An Australian Government Initiative

NATIONAL CONTROL PLAN

European fan worm
Sabella spallanzanii

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 fan worm *Sabella spallanzanii*

Prepared for the Australian Government
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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 fan worm *Sabella spallanzanii*.

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LIST OF ACRONYMS

CCIMPE	Consultative Committee on Introduced Marine Pest Emergencies
CRIMP	Centre for Research on Introduced Marine Pests
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 *Sabella spallanzanii*, 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.
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.
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 *Sabella spallanzanii* (hereafter referred to as *Sabella*) 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.
- 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 is highlighted in each decision support framework. The decision support frameworks and also provides 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 *Sabella* within Australian environments.

The overarching decision support framework for *Sabella* 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 *Sabella*, 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.

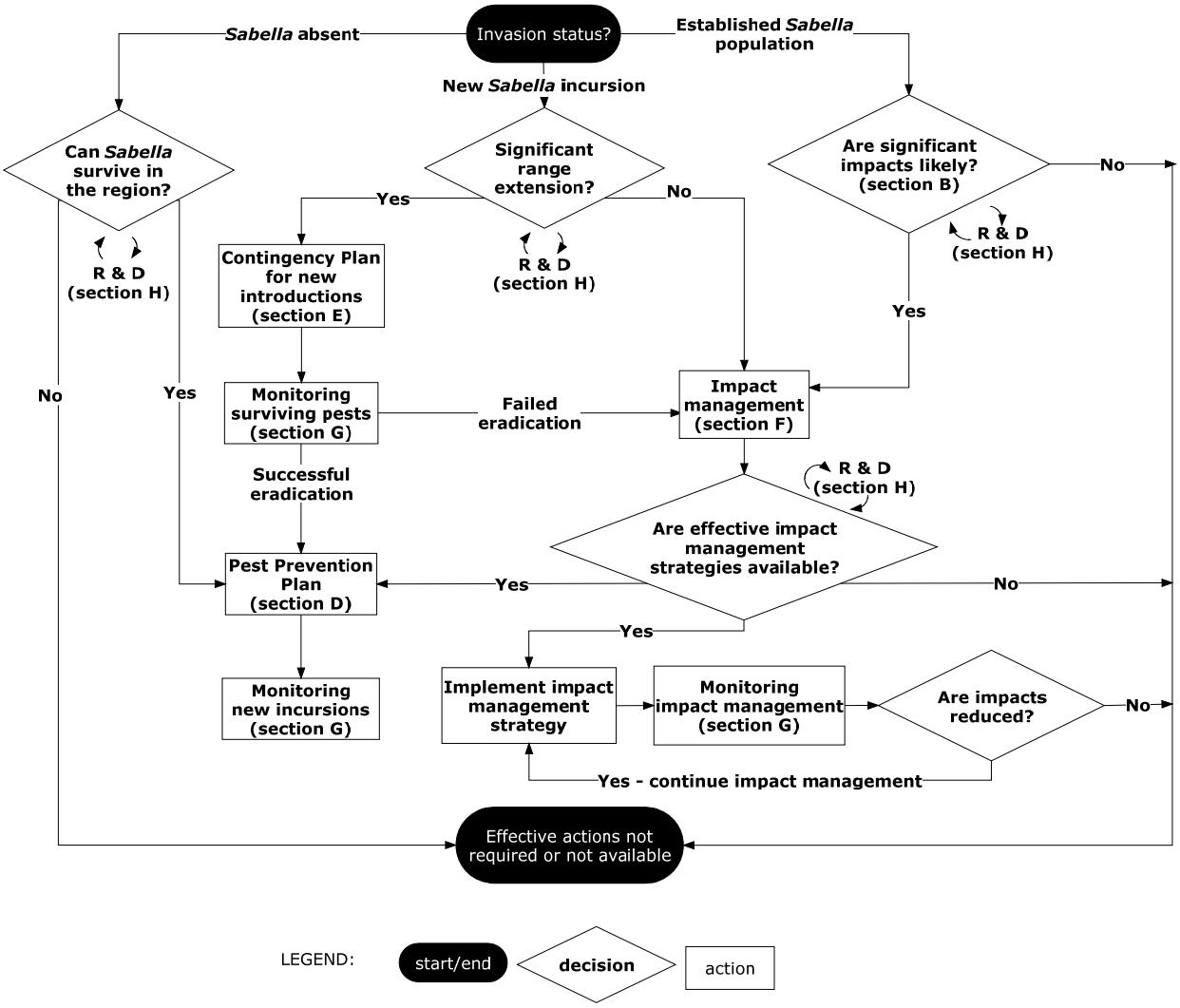

Figure 1. **Overarching decision support framework for *Sabella* management. There is inherent uncertainty associated with some questions (e.g. Can *Sabella* survive in the region?) so decisions must be made on the best available information (e.g. species range mapping data[2]). Note that if effective 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 *Sabella* to environmental, social and economic values should the species not be controlled. It is based upon an assessment of demonstrable and potential impacts of *Sabella* against the relevant CCIMPE criteria[4] (i.e. economy, environment, human health, amenity):

Economy:

Impacts in native range

In its native range there are no documented economic impacts attributable to *Sabella*.

Impacts in Australia

The economic impacts of *Sabella* in Australia have not been quantified. Impacts on the scallop fishing industry in Port Phillip Bay were recorded following invasion where fishermen found it increasingly time-consuming to sort catches from dredges clogged with *Sabella*[5]. Impacts on the Port Phillip Bay scallop fishery are not considered a current problem because the fishery has been closed since 1996 amidst concerns associated with the effects of dredging on benthic communities[6]. Future impacts on scallop fisheries operating on exposed coastlines are considered unlikely, considering *Sabella's* apparent preference for sheltered, nutrient enriched waters[5]. Impacts on commercial fishing operations in Western Australia have been reported as negligible, because of the minimal overlap between *Sabella* distribution and commercially fished areas[7]. It should be noted that this assessment was made in the early stages of the *Sabella* invasion (1995) and that additional research is required to investigate whether subsequent impacts on commercial fisheries have occurred.

