-draining bins). Such guidelines could be directly applicable to prevention of *Varicorbula* spread and would sensibly target commercial fishing activities that involve direct contact with the benthos (e.g. dredging). The importance of rigorous cleaning protocols is arguably more important for small inconspicuous species such as *Varicorbula*, which may escape visual detection more easily compared to more recognisable pests such as *A. amurensis*.
- Given the clear link between organic enrichment of the benthos and *Varicorbula* abundance, an additional pest prevention strategy that may be considered involves habitat management. Where nutrient inputs can be linked to human activity, management strategies that aim to minimise organic enrichment of the sediment should be seen as an indirect method of reducing the likelihood of *Varicorbula* invasion.

E. A contingency plan for responses to new introductions and translocations, including reference to National System emergency management arrangements

A framework for responding to new introductions of *Varicorbula* is provided in Figure 3. The decision on a national response to eradicate new introductions or range extensions of *Varicorbula* is dependent on whether or not a 'significant range extension' has occurred. As defined in the CCIMPE Standard Operating Guidelines[4], a significant range extension is considered to have occurred when the secondary introduction of an exotic marine pest species, that is limited in its known distribution within Australia, is detected that is deemed:

1. *to meet the EMPPlan criteria for a marine pest emergency alert;*
2. *is unlikely to be due to spread by natural means;*

and either:

3(a). *is likely to have considerable direct impacts on the economy, environment, public health, and/or amenity in the affected region;*

or

3(b). *is likely to considerably increase the indirect risk to assets (economic, environmental, public health, and/or amenity) in other regions.*

If a significant range extension has occurred and it is deemed feasible to eradicate the new incursion, an Emergency Eradication Operational Response (EEOR) may be instigated, pending approval of the National Management Group. A detailed breakdown of the EEOR and the procedures to be followed in the case of a marine pest emergency can be found in the Australian Emergency Marine Pest Plan (EMPPlan)[27].

A key component of the EEOR involves implementation of measures to eradicate the pest species from infested sites. Rapid Response Manuals (RRMs) are currently under development (commissioned by the Australian Government Department of Agriculture Fisheries and Forestry (DAFF)) that will specifically deal with eradication options for new marine pest incursions. The National Introduced Marine Pest Information System NIMPIS rapid response toolbox[28] also provides a range of physical, chemical and biological eradication options that should be consulted in the case of a marine pest emergency, while a recent review of currently available technology commissioned by DAFF provides an up-to-date assessment of emergency eradication options including novel treatment methods[29]. Another recently commissioned DAFF study provides tools to estimate the cost involved in emergency eradication or response based on the biology of the pest species and environmental conditions of the infected site[30].

The range of treatment options available for a marine pest emergency involving *Varicorbula* depends on the area of infestation and the environmental circumstances associated with the incursion. As applies to all marine pest emergencies, the most effective way to deal with a new *Varicorbula* incursion is to detect it early and eradicate or contain the population before further spread occurs. For a successful eradication, it is vital that *Varicorbula* is removed before spawning occurs, however, in Australian environments the spawning period remains unknown (see section H). In its native range, *Varicorbula* appears capable of multiple spawning events in a single year[10].

Another important question for managers when responding to new *Varicorbula* translocations is whether or not the introduction is deemed "unlikely to be due to spread by natural means". This necessitates an understanding of the capacity for natural spread, which depends on the

interaction between larval life history and local environment[31]. The capacity for natural dispersal remains poorly known for *Varicorbula*. Some authors estimate larval duration to be greater than three months, whilst others consider it to be less than one month[8]. While it is considered to be capable of long-distance dispersal[11], recent genetic studies showed that *Varicorbula* populations separated by as little five kilometres were genetically distinct, indicative of a dispersal capacity much lower than previously thought[8]. Improved understanding of the potential for natural *Varicorbula* dispersal is clearly required (see section H).