Sabella has the potential to influence aquaculture operations, both as a nuisance fouler and as a competitor of cultured filter-feeding species. In Western Australia, impacts of *Sabella* on mussel farms are perceived to be minimal based on interviews with commercial operators, constituting little more than a slight nuisance[7]. The extent and impacts of *Sabella* fouling on aquaculture operations in Port Phillip Bay is poorly understood. Protocols designed to minimise translocation of *Sabella* and other marine pests between Port Phillip Bay and uninfected regions have been developed for the mussel industry[8]and involve a combination of freshwater immersion and air drying. Quantifying the economic impact of implementing such protocols is complicated by the fact that unexpected benefits to the industry have been observed (better growth rates and product quality), due to the reduction in general fouling that accompanies treatment of aquaculture farming equipment[8].

Sabella also has the potential to influence operators of commercial vessels as a result of decreased efficiency due to hull fouling. While the frequency and extent of *Sabella* fouling on commercial vessels remains poorly understood, the incidence of *Sabella* fouling should be significantly reduced by adherence to biofouling guidelines proposed under the National System (see section D).

Environment:

Impacts in native range

Significant impacts of *Sabella* have not been documented in its native range.

Impacts in Australia

In Australia *Sabella* occurs on both soft-sediments and hard substrates in sheltered habitats (refer to NIMPIS[9] for details on *Sabella* distribution in Australia). On hard substrates, detailed experiments examining ecological interactions between *Sabella* and sessile invertebrate assemblages have been conducted[10, 11]. The presence of a dense *Sabella* canopy has been shown to influence larval abundance and recruitment patterns of sessile fauna[10]. In the early stages of community development (up until 10 weeks), impacts of *Sabella* on community composition have also been observed[11], however, after six months, there was little evidence that *Sabella* affected established assemblages despite good statistical power and a high *Sabella* treatment density (~250 *Sabella* m^{-2}). The disappearance of apparent impacts after an extended period of time has implications for studies on the ecological effects of exotic species.

In soft sediment habitats, the spatial distribution of *Sabella* appears to influence impacts on benthic infauna, with *Sabella* individuals occurring randomly at some sites and in dense clumps at other sites (Ross *et al*. unpublished data). Recent experimental manipulations on soft sediment habitats in Port Phillip Bay concluded that the effects of *Sabella* on soft sediment assemblages in Port Phillip Bay are likely to be negligible in circumstances where *Sabella* individuals are randomly distributed in the benthos (Ross *et al*. unpublished data). A negative relationship between *Sabella* density and the abundance of lumbrinerid polychaetes and gammarid amphipods was observed, but these taxa represented only a small proportion of those present.

Sabella appears to have a significant impact on benthic infauna in localised dense patches (clumps of 10 or more individuals)[12]. Significant changes to the abundance of taxa, particularly surface dwelling crustaceans, have been observed in the sediments occurring directly under *Sabella* clumps. The network of tubes in the clumps also provided a habitat for a range of sessile and mobile invertebrates. It is not known whether the clumps lead to larger scale effects beyond the sediments directly underneath the *Sabella* canopy.

The impact of *Sabella* on nutrient cycling has been the subject of recent detailed research efforts in Port Phillip Bay which are nearing completion (Ross *et al*. unpublished data). A focus of this recent research has been the influence of *Sabella* on rates of denitrification, since this is a key process that determines whether or not eutrophication occurs. The spatial arrangement and density of *Sabella* individuals again appears to have a significant influence on impacts, with significantly lowered denitrification efficiency associated with 'clumped' *Sabella* distributions, but not 'random' *Sabella* distributions. While significant reductions were observed, it is noted that reduction in denitrification efficiency is concluded to be relatively minor and should only become a management issue for very high density *Sabella* patches. Improved understanding of the overall impact of *Sabella* (i.e. impacts on benthic communities and nutrient cycling) within Port Phillip Bay clearly requires improved understanding of the spatial extent of the different *Sabella* distribution patterns (i.e. 'random' vs. 'clumped').

Impacts of *Sabella* on higher trophic levels have also been observed. For example, increased abundance of little rock whiting *Neoodax balteatus*[13] have been linked to *Sabella* invasion. The observed increase in *N. balteatus* was thought to be the result of "forests" of *Sabella* tubes providing these fish a refuge from predators.

Human Health & Amenity:

There are no reported or anticipated human health concerns associated with establishment of *Sabella* populations. Impacts on amenity are considered to be relatively minor. Potential negative impacts include reduced natural value of habitats frequented by recreational divers and fishermen.

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 *Sabella* was finalised in 2006[14]. The business case summarises the likely threat and impacts of *Sabella* 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 *Sabella*, 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 Sabella

Sabella 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:

Sabella spallanzanii is a vigorous coloniser of marine substrate causing: nuisance fouling of vessels and marine structures; loss of aquaculture, recreational and commercial harvest; detrimental native habitat modification; and alteration of food webs. It is present in six out of 60 Australian marine bioregions (as defined in the Interim Marine and Coastal Bioregionalisation for Australia – IMCRA[15]).

Potential for further introductions and spread of Sabella

Sabella can be transported in ballast water and via biofouling.

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). *Sabella* has significant potential to invade additional places in IMCRA bioregions where the species are already present, as well as bioregions which have not yet been invaded.

Sabella 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 *Sabella* to establish pest populations. On the basis of water temperature it has the potential to invade 22 bioregions (currently present in six).

Benefits of National Control Plans

NIMPCG considers that the implementation of a NCP for *Sabella* 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 *Sabella* 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. 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 *Sabella*, the benefit to cost ratio was 0.0 where eradication of the species was not considered possible and 1.5 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 that outlines the range of pest prevention strategies applicable to *Sabella*, including existing arrangements, is shown in Figure 2. Reducing the risk of ballast water mediated translocation of *Sabella* 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. *Sabella* has been nominated as one of the species for which ballast water management between Australian ports will be required.

Biofouling:

Sabella has the potential to be transferred via biofouling. National best practice management guidelines for management of biofouling are currently being developed for various marine sectors[16] including domestic recreational vessels, aquaculture, commercial fishing and petroleum industries. Adherence to these guidelines should ensure that translocation risk for *Sabella* is reduced.

There is strong evidence to suggest that hull fouling is the principal vector in the translocation of *Sabella* within Australia. The organism has been observed attached to the hulls of several vessels moored within Port Phillip Bay, including car ferries, fishing boats and pleasure craft[5]. Therefore it is particularly important that measures are taken to reduce the risk of *Sabella* spread via this vector. While the aforementioned biofouling guidelines are currently under development, a range of potential protocols are available to reduce translocation risk. Potential protocols include: regular slipping and dry-docking of the vessel to enable inspection; repair or renewal of the anti-fouling coating; in-water inspection by divers, and undertaking in-water clean (note that prior approval to undertake in-water cleaning is required from the relevant state/territory authority) or dry-docking as necessary; inspecting internal seawater systems; cleaning strainer boxes, and dosing or flushing of these systems; and inspecting and cleaning equipment and areas which may accumulate mud, sediments and/or fouling organisms, including dredge fittings, anchor cables and lockers, buoys, floats and booms and similar equipment.

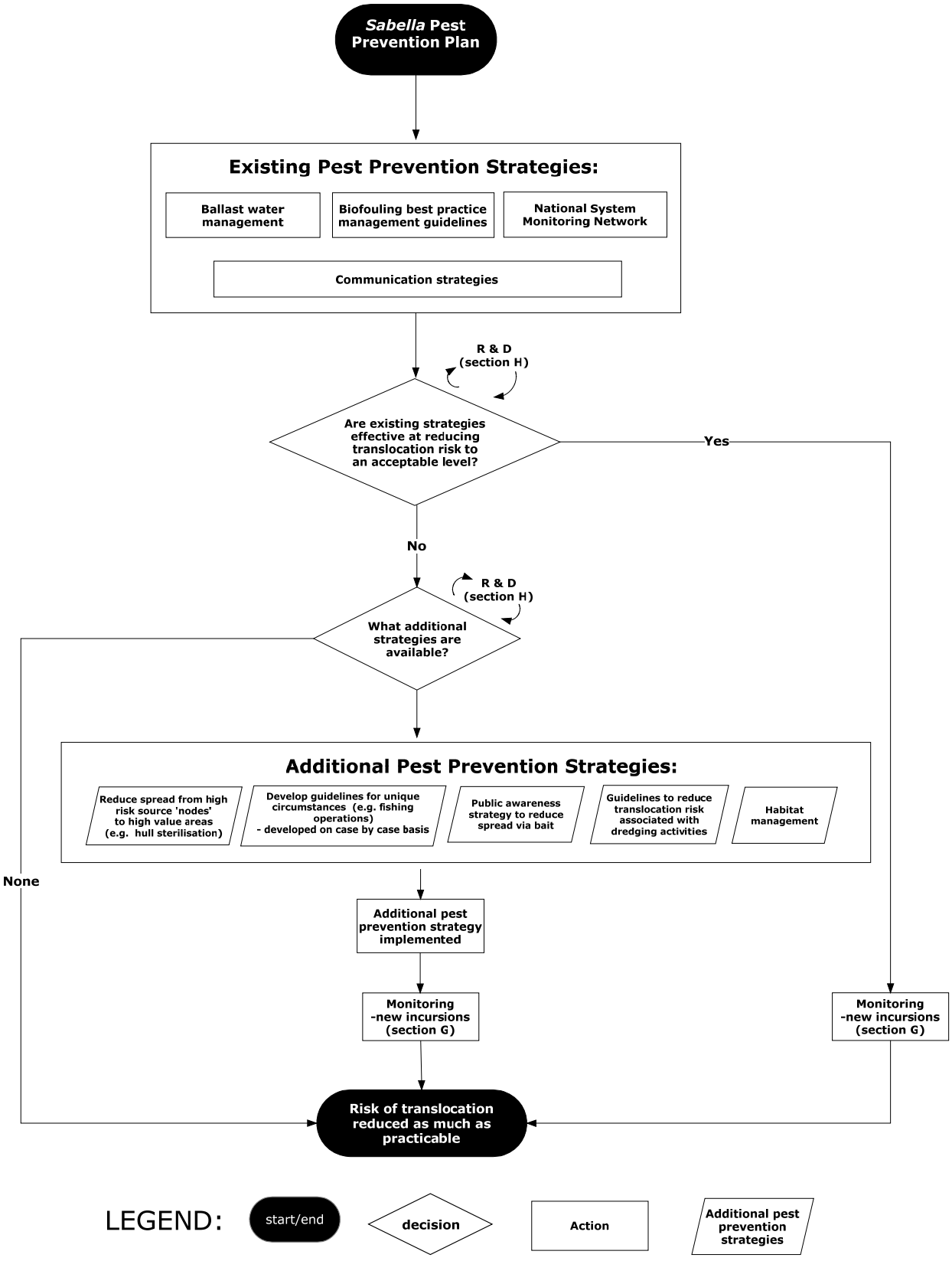

Figure 2. **Pest prevention plan and decision support framework applicable to *Sabella*.**