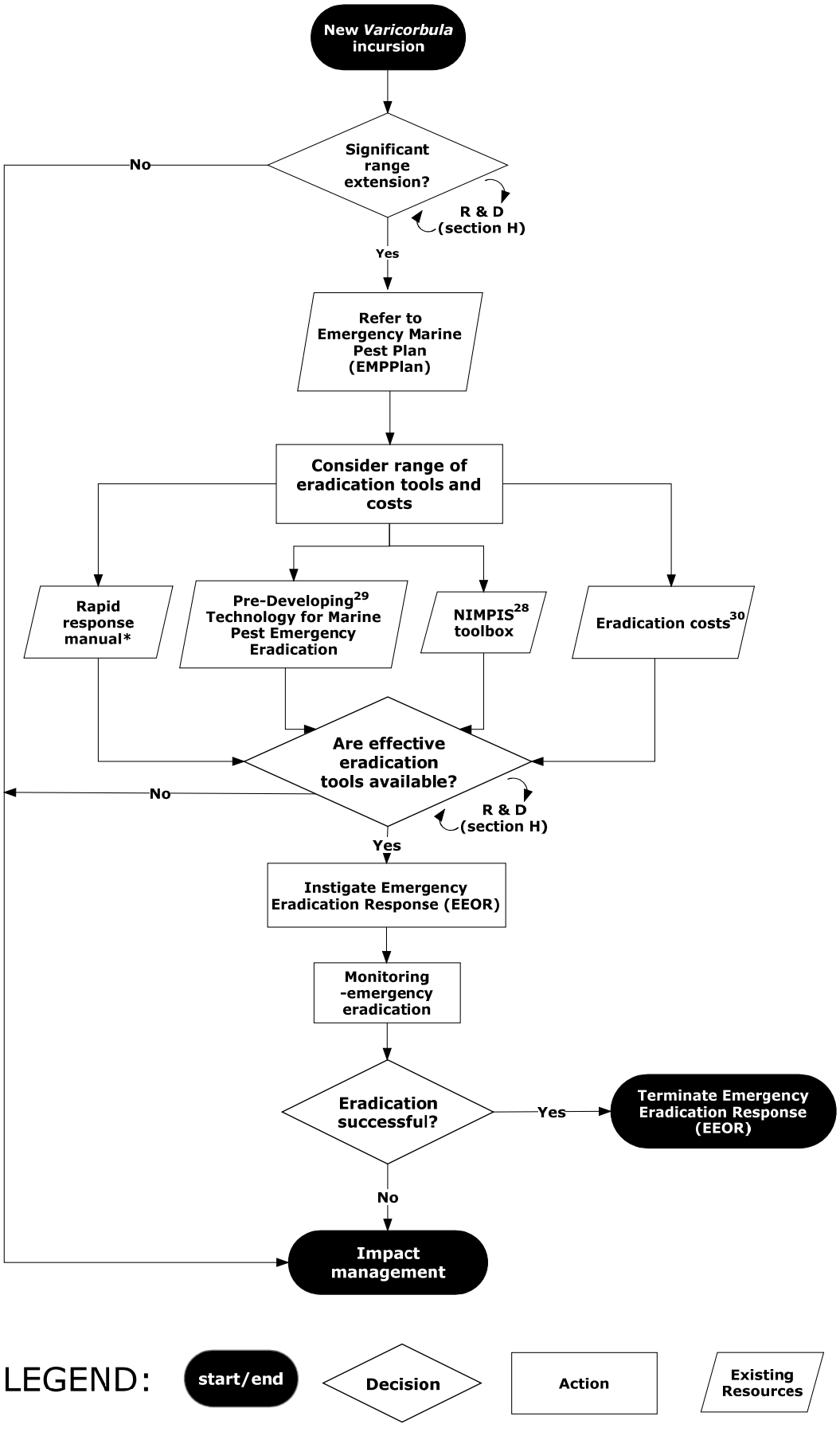

Figure 3. Decision support framework for new introductions of *Varicorbula* highlighting the currently available resources to assist the decision-making process. *Resources currently under development.

F. A plan for species impact management i.e. physical, chemical and biological measures to attack existing populations if feasible; and habitat management

A generalised decision support framework applicable for *Varicorbula* impact management is outlined in Figure 4. Assessing impacts is the first stage in the decision-making process which will be based on likely impacts for most jurisdictions given the current lack of impact data in Australian environments (see section B). The impact of *Varicorbula* in each jurisdiction will depend upon the industries operating within a jurisdiction, the nature of biological communities and habitats present, and other values of the region. Prioritisation for management purposes will also be based on relative impacts and the presence of other pest species within a particular jurisdiction.

Notwithstanding these issues, based on the available information in Australia and overseas, *Varicorbula* impact is likely to be 'low' for both economic and environmental categories in the scheme proposed in Figure 4, based on the analysis of likely impacts detailed in section B. In economic terms, *Varicorbula* does not have recorded impacts in its native range and the potential for economic impacts in Australia are considered low. In relation to environmental impacts, there is strong evidence that *Varicorbula* establishes in high densities in response to habitat degradation (see section B) and does not dominate in undisturbed environments. In Australian environments this has yet to be proven, however, evidence of "boom and bust" cycles[18, 19] suggest that it is also likely to be tracking environmental disturbance and should therefore be considered a low priority for impact management.

If *Varicorbula* impact management should be pursued, it is important to establish clear objectives which can be used to measure the subsequent success of management activities. As part of the decision-making process it is also vital to assess the likely benefits of impact management and the associated costs. To justify investment in on-going management, it is essential that likely benefits exceed management costs. In most circumstances it will not be possible to control all populations, so it will be at the discretion of each jurisdiction to identify high value areas (e.g. MPAs, fisheries, key aquaculture areas) where there is greatest need to reduce impact. In relation to determining environmental values, resources such as 'The Interim Marine and Coastal Regionalisation of Australia (IMCRA)[21]' should be consulted to identify areas of biological significance.

Currently available impact management options:

Impact management options are defined under three broad categories, including: (1) direct targeting of *Varicorbula*; (2) habitat management; and (3) impact mitigation. A summary of the efficacy and feasibility of currently available control options is provided in Table 1. It should be recognised that the various options are not mutually exclusive and multiple methodologies may be incorporated into an integrated management strategy. The range of available impact management options will largely depend on the management objectives. The likely effectiveness and feasibility of impact management will also depend on the spatial extent and density of the target population which will require assessment on a case-by-case basis.

(1) Direct targeting of Varicorbula:

Physical removal

Directly targeting established *Varicorbula* populations presents significant problems for management. This is due to its small size (15-20mm), ability to form high density populations, and its occurrence in deep (> 20 m), soft sediment habitats where diving related control methods are not feasible. Dredging has been proposed as a control measure, however, dredging is likely to

have significant impacts on the broader benthic community and the environmental effects of an ongoing dredging program are not likely to be publicly acceptable. Furthermore, the effectiveness of dredging as an impact management measure is questionable for *Varicorbula*, given the species' ability to successfully colonise disturbed habitats (see section B) and observations of *Varicorbula* booms in Europe following dredging activities[32]. In a study that examined the impacts of dredging in Port Phillip Bay, abundance of *Varicorbula* was lower following dredging, however, eight months later *Varicorbula* abundance was comparable with control areas. Unless ongoing dredging activities are planned there is a strong likelihood that dredging will result in only a of short term reduction in *Varicorbula* populations followed by further recruitment events. One circumstance where dredging might be considered worthwhile is for a small isolated populations located within high risk source nodes. In this case, if the *Varicorbula* population density could be effectively reduced and risk of further spread could potentially be minimised.