Additional Pest Prevention Strategies:

- Transfer of *Sabella* 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 hull and internal seawater systems might be recommended for vessels travelling to high value areas. Effective public awareness and communication campaigns will be an integral component of this strategy.
- 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 fishers on the east coast of Tasmania[17]. Fishermen have been provided with a clear set of guidelines that outline cleaning procedures to prevent translocation between fishing grounds, along with clear instructions on how to store *A. amurensis* that have been caught in their fishing gear (e.g. non-draining bins). Entrainment of *Sabella* in fishing gear has previously been reported[18] so similar protocols may need to be developed if there is risk of *Sabella* entrainment and translocation associated with commercial fishing activities.
- Local spread of *Sabella* may also be associated with use as fishing bait by recreational fishermen[19]. Recreational fishermen use pieces of *Sabella* to bait hooks in some areas and lost or discarded bait has the potential to contribute to local spread, particularly given its ability to regenerate missing body parts. To prevent spread via this vector, a targeted public awareness campaign should be considered to discourage the use of *Sabella* as bait (see section I).
- Another potential vector in relation to translocation of *Sabella* is associated with dredging activities. Dredging operations for port maintenance and capital works could serve as a vector for *Sabella*. Dredging activity could lead to localised re-distribution of *Sabella*, but more importantly, further spread could occur if spoil is lost overboard while en-route to the disposal site. This is particularly relevant for *Sabella* since damaged worms or fragments have the capacity to regenerate[7]. Another concern with dredging activity is that disturbance to mature *Sabella* individuals during the spawning period (March-September, reaches a maximum during May/June in Port Phillip Bay[5]) could trigger spawning resulting in release of gametes to the water column as material is removed. Existing regulations controlling dumping of dredge spoil (e.g. *Sea Dumping Act 1981*[20]) may at least partly reduce the spread via this vector. Depending on the circumstances, additional guidelines may be considered necessary to further reduce the risk of *Sabella* translocation, especially for dredging operations in high risk source 'nodes'.
- Habitat management may be considered as an indirect means of controlling further spread of *Sabella*. Given the apparent preference of *Sabella* for nutrient enriched habitats[5], an additional pest prevention strategy that may be considered involves management of nutrient inputs. Where nutrient inputs can be linked to human activity, management strategies that aim to minimise organic enrichment should be seen as an indirect method of reducing the likelihood of *Sabella* 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 *Sabella* is provided in Figure 3. The decision on a national response to eradicate new introductions or range extensions of *Sabella* 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)[21].

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 *Sabella* incursions. The National Introduced Marine Pest Information System (NIMPIS) rapid response toolbox[22] 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[23]. 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[24].

The range of treatment options available for a marine pest emergency involving *Sabella* 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 *Sabella* incursion is to detect it early and eradicate or contain the population before further spread occurs.

It should be noted that handpicking by divers to eradicate *Sabella* individuals from Eden (Twofold Bay) on the NSW coast has been ongoing since 1996. Following the initial discovery of two *Sabella* individuals on wharf piles, annual handpicking has been conducted to remove *Sabella* in this area. In May 2005, *Sabella* was found on nearby soft-sediment and by October 2005 there were too many for manual removal to be practical. It seems clear that an annual 'hand picking' exercise by a single

team of research divers over two to three days is inadequate to eradicate *Sabella* (B. Creese, NSW DPI, pers. comm., Jan 2008).

A key question for managers when responding to new *Sabella* 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[25]. While natural spread has not been measured experimentally, the larval period of *Sabella* is known to be around two weeks[26]. Observations of *Sabella* spread within Port Phillip Bay indicate that larval dispersal is less than 20 km per year[27].

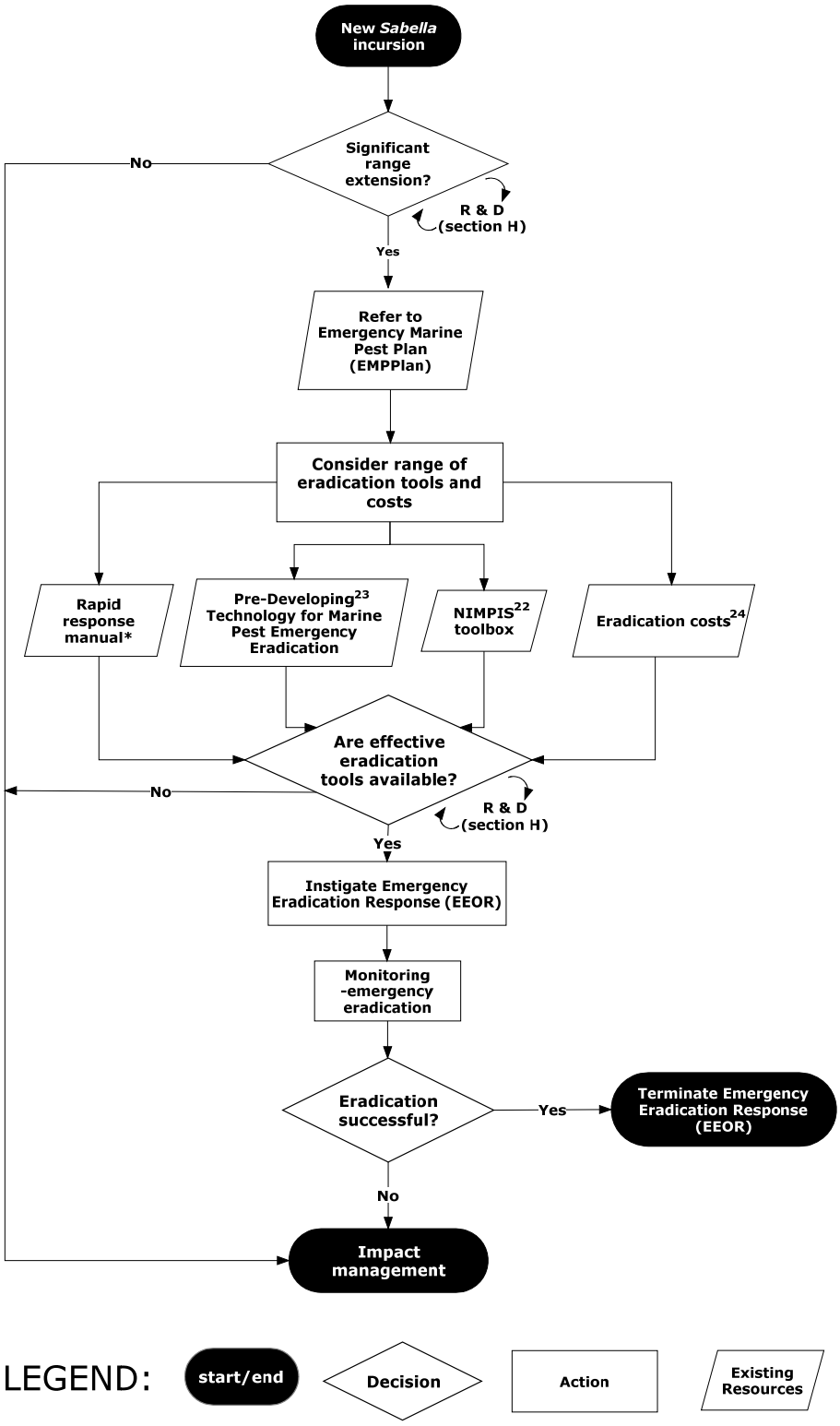

Figure 3. Decision support framework for new introductions of *Sabella* highlighting the currently available resources to assist the decision-making process. *Resources currently under development.

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 *Sabella* impact management is outlined in Figure 4. Assessing impacts is the first stage in the decision-making process (see section B). It is not appropriate to assign *Sabella* to impact categories across all jurisdictions since the extent of impacts 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, in most jurisdictions the likely economic impact of *Sabella* falls under the 'None' category based on currently available information presented in Section B. In terms of environmental impacts further work is required before its impacts are fully understood, but likely impacts are in the 'low-moderate' category in the scheme proposed in Figure 4 based on the analysis of impacts in Section B.

Before potential impact management options are identified, it is important to establish clear objectives for management which can be used to measure the subsequent success of management actions. As part of the decision-making process it is also vital to assess the likely benefits of impact management and the associated costs involved. 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)[15]' should be consulted to identify areas of biological significance.

Currently available impact management options:

Control options are defined under three broad categories, including (1) direct targeting of *Sabella*; (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 impact management 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 Sabella:

Physical removal

Options for direct control of *Sabella* populations are extremely limited. The most likely method to be effective for controlling established *Sabella* populations involves manual removal by divers. Mechanical removal methods such as dredging are not only inappropriate as a control measure but may well contribute to further spread due to the ability of *Sabella* to regenerate from fragments[7]. While manual removal by divers is a potential control measure, it should be recognised that it would require an intensive and ongoing diving program and is only likely to be practical for populations with a restricted spatial distribution. Even in these circumstances, manual removal may not be sufficient to control *Sabella* populations, as evidenced by the control attempts undertaken in Eden (see section E). It should also be noted that handpicking of *Sabella* requires diver education and care

because of the presence of similar-looking native species (e.g. *Sabellastarte* spp.) around Australia[22]. If manual removal is used as a control option, consideration should be given to removing *Sabella* individuals prior to the spawning period, which occurs in Victorian waters from March until September, reaching a maximum during May/June[5].

Biological control

Biological control has been considered as a management option for other introduced species (e.g. *Carcinus maenas*[28], *Asterias amurensis*[29]). Preliminary work has failed to identify specialised parasites or signs of pathogens on *Sabella* from Victorian waters or Italy (C.L. Goggin and N. Murphy, CRIMP, pers. comm.). Further research is required before it could be considered a serious control option. 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[30]. While the technique has great potential (e.g. sonless/daughterless offspring), 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.

Chemical control

While a range of chemicals are potentially effective against marine pests[22], they are only likely to come under consideration in circumstances where the population is contained (e.g. marinas). For established *Sabella* 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

Another option that may be considered as an option to reduce reproductive output from high risk 'source' nodes is wrapping/encapsulation of man-made structures. This method has been used as an eradication tool for introduced sessile invertebrates in New Zealand (e.g. *Didemnum vexillum, Styela clava*) and involves covering artificial structures with plastic[31, 32]. Anoxic conditions that develop beneath the wrap kill fouling organisms and this may be accelerated by addition of chemicals (e.g. chlorine, acetic acid). For *Sabella*, this could be considered as a means of reducing population size in a high risk source node. As with diver removal, this may be practical in small ports, but for large commercial sized ports it would be a major on-going expense and is not likely to be a practical option. A similar smothering principle can be applied to natural substrates, however, obtaining an adequate seal on the benthos can limit the efficacy of the method[31].