Biological control

Biological control has been considered as a management option for other introduced species (e.g. *Carcinus maenas*[33], *Asterias amurensis*[34]), however further research is required before it could be considered a serious control option against *Varicorbula*. Genetic manipulation of pest species is the subject of ongoing research efforts at CSIRO. Modelling studies show that it could be an effective control strategy to reduce or eradicate pest populations[35]. While this technique has great potential (e.g. sonless/daughterless offspring), strong evidence would be required to ensure that the genetic modification remains confined to the pest species. Even if the efficacy of genetic modification could be demonstrated, public concern and legislative restrictions associated with release of genetically manipulated organisms would need to be overcome before it could be applied in a field setting in the marine environment.

Another potential habitat management approach involves enhancement of native predator populations. Native predators are known to be an important factor limiting *Varicorbula* populations in its native range[11] and there is evidence of predation of *Varicorbula* in Australia[17, 36]. If habitat management involving managing nutrient inputs is successfully implemented (see below), native predator populations should re-establish through natural processes, however, enhancement of native predator populations may increase the rate of recovery of native communities.

Chemical control

While a range of chemicals (e.g. molluscicides) have been demonstrated to be toxic against molluscs[28] and are likely to be toxic against *Varicorbula*, they are only likely to come under consideration in circumstances where the population is contained (e.g. marinas). For established *Varicorbula* populations in open systems, chemical application is not a practical impact management option because of the complexities associated with maintaining desired chemical concentrations and concerns associated with their broader impacts on the marine environment. These circumstances apply to most populations observed in Australia.

Wrapping/smothering techniques

A control option that may be considered for localised reduction of *Varicorbula* populations involves smothering the benthos. This method has been used as an eradication tool for introduced sessile invertebrates in New Zealand (e.g. *Didemnum vexillum*, *Styela clava*) and involves smothering artificial structures or natural substrates with plastic[37, 38]. Anoxic conditions that develop beneath the wrap kill fouling organisms and this may be accelerated by addition of chemicals (e.g. chlorine, acetic acid). While the efficacy of wrapping/smothering techniques against *Varicorbula* remains unknown, it is likely that chemical addition would be essential,

given that *Varicorbula* is tolerant of anoxic conditions[39]. The effectiveness of wrapping/smothering techniques is also reliant on obtaining an adequate seal around the treatment area. This can be achieved on artificial structures with relative ease, however, obtaining an adequate seal on natural substrates (where *Varicorbula* occurs) is more difficult, potentially compromising treatment success.

Smothering may be a feasible control option to reduce reproductive output from small *Varicorbula* populations associated with high risk source nodes (e.g. small port), but for large commercial sized ports it would be a major on-going expense and is not likely to be a practical option. As is the case with dredging, the treatment provides substrate for further recruitment of opportunistic species (including *Varicorbula*) and it is likely that on-going treatments would be required. A further limitation is that the smothering process is also likely to kill a range of other organisms.

(2) Habitat management:
Habitat management is currently considered the most feasible impact management strategy for *Varicorbula*. While the link between habitat degradation and *Varicorbula* abundance requires further investigation in Australian environments, it appears to occupy similar habitats as in Europe[11]. Furthermore, its occurrence in areas subject to significant anthropogenic activity (e.g. Port Phillip Bay) and association with organically enriched sediments[18] suggest that it is associated with habitat degradation in Australian environments.

Management of anthropogenic sources of nutrients into the coastal zone is a potential strategy that may indirectly control *Varicorbula* population density. This may include management of point-source (e.g. industrial waste, sewage) and diffuse pollution sources associated with land-based activities (e.g. agriculture, urbanisation), as well as organic enrichment of the benthos resulting from aquaculture operations.

While impact management has not been implemented in its native range, improvement in habitat quality typically leads to recovery of stable benthic communities[11]. Consequently, habitat management that leads to improvement in habitat quality should lead to gradual replacement of *Varicorbula* populations with native predators and competitors[11].

Determining whether the benefits of habitat management for *Varicorbula* exceed costs is an important question when considering whether to proceed with management action (Figure 4). When *Varicorbula* impacts are considered in isolation, likely benefits may not exceed management costs and consequently management action would not be recommended (Figure 4). It is more likely that a broader strategy that aims to reduce nutrient loads and improve ecosystem health in general will have the additional benefit of reducing population density of marine pests such as *Varicorbula*.

(3) Impact mitigation:
Currently available evidence suggests that impacts are low and as a consequence, impact mitigation is not considered necessary.