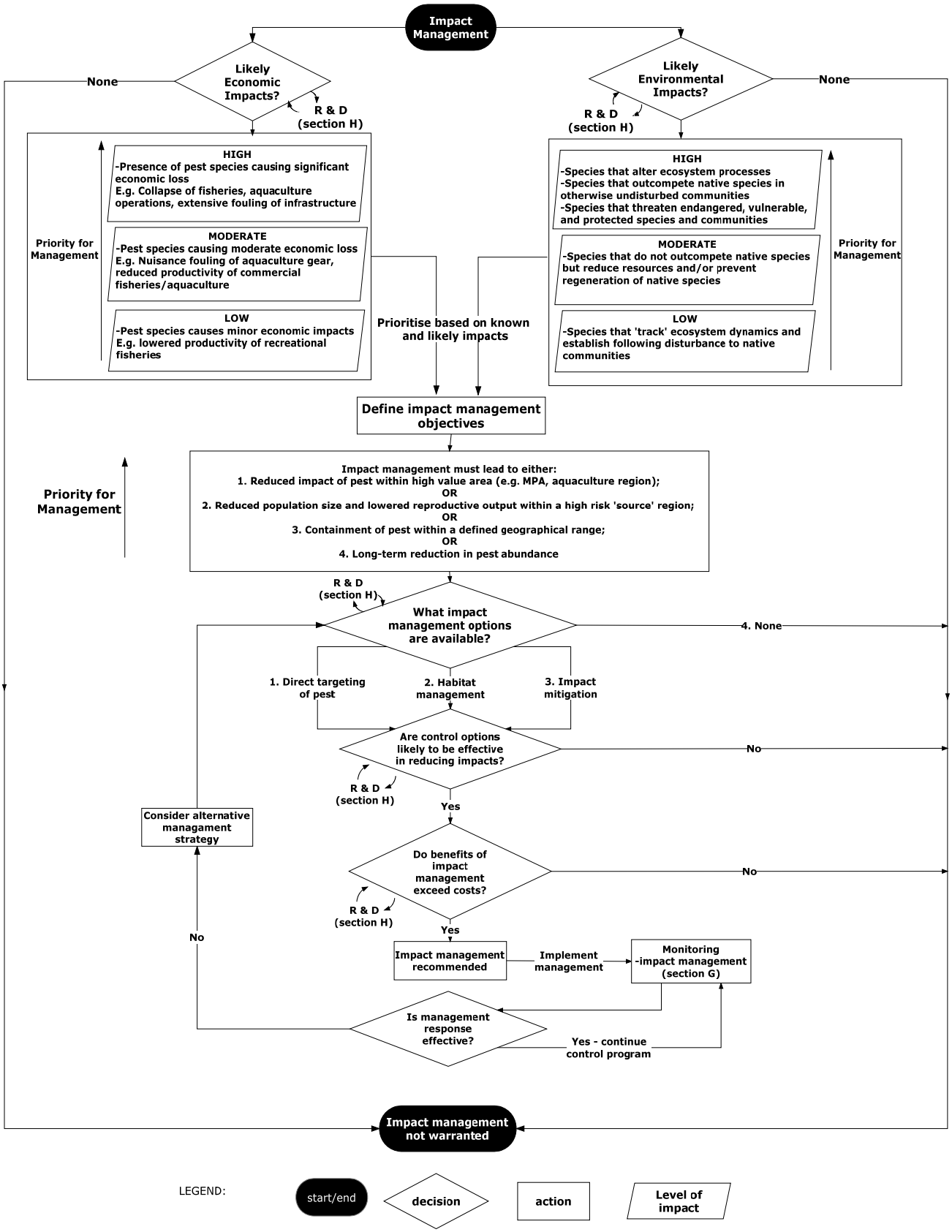

Figure 4. Impact management decision support framework applicable to *Sabella*.

(2) Habitat management:
While not experimentally tested, there are links between disturbance and invasion success for *Sabella*. Studies in Victoria indicate *Sabella*'s preference for sheltered, nutrient enriched waters, while in Western Australia, *Sabella* is frequently associated with man-made made structures and disturbed habitats[7]. The link between disturbance and invasion success provides potential control options for *Sabella*. Where disturbance can be linked to human activity, it may be more effective to target the cause of the disturbance, rather than directly targeting the worm. Disturbance to seagrass beds is probably the most important disturbance to consider in this context. Potential anthropogenic activities that may be responsible for seagrass loss[33] include eutrophication, sedimentation, toxicants, freshwater, physical damage and global warming.

(3) Impact mitigation:
The direct economic impacts of *Sabella* are currently considered minimal in economic terms. Impact mitigation measures may require development if circumstances change in the future. The most likely impacts relate to nuisance fouling of aquaculture equipment. If such nuisance fouling becomes an issue, a range of potential treatments could be considered. For example, periodic removal of equipment from the water for cleaning and treatment (e.g. air drying, water blasting[34]) is likely to reduce levels of *Sabella* fouling.

Table 1. **Currently available impact management options for *Sabella* (Note that potential control options such as genetic control that are under development are not included in the table).**

Method	Likely Efficacy	Feasibility	Environmental/public concerns
1.Directly targeting *Sabella*			
-*Manual removal by divers*	Potentially effective for *Sabella* control at small spatial scales*.	Feasible but thorough, systematic searching by divers required in order to be effective. Thus, a very slow and time-consuming method requiring on-going efforts.	Care and proper training is required to ensure that native species are not inadvertently removed.
-*Wrapping/encapsulation of artificial structures*	Likely to be effective against *Sabella* and other fouling organisms. Best suited to circumstances where *Sabella* is strongly associated with man-made structures.	Only feasible for small spatial scales*. Labour intensive, but reduces the need for on-going dive surveys.	May be environmental concerns if chemicals (e.g. chlorine) are used to accelerate mortality.
2. Habitat management			
-*Manage disturbances that influence competitors of Sabella* (e.g. prevent disturbance to native seagrass beds, reduce nutrient inputs)	Unknown.	May be feasible depending on disturbances involved and links with anthropogenic activity.	Minimal environmental concerns.
3. Impact Mitigation			
-*Modify aquaculture practices* (e.g. treatment of equipment).	May be effective in reducing *Sabella* fouling.	Feasible but there will be high labour costs incurred to industry.	Minimal environmental concerns – unless chemicals are used.