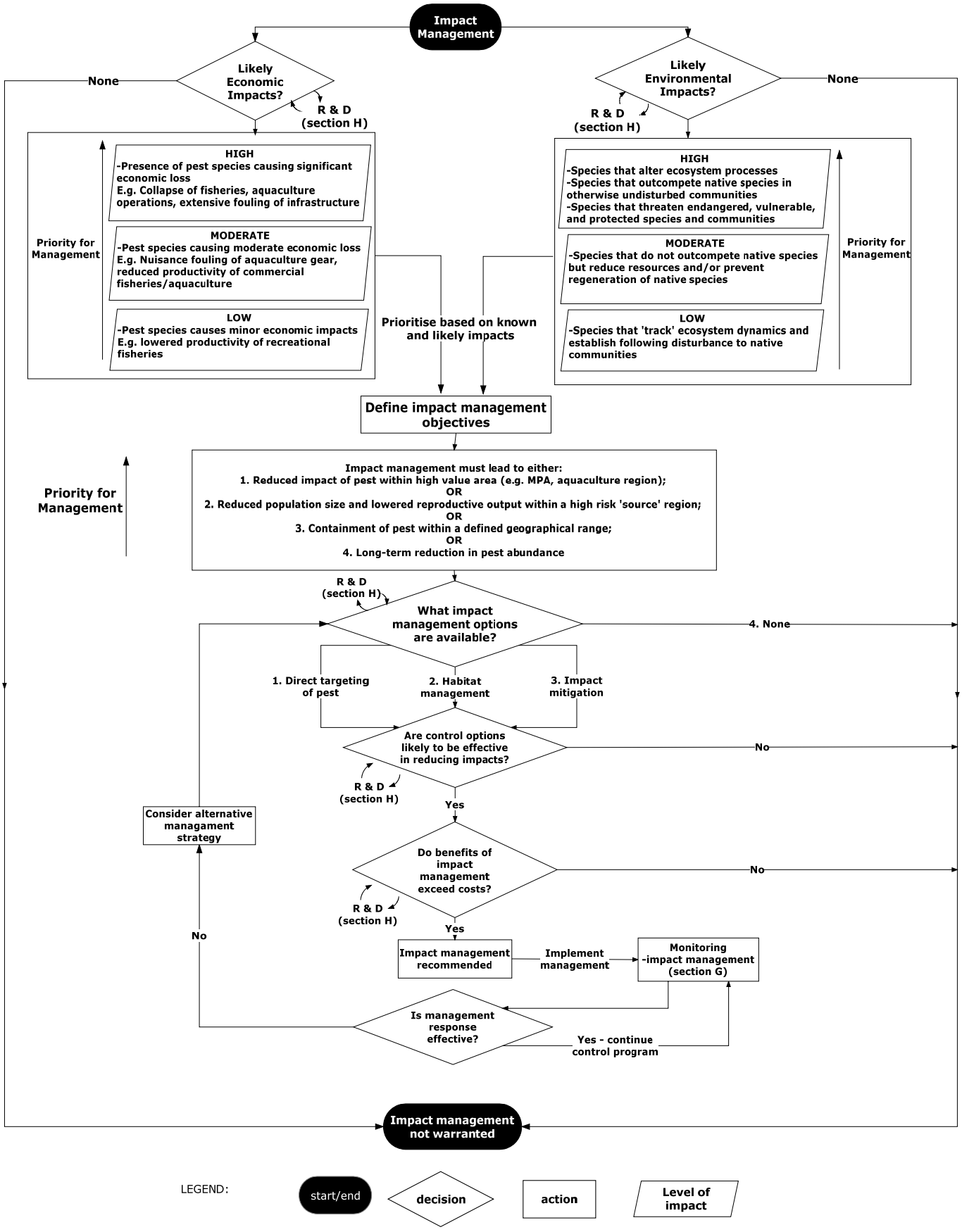

Figure 4. **Impact management decision support framework applicable to *Varicorbula*.**

Table 1. **Currently available impact management options considered suitable for *Varicorbula*. (Note that potential control options such as genetic control that are under development or are considered environmentally unacceptable are not included).**

Method	Likely Efficacy	Feasibility	Environmental/public concerns
1.Directly targeting *Varicorbula*			
Dredging	Potentially effective for localised reduction of *Varicorbula*. On-going efforts would be required, since *Varicorbula* is likely to recruit following dredging activities.	Feasible but ongoing efforts would be required, necessitating significant expenditure.	Significant impacts on non-target species. Opportunistic species likely to recruit following dredging.
Smothering of sediment	Efficacy .remains unknown, but likely to be effective when combined with chemical application, provided that an adequate seal can be achieved around the treatment area.	Only feasible for small – moderate spatial scales*. Chemicals will be required to accelerate mortality. Labour intensive method.	Environmental concerns associated with chemical usage. Likely to result in mortality of non-target organisms.
Biocontrol *-enhancement of native predators*	Requires understanding of native predators of *Varicorbula*. Likely efficacy remains unknown.	Practical application remains unknown.	May need to consider effects of predator on native species.
2. Habitat management			
Manage disturbances that influence competitors of Varicorbula (e.g. reduce nutrient inputs)	If integrity of native communities can be maintained or rehabilitated, may be effective in preventing spread and reducing abundance of *Varicorbula*.	May be feasible depending on disturbances involved and links with anthropogenic activity.	Minimal environmental concerns.

*Small spatial scale = < 1000 m^2; moderate spatial scale = 1000 – 10 000 m^2; large spatial scale = > 10 000 m^2.

Overall recommendations:

- It should be recognised that for many jurisdictions, application of the proposed decision support framework (Figure 4) is not likely to recommend management action(s) proceed to control *Varicorbula*.
- With currently available technology, control options involving direct targeting of *Varicorbula* populations are extremely limited. Direct targeting of *Varicorbula* populations by dredging or smothering is only worth consideration in circumstances involving small, isolated populations associated with high risk source nodes.
- The only potentially effective and publicly acceptable control method currently available for *Varicorbula* involves habitat management. Based on the limited impacts of *Varicorbula*, habitat management may not be justifiable in isolation due to the considerable costs involved. However, any broader strategy that aims to improve ecosystem health is likely to subsequently reduce abundance of *Varicorbula*.

G. A monitoring strategy for the species, including the National System Monitoring Network and Monitoring Guidelines

Monitoring of *Varicorbula* is included in the National Monitoring Network (NMN), which is comprised of 18 locations across Australia[40]. Guidelines for monitoring *Varicorbula* within the NMN are included in the Marine Pest Monitoring Manual[41]. The primary objectives of the network are: (1) to detect new incursions of established target species at a given location i.e. species already established elsewhere in Australia but not recorded at that location; and (2) to detect target species not previously recorded in Australia that are known to be pests elsewhere.

Additional Monitoring:

The requirements for additional monitoring will be governed by the status of the pest within a particular jurisdiction and the components of the NCP that are relevant at the time. The preceding decision support frameworks (Figures 1-4) can be used to determine whether additional monitoring is required. Additional monitoring to be considered for the *Varicorbula* NCP (summarised in Table 1) comprises three broad categories:

1. *Pest Prevention*

Additional monitoring sites should be considered by local jurisdictions on a case-by-case basis, considering transport pathways not addressed in the NMN (e.g. commercial vessels, transfer of aquaculture gear). When considering additional monitoring sites, priority should be given to sites in high value areas, particularly if strategies are in place to prevent translocation of *Varicorbula* from a high risk source node to these high value areas.

2. *Contingency Plan for new introductions*

Monitoring new incursions will involve surveys that determine the spatial extent of the new incursion, including monitoring of suitable habitats in areas adjacent to the known population of *Varicorbula*. If an eradication attempt is initiated, monitoring will form a core component of the eradication program. Monitoring will involve quantifying *Varicorbula* abundance and is likely to be required on an ongoing basis to ensure eradication success.

3. *Impact management*

If an impact management strategy is implemented, a range of monitoring strategies should be considered depending on the management objectives (see Figure 4). If the objective of the control strategy is to reduce abundance of *Varicorbula* within a high risk source 'node', for example, estimating the abundance of *Varicorbula* should form a core component of the monitoring strategy. Where possible, incorporating 'treatment' and 'control' areas is recommended so the effectiveness of management activities can be critically evaluated. Monitoring the rate of spread of *Varicorbula* should also be considered within the 'Impact Management' category because the spatial extent of the pest is an important component of overall impact. It is also important when determining whether or not a significant range extension has occurred and consequently, whether or not an eradication attempt should proceed.

Incorporating results from other monitoring programs into NIMPIS[5]:

In many states, results from industry-based surveys may be appropriate for monitoring *Varicorbula* abundance and this could be incorporated into NIMPIS. For example, aquaculture operations may monitor marine pests and in some jurisdictions this is a legislative requirement. In Tasmania one of the conditions of a marine farming licence is that: "The licence holder must notify the Department of Primary Industries and Water of the presence of any introduced marine pests within the lease area". Similarly, in Victorian waters, aquaculture licence holders operating

in marine waters are required to report the presence of suspected new incursions of exotic marine organisms at the specified site to the Secretary (or delegate), Department of Sustainability and Environment, within 24 hours of detection. Given the significant costs involved with monitoring programs, in circumstances where the surveys are appropriate for *Varicorbula* it would be of considerable benefit if a mechanism was in place to incorporate this data into NIMPIS. The information supplied not only provides potential information on distribution and abundance of *Varicorbula*, but may also provide observations in relation to impacts. Where possible, state jurisdictions should engage industry to ensure collection of *Varicorbula* data that will be of most benefit to management agencies. Providing quality information requires goodwill on the part of industry. Consequently it is very important that industry participants understand the value of the information they collect and are provided with adequate feedback to encourage continued cooperation.

Another potential data source lies with relevant government authorities. Approval of developments in the coastal zone may include surveys of soft sediment habitats as part of environmental impact assessments. Information collected as part of these surveys could be relevant to *Varicorbula* and it is recommended that results from these surveys should also be incorporated into NIMPIS. Incorporating such data into NIMPIS may at least partly alleviate the need to carry out additional monitoring that may be recommended in the control plan and could represent a considerable cost saving. It would also be invaluable if NIMPIS includes results associated with control/eradication attempts. An efficient mechanism of extracting the relevant industry data compiled by state and territory governments and inputting it into NIMPIS is needed.

While results from other monitoring programs are a potentially valuable resource, it should be noted that such data must meet minimum quality assurance standards before it is incorporated into NIMPIS. Alternatively, its use in a decision-making framework should be guided by an assessment of data quality.

Table 2. **Additional monitoring strategies that may be required for *Varicorbula*.**

NCP Section & Monitoring objectives	Additional monitoring locations	Nature of data
1. Pest Prevention		
- To detect new incursions	Select additional sites based on transport pathways and environmental conditions at recipient locations	Presence/absence
- To detect new incursions in high value areas	Selected high value areas (e.g. aquaculture areas, Marine Protected Areas)	Presence/absence
2. Contingency Plan for new introductions		
- To determine spatial extent of new incursion and whether additional populations exist	Site of infestation along with adjacent suitable habitats	Presence/absence
- To assess the effectiveness of eradication attempts	Eradication site(s)	Abundance
3. Impact Management		
- To assess effectiveness of impact management strategies	Monitor in locations with/without impact management strategies.	Abundance
- To monitor the rate of spread	Various locations to establish the range of *Varicorbula*	Presence/absence

H. A research and development strategy to improve vector controls, techniques for control and eradication of existing populations and detection and monitoring

A National strategy (2006-2016) for marine pest Research & Development has been completed[42] and includes a variety of research areas that should contribute to improved management of marine pests (including *Varicorbula*) within Australia. The purpose of the R&D outlined in the *Varicorbula* NCP is to highlight key R&D areas that will specifically enhance the performance of the plan, rather than presenting a comprehensive list of potential research areas. Most of the key R&D areas (summarised in Table 2) have been highlighted previously in the relevant decision support frameworks (Figures 1-4). In the long-term, the proposed R&D will reduce uncertainty associated with the decision-making process and lead to more efficient investment of resources. Table 2 also includes a scheme for prioritising the proposed R&D based upon the importance of the research area to the NCP, its cost effectiveness and feasibility. It must be emphasised that the R&D areas and their relative priority is likely to change through time, so it is vital that a flexible approach is maintained. For example, the proposed R&D strategy does not include mitigation strategies for fishing or aquaculture industries because impacts are currently considered minimal. If economic impacts are identified in the future, R&D investment investigating mitigation of impacts may be warranted.