*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 based on currently available information, for many jurisdictions application of the proposed decision support framework (Figure 4) is not likely to recommend management action(s) to control existing *Sabella* populations.
- With currently available technology, control options involving direct targeting of *Sabella* populations are extremely limited. Direct targeting of *Sabella* populations by diver removal or smothering is only likely to be worth consideration in circumstances involving small (< 1000 m^2), isolated populations associated with high risk source nodes.
- The only potentially effective and publicly acceptable control method currently available for *Sabella* involves habitat management. Based on the limited impacts of *Sabella*, 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 *Sabella*.

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

Monitoring of *Sabella* is included in the National Monitoring Network (NMN), which is comprised of 18 locations across Australia[35]. Guidelines for monitoring *Sabella* within the NMN are included in the Marine Pest Monitoring Manual[36]. 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 *Sabella* NCP (summarised in Table 2) 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 considered in the NMN (e.g. recreational vessels, transfer of aquaculture gear etc.). Based on environmental tolerance information[2, 37], only nine of the 18 NMN locations are of relevance to *Sabella* and three of these locations already have established populations. 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 *Sabella* 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 *Sabella*. If an eradication attempt is initiated, monitoring will form a core component of the eradication program. Monitoring will involve quantifying *Sabella* 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 *Sabella* within a high value area, for example, estimating the abundance of *Sabella* should form a core component of the monitoring strategy. Monitoring of the impact itself is also recommended in these circumstances so the success of impact management can be assessed. If the high value area is based on the presence of an industry (e.g. aquaculture, fishery), monitoring should also include estimates of abundance or productivity for the species that the industry is based upon. Alternatively, if the high value area is based on environmental values, monitoring should involve quantifying the diversity and abundance of species of environmental value. 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 *Sabella* 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[9]:

In many states there are programs in place involving monitoring of marine communities (e.g. community-based surveys, MPA surveys) and in some instances these programs collect information on the distribution and abundance of marine pests. Given the significant costs involved with monitoring programs, in circumstances where the surveys are appropriate for *Sabella* it would be of considerable benefit if a mechanism was in place to incorporate this data 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 NCP and could represent a considerable cost saving. It would also be invaluable if NIMPIS includes results associated with control/eradication attempts.

Another potential data source lies with relevant government authorities. Approval of developments in the coastal zone may include biological surveys as part of environmental impact assessments. Information collected as part of these surveys could be relevant to *Sabella* and it is recommended that results from these surveys should also be incorporated into NIMPIS. There are also opportunities to incorporate industry based monitoring 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. It is recommended that this type of information should also be incorporated into NIMPIS. The information supplied not only provides potential information on distribution and abundance of *Sabella*, but may also provide observations in relation to impacts. Where possible, state jurisdictions should engage industry to ensure collection of *Sabella* 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. An efficient mechanism of extracting the relevant industry data compiled by state and territory governments and inputting it into NIMPIS is also 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 *Sabella*.

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 programs.	Abundance; Monitoring of specific impacts may also be warranted (e.g. impacted industries or biota)
- To monitor the rate of spread	Various locations to establish the range of *Sabella*	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 (R&D) has been completed[38] and includes a variety of research areas that should contribute to improved management of marine pests (including *Sabella*) within Australia. The purpose of the R&D outlined in the *Sabella* 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 3) 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 3 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 aquaculture activities because impacts on this industry are currently considered minimal. If impacts on aquaculture are identified in the future, mitigation of impacts is likely to be central to management and this may warrant R&D investment.

A brief justification of the inclusion of the proposed R&D areas is provided for the relevant sections of the *Sabella* 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 hull fouling as a translocation vector for *Sabella*, it is particularly important that an assessment of the likely efficacy of the national system best practice management guidelines for biofouling be conducted for the relevant sectors. (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 *Sabella*, 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 *Sabella* 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[37].

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[39]. Development of innovative tools to eradicate and/or control *Sabella* populations should therefore be an on-going research priority, despite the technical challenges associated with eliminating species from open marine environments (Table 3; CP1). As part of this research it is recommended that the efficacy of wrapping methods[31, 32] is tested against *Sabella* under field conditions. Understanding the capacity for natural *Sabella* spread is another key research question that has significant implications for managers (Table 3; 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.

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 are biofouling best practice guidelines in reducing translocation risk? *(Figure 2)*	4	4 (75)	4	12	**4**
	PP2. Improved understanding of life-stage specific data *(Figure 2)*	4	4 (75)	4	12	**4**
Contingency Plan for new introductions	CP1. Development and testing of novel eradication and/or control tools *(Figure 3)*	5	2 (200)	1	8	**2**
	CP2. What is the capacity for natural *Sabella* spread? *(Figures 1, 3)*	5	3 (100)	2	10	**3**
Impact Management	IM1. What are the economic impacts of *Sabella* in Australia? *(Figure 4)*	5	5 (50)	3	13	**5**
	IM2. Improved understanding of invasion process, particularly the role of disturbance in the invasion ecology of *Sabella* *(Figure 4)*	4	2 (200)	4	10	**3**

Impact Management

Understanding the economic impact (Table 3; IM1) of *Sabella* is vital because it plays a pivotal role in determining whether or not control actions should be pursued. A critical question when deciding whether or not a management response is required is "Do benefits of impact management exceed costs" (see Figure 4). While environmental impacts are reasonably well understood, it is important that a clear understanding of the economic impact of *Sabella* is obtained at the local level.