A brief justification of the inclusion of the proposed R&D areas is provided for the relevant sections of the *Varicorbula* NCP:

Pest Prevention

Understanding the effectiveness of existing management arrangements is an important component of the R&D strategy, since the requirement for additional pest prevention measures will be largely determined by the success of these strategies. Given the potential importance of sea chests as a translocation vector for *Varicorbula*, it is particularly important that an assessment of the likely efficacy of the national system best practice management guidelines for biofouling be conducted. (Table 2; PP1). To enhance the efficiency of the ballast water decision system (DSS) that underpins ballast water management, improved understanding of life-stage specific data is required for *Varicorbula*, particularly in relation to larval duration and temperature tolerance (Table 2; PP2). These variables play an important role in determining whether a vessel will become infected with *Varicorbula* during ballast uptake, and whether or not it will complete its life-cycle in a recipient port. In the absence of this data, a conservative approach is currently being adopted leading to risk overestimates[43].

Contingency Plan for new introductions

While a range of resources are available to managers to assist in dealing with new introductions, publicly acceptable methods generally have a low probability of success against established pests[44]. Development of innovative tools to eradicate and/or control *Varicorbula* populations should therefore be an on-going research priority, despite the technical challenges associated with eradicating a mobile species in an open marine environment (Table 2; CP1). Understanding the capacity for natural *Varicorbula* spread is another key research question that has significant implications for managers (Table 2; CP2). Addressing this question will provide an indication of the likely spatial extent of impact and is also of critical importance when deciding whether or not an emergency eradication response should proceed. An understanding of the reproductive ecology of *Varicorbula* in Australian environments is also considered to be a priority research area (Table 2; CP3). This knowledge should benefit the decision-making process involved in emergency response plans, since it is important that eradication attempts are undertaken before *Varicorbula* spawning occurs. Improved understanding of the reproductive ecology of

Varicorbula will also inform potential actions outlined in the pest prevention and impact management sections of the NCP.

Impact management

Understanding the invasion process, particularly the importance of human-mediated disturbance, is a fundamental stage in assessing impact and prioritising management activities (Table 2; IM1). If *Varicorbula* requires disturbance to invade, it is less threatening to the integrity of natural communities than if it is capable of invading undisturbed habitats (see Figure 4). In its native range disturbance appears to play a key role in the ecology of *Varicorbula* populations (see section B). If disturbance plays a similar role in the invasion process in Australia, the threat posed by *Varicorbula* would be considered minimal in which case management funds would be best allocated to more threatening species or processes. It is also important to understand whether continued disturbance is required for persistence of *Varicorbula* populations, or alternatively, whether *Varicorbula* can persist in the absence of the primary disturbance factor. Understanding the role of native predators in conferring resistance to invasion is also recommended as a key research area that may lead to an increased range of control options (Table 2; IM1).

Table 3. Summary of R&D strategy including a relative ranking system for prioritising research efforts. Scores for a range of assessment categories were summed to provide the overall priority score and allow a relative priority ranking to be assigned to each R&D area. Scores 0 = low, 5 = high, for assessment categories and relative priority ranking. Where appropriate, the relevant decision support framework figures are referenced to demonstrate how the proposed R&D areas will aid the decision-making process. Estimated indicative costs to complete each R&D section are also provided under the 'cost effectiveness' category. Since it is not possible to quantify benefits of each R&D area, cost effectiveness cannot be determined in quantitative terms. Instead, research areas requiring less expenditure have been prioritised at a higher level to reflect the likelihood that research funding will be limited.

NCP section	R&D area *(Relevant decision support framework)*	Relative importance to NCP	Cost effectiveness (indicative costs $'000)	Technical Feasibility	Priority score	Relative priority
Pest Prevention	PP1. How effective will best practice guidelines for biofouling be in reducing *Varicorbula* translocation risk associated with sea chests? *(Figure 2)*	4	4 (75)	3	11	**4**
	PP2. Improved understanding of life-stage specific data *(Figure 2)*	4	4 (75)	4	12	**5**
Contingency Plan for new introductions	CP1. Development and testing of novel eradication/control tools *(Figure 2)*	5	2 (200)	1	8	**2**
	CP2. What is the likely capacity for natural *Varicorbula* spread? *(Figures 1, 3)*	5	3 (100)	2	10	**3**
	CP3. Improved understanding of *Varicorbula* reproductive ecology? *(Figures 2, 3, 4)*	5	3 (100)	4	12	**5**
Impact management	IM1. Improved understanding of invasion process, including the role of disturbance in establishment and maintenance of *Varicorbula* populations and the role of native predators in conferring invasion resistance? (*Figure 4*)	5	1 (300)	4	10	**3**

I. Public awareness and education strategies for the species

The Communications and Awareness Strategy for the National System is currently under development. While the activities planned are not species-specific, their implementation should generally be effective in meeting a number of the objectives of the *Varicorbula* NCP. For example, public awareness and education strategies aimed at reducing the spread of marine pests through management of biofouling will be applicable to *Varicorbula*. Additional strategies which should be considered to enhance the effectiveness of the *Varicorbula* NCP include:

Additional strategies – Pest prevention

Additional public awareness strategies may include targeted public awareness campaigns directed at high risk nodes where *Varicorbula* is already established (e.g. ports, marinas) to reduce the risk of further translocation events. The proximity of transport vectors to high value locations such as aquaculture areas, important fisheries habitats and conservation areas may also warrant additional targeted public awareness strategies at the local level. Of the potential transport vectors, fishing (particularly scallop fishing) and dredging activities probably represent the greatest risk for translocation of *Varicorbula*. If additional public awareness strategies are developed, it is vital that stakeholders from these sectors are targeted.