Improved understanding of the invasion process, including the role of native predators in conferring resistance is recommended as a key research area that may lead to a better understanding of impact and an increased range of control options (Table 3; IM2). Increased understanding of the ecology of *Sabella*, including definition of the parameters that limit its distribution may also allow prediction of

areas most vulnerable to invasion and better allocation of monitoring and control efforts. While this fundamental biological research has the potential to lead to a greater range of impact management options, it should be noted that it by no means guarantees a solution to an introduced species problem[40]. Understanding the importance of human-mediated disturbance in the invasion process for *Sabella* is also of benefit when assessing impact and prioritising management activity. If *Sabella* 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). This is an important research question because the relationship between human-mediated disturbance and *Sabella* invasion success remains poorly understood, despite speculation that disturbance may be an important factor contributing to invasion success[5, 7].

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 *Sabella* NCP. For example public awareness and education strategies aimed at reducing the spread of marine pests through management of biofouling will be applicable to *Sabella*. Additional strategies which should be considered to enhance the effectiveness of the *Sabella* NCP include:

Additional strategies – Pest prevention

Additional public awareness strategies may include targeted public awareness campaigns directed at high risk nodes where *Sabella* is already established (e.g. ports, marinas and boat launching facilities) 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, hull fouling and recreational fishers (via use of *Sabella* as bait) probably represent the greatest risk in terms of *Sabella* translocation. If additional public awareness strategies are developed, it is vital that stakeholders associated with these vectors 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 *Sabella* 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 *Sabella* so the public can be properly educated/informed.

Due to the potentially dynamic nature of the spread and spatial extent of *Sabella*, 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 *Sabella* incursions, public awareness strategies in relation to emergency response are covered in the Australian Emergency Marine Pest Plan[21] (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 *Sabella*, the control approach (e.g. manual removal by divers) 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. Providing a budget for impact management (e.g. diver removal) is complex because costs will depend upon numerous factors such as the spatial extent of the population, the location (i.e. accessible versus remote) and depth (e.g. restricting dive times). The ability to utilise volunteers also has a strong influence on the budget required to implement NCP activities (see Table 4, Impact management), but it should be noted that there are potentially significant occupational health and safety issues associated with use of volunteers.

Despite the uncertainties associated with provision of budgets, indicative costs for management activity within the relevant NCP sections have been provided in Table 4. 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 *Sabella* within a small port. Three case studies are provided to give managers an indication of potential costs associated with impact management including: (1) physical removal by professional divers; (2) physical removal by volunteers; and (3) control of *Sabella* by wrapping wharf artificial structures and smothering the benthos with plastic. To provide a realistic budget, impact management activities are based upon targeting a *Sabella* infestation associated with a small coastal wharf, comprising 200 wharf piles and approximately 10 000 m^2 of seafloor. These dimensions closely match the size of a New Zealand wharf that was recently the subject of control efforts against a fouling invertebrate pest[41].

Note that salary for a project officer at a nominal level of 0.5 FTE has been included to co-ordinate 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 *Sabella* 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 1. Diver removal program[a] – fully funded. Labour ($72 000[b]), Boat hire ($18 000[c]), Car hire ($3600[d]), Tank fills ($3456[e]), Consumables ($500[f]).	$97 556 per year	State/territory governments
	Case study example 2. Diver removal program[a] – volunteer based. Boat hire ($18 000[c]), Car hire ($3600[d]), Tank fills ($3456[e]), Consumables ($500[f]).	$25 556 per year	State/territory governments
	Case study example 3. Wrapping of wharf piles and smothering of benthos beneath wharf[g]. Wharf piles[h]: Labour - including application & removal ($35 000), Materials ($3830) Benthos[h]: Labour - including application & removal ($26 200), Materials ($5500)	$70 530 per year	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[i] per site per year	State/territory governments
	Monitoring environmental variables to evaluate impact management strategy E.g. Quarterly sampling of control and impact areas[j] Labour ($12 000[b]), Boat hire ($4000[c]), Car hire ($800[d]), Tank fills ($576[k]), Consumables ($500[f]), Data analysis and write-up ($30 000[l])	$47 876 per year	To be advised
	Monitoring rate of spread	$10 000 per year	To be advised
R&D	Various R&D areas (see Table 3)	$0.7 million[m] over 3 years	Commonwealth & state/territory governments
Communications strategy	Depends on the impact management measures implemented	Uncertain	State/territory governments
Overall co-ordination	Salary for project officer (0.5 FTE)	$50 000 per year	To be advised

[a] Based on monthly removals, 12 diver days/month; [b] Divers cost $500/day (salary plus per diem), based on 4 person dive team & 3 field days/month; [c] Boat hire $500/day,; [d] Car hire $100/day; [e] Tank fills based on 36 fills/month @ $8 per fill; [f] Consumables including waterproof paper, slates, stationary; [g] Based on 200 wharf piles and 10 000 m^2 of seabed beneath wharf; [h] Refer to Coutts (2006)[31] and Pannell and Coutts (2007)[41] for details on cost estimates; [i] Cost effectiveness could be improved by surveying multiple pest species; [j] Based on 4 sites, 'impact' site and three control sites, 6 diver days/quarter; [k] Tank fills based on 18 fills/quarter @ $8 per fill; [l] Data analysis and write-up by suitably qualified scientist; [m] Assumes all priority R&D areas are addressed.

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 5.

Table 5. Potential performance indicators for the *Sabella* 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 *Sabella* impact management relative to other threats	*Sabella* 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 *Sabella* 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[9] http://crimp.marine.csiro.au/nimpis.
- The Web-Based Rapid Response Toolbox[22] http://crimp.marine.csiro.au/NIMPIS/controls.htm
- Pre-Developing Technology for Marine Pest Emergency Eradication Response[23] (in review)
- Rapid Response Manual – Generic (under development)
- Australian Emergency Marine Pest Plan[21] (EMPPlan)
- National System Marine Pest Identification Card – *Sabella spallanzanii* (under development)

Monitoring

- Australian Marine Pest Monitoring Guidelines: Version 1 (December 2006)[36]
- Marine Pest Monitoring Manual: Version 1 (December 2006)[37]