Additional strategies – Contingency plan for new introductions

Early detection of new incursions is a critical factor in the success of eradication programs and the public can play a key role in this regard. Detection of new *Varicorbula* incursions is reliant upon an understanding of current distribution patterns and whether or not a 'significant range extension' has occurred. This is a complex issue when considering public awareness, for two main reasons. Firstly, spatial extent and spread is subject to change so public awareness strategies need to reflect this dynamic situation. Secondly, an improved understanding of likely natural spread is required to determine whether a 'significant range extension' has occurred. As outlined previously, scientists and managers need to clearly define what constitutes a 'significant range extension' for *Varicorbula* so the public can be properly educated/informed.

Due to the potentially dynamic nature of the spread and spatial extent of *Varicorbula*, monitoring results will be incorporated into a new web-based system (i.e. via NIMPIS), including locations that would be considered a 'significant range extension'. Clearly for this to be effective, the marine pest monitoring database under the National System must include the most up-to-date information available.

With regard to new *Varicorbula* incursions, public awareness strategies in relation to emergency response are covered in the Australian Emergency Marine Pest Plan[27] (EMPPlan).

Additional strategies – Impact management

Additional public awareness and education strategies will require development on a case-by-case basis depending on the jurisdiction and impact management activities that are implemented. Information to be disseminated should highlight the threat posed by *Varicorbula*, the control approach (e.g. dredging) and the likely benefits of impact management (e.g. biodiversity, commercial activities).

J. Agreed funding mechanisms

The Intergovernmental Agreement (IGA) on a National System for the Prevention and Management of Marine Pest Incursions addresses the agreed funding mechanisms for implementing National Control Plans. In particular, Section 24.1 states that:

'The Parties agree that funding for the ongoing management and control measures of the National System will need to be provided by the Parties in accordance with the shared and co-operative measures agreed through National Control Plans on a case by case basis. That Parties acknowledge that, where relevant, Partnership Agreements should be developed to provide funding support for ongoing management and control measures based on the level of benefit of the arrangement to stakeholders and government.'

Within the IGA a "Partnership Agreement means the agreement by that name (including any attachments or annexes to that agreement) between a stakeholder organisation and governments with respect to implementing and/or funding the National System".

K. A multi-year budget

Providing accurate budget estimates is problematic because costs will depend on the management actions that are conducted by the relevant jurisdictions. There are also significant uncertainties associated with budget estimates for each section of the NCP. For example, costs associated with monitoring will depend on the need for additional monitoring sites and whether or not impact management activities required.

Despite the uncertainties associated with provision of budgets, indicative costs for management activity within the relevant NCP sections have been provided in Table 3. These are intended as a rough guide for managers to assess the cost of implementing the various management activities outlined in the plan. A case study for impact management has been included in the budget based on control of a small *Varicorbula* population. A dredging program is proposed as an example because it is considered the only potentially effective option for direct control of *Varicorbula* populations, despite the significant limitations that are associated with dredging activities (see section F).

The costs involved in habitat management were not included in the indicative budget for a number of reasons. Firstly, there is a significant level of uncertainty associated with cost estimates for managing pollutants because pollution sources (e.g. industrial waste, urban pollution, agriculture) and the ability to manage them depend on the jurisdiction concerned. Secondly, including habitat management within a *Varicorbula* budget is not considered appropriate, because it is unlikely that habitat management would be the carried out for the sole purpose of controlling *Varicorbula* populations (as discussed in section F).

Note that salary for a project officer at a nominal level of 0.5 FTE has been included to coordinate management activities outlined in the plan. It is envisaged that a full time position would incorporate management of other marine pest species at a national level – allocation of effort for each particular species would be based on the funding made available for each species.

Table 4. Indicative budget for *Varicorbula* National Control Plan (as at January 2008).

NCP section	Budget items	Likely Costs ($AUD)	Funding arrangements/ expected financier
Pest prevention	No applicable budget items	NA	**NA**
Contingency plan for new introductions	Eradication of new incursion (including on-going monitoring)	$860 000 – 263 million per incursion[2]	Interim cost-sharing arrangements are in place
Impact management	Case study example. Dredging program to control small *Varicorbula* population within high risk source region[a].	$90 000 per year	State/territory governments
	Habitat management (e.g. manage anthropogenic inputs, enhance native predator populations)	Uncertain	State/territory governments
Monitoring	Additional monitoring sites to detect new incursions. -Requirement for additional monitoring sites will depend on jurisdiction and vectors operating.	$10 000- $20 000[b] per site per year	State/territory governments
	Monitoring to evaluate impact management strategy e.g. Quarterly sampling of control and impact bays[c]. Field staff ($8000[d]), Data analysis and write-up ($30 000[e]) Car hire ($800[f]), Boat hire ($4000[g]) Consumables ($500[h]).	$40 100 per year	To be advised
	Monitoring rate of spread	$10 000 per year	To be advised
R&D	Various R&D areas (see Table 2)	$750 000[i] over 3 years	Commonwealth
Communications strategy	Depends on the impact management measures implemented	Uncertain	
Overall co-ordination	Salary for project officer (0.5 FTE)	$50 000 per year	To be advised

[a] Based on hire of vessel, dredge and crew @ $2500/day; proposed dredging frequency = 3 days/ month. [b] Cost effectiveness could be improved by surveying multiple pest species; [c] Based on 4 sites, 'impact' site and three control sites, 2 sites surveyed/day, total of 8 surveys; [d] Field biologists cost $500/day, 2 biologists/survey [e] Car hire $100/day. [f] Research vessel cost $500/day. [g] Data analysis and write-up by suitably qualified scientist; [h] Consumables including waterproof paper, slates, stationary; [i] Assumes all priority R&D areas are addressed; NA = not applicable.

L. A mechanism for monitoring of implementation of the National Control Plan and ongoing evaluation

An important component of the NCP involves monitoring implementation of the plan and critical evaluation of its effectiveness. Proposed performance indicators have been identified and these are provided in Table 4.

Table 5. Potential performance indicators for the *Varicorbula* National Control Plan. Note that monitoring was not included as a criterion in its own right because the proposed performance indicators are inextricably linked to monitoring (e.g. Pest prevention - number of new populations; Emergency response - detection of new invasions; Impact Management – change in abundance over time).

Criteria	Objectives	Performance Indicators
Pest prevention	(i) Prevent significant range extensions	Number of significant range extensions
	(ii) Prevent new populations establishing within current range of natural spread	Number of new self sustaining populations minimised, especially in high value areas
	(iii) Reduce translocation risk by improved vector management	Uptake of existing or proposed guidelines
	(iv) Development of additional strategies as required	Number of additional pest prevention measures developed
Contingency plan for new introductions	(i) Detect new invasions early enough to enable rapid response	Proportion of invasions detected in time for rapid response
	(ii) Eradication of new incursions	Eradication of new populations prior to spawning
	(iii) Increase range of effective eradication techniques	Number of effective eradication tools evaluated and available
Impact management	(i) Prioritise *Varicorbula* impact management relative to other threats	*Varicorbula* impact management prioritised based on known and likely impacts
	(ii) Reduce impacts in high value areas	Detectable reduction in impacts
	(iii) Reduced population size & lowered reproductive output within high risk source regions	Detectable reduction in reproductive output in high risk source regions
	(iv) Long-term reduction in *Varicorbula* abundance	Decrease in abundance over time (e.g. 10 years)
R&D	(i) Implement priority R&D areas highlighted in plan	Number of priority R&D areas completed
	(ii) Re-evaluate R&D in response to research outcomes	Regular assessment and prioritisation of R&D activities
Public education	(i) Increased public awareness	Increased community knowledge of risk, impact & prevention/control measures
	(ii) Increase effective community involvement	Increased community involvement in detection and impact management activities; Increase in proportion of informative reports (e.g. correct ID's)

M. Stated commitments of relevant parties, including Australian Government, State/Territory governments, local government, industry and NGOs

The Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions (IGA) addresses the stated commitments of the Australian Government and the State and Northern Territory Governments in implementing the National Control Plans. In particular, Section 16a-16c states that:

The Parties will implement the ongoing management and control component of the National System as follows:

(a) each Party accepts responsibility for ongoing management and control activities for agreed pests of concern within waters under its control;

(b) National Control Plans, reflecting an agreed national response, will be developed to reduce, eliminate or prevent the impacts (including translocation) of agreed pests of concern; and

(c) each Party will use reasonable endeavours to develop and implement the relevant National Control Plans.

(Currently, all States and the Northern Territory, with the exception of NSW, have signed the IGA. NSW have, however, agreed to intent of the IGA and are only concerned about the funding model in regards to a marine pest outbreak. This situation may change in the future.)

Agreements to implement a control plan by a jurisdiction may involve consultation and cooperation with other relevant jurisdictions (i.e., other State and Territory Governments) and with relevant local government, industry and the non-government organisations. These arrangements will depend on the nature of the particular control operation and will vary between operations.

Agreed Control Plan actions by the Australian Government, State and Territory Governments and stakeholder agencies will be identified as part of a National Implementation Strategy. The National Implementation Strategy document will be maintained independently of the National Control Plan documents, and updated to reflect current and proposed commitments.

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APPENDIX I – List of available resources to assist with implementation of NCP

Pest Prevention

- Australian domestic ballast water arrangements (under development)
- Biofouling Guidelines (guidelines for many sectors still under development)
  - National Biofouling Management Guidelines for Non-trading Vessels
  - National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry
  - National Best Practice Management Biofouling Guidelines for the Aquaculture Industry
  - Best Practice Guidelines for Domestic Commercial Fishing Vessels
  - National Best Practice Management Guidelines for the Prevention of Biofouling on Commercial Vessels
  - National Biofouling Management Guidelines for Domestic Recreational Vessels
  - National Best Management Practice Biofouling Guidelines for Nodes- Commercial Trading Ports
  - National Best Management Practice Guidelines for Abandoned, Unseaworthy and Poorly Maintained Vessels
  - National Best Practice Management Biofouling Guidelines for Nodes- Boat Harbours, Marinas and Boat Maintenance Facilities

Contingency Plan for New Introductions

- National Introduced Marine Pest Information System[5] http://crimp.marine.csiro.au/nimpis.
- The Web-Based Rapid Response Toolbox[28] http://crimp.marine.csiro.au/NIMPIS/controls.htm
- Pre-Developing Technology for Marine Pest Emergency Eradication Response[29] (in review)
- Rapid Response Manual – Generic (under development)
- Australian Emergency Marine Pest Plan[27] (EMPPlan)
- National System Marine Pest Identification Card – *Varicorbula gibba* (under development)

Monitoring

- Australian Marine Pest Monitoring Guidelines: Version 1 (December 2006)[40]
- Marine Pest Monitoring Manual: Version 1 (December 2006)[41]