National Marine Science Plan: White Paper on Nonindigenous Marine Species effects to Biodiversity Conservation and Ecosystem Health

1 Background

Australian coastal, shelf and slope systems are uniquely biodiverse with current estimates suggesting that ~22% of global marine biodiversity resides in these habitats [1]. Consequently Australia's commitment to biodiversity conservation and maintaining ecosystem health is clearly demonstrated through national legislation and policy and international treaty obligations. The *Environmental Protection and Biodiversity Conservation Act (1999)* clearly outlines the legal framework for protection of species and the environment as well as maintenance of ecosystem health in the face of development.

Numerous threats to marine biodiversity have been identified in *Australia's Biodiversity Conservation Strategy 2010–2030*, which identifies the desire to reduce the impacts of existing threats, including nonindigenous marine species (NIMS), to our biological heritage so that their impacts to biodiversity is deemed negligible. In a marine context, human mediated invasions of NIMS have been identified as one of the top threats to biodiversity and ecosystem health, with an explicit concern over the continued exposure to additional invasions and the lack of mechanisms to manage impacts [2].

Australia is signatory to a suite of international treaties which place explicit and implicit obligations on Parties relating to biodiversity conservation and biological invasions. As a signatory to the United Nations Convention on the Law of the Sea [3] Australia is encouraged to "…ensure that ecosystems' structures and functions are sustained for the benefit of present and future generations." This includes explicit obligations to take measures "to prevent, reduce and control pollution of the marine environment resulting from…the intentional or accidental introduction of species alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto" (Article 196).

Signatory Parties to the Convention on Biological Diversity [4] have obligations to:

- ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction (Article 3).
- prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species (Article 8(h)).
- ensure that the environmental consequences of its programmes and policies that are likely to have significant adverse impacts on biological diversity are duly taken into account (Article 14.1).

Similarly, Parties of the World Heritage Convention [5], who act to establish World Heritage Sites in the marine environment, assume obligations to protect the values for which the site has been identified (e.g., important and significant habitats for conservation of biological diversity). Inaction by a Party to respond to invasive alien species, including failure to make provisions through national management plans, legislation and regulations, could impair the values of a Property, possibly resulting in the removal of the Property from World Heritage listing.

Marine research on invasion biology and ecology in Australia, specifically focussed on impacts to biodiversity and ecosystem health, occurs in Universities, Museums, State based research departments and research institutes. Australian research was one of the first demonstrations of ballast water and sediment transfers of marine organisms including harmful algal blooms [6, 7]. Similarly, the Australian Museum and NSW Fisheries led one of the first port baseline surveys to detect new NIMS [8, 9, 10]. This intense focus on marine invasion ecology that demonstrated the human role in the transfer and establishment of species and the clear articulation of biodiversity and economic impacts of high profile invasions, led to the funding and establishment of the CSIRO Centre for Research on Introduced Marine Pests (CRIMP) in the 1990s. CRIMP was tasked specifically with developing an understanding of the scale and scope of marine invasions in Australia, determining the vectors by which new invasions arrived, and undertaking an analysis of possible management options to prevent or control invasions.

Research on marine invasion ecology, and marine biosecurity in general, is currently under-resourced in Australia. The 2012 capability audit on national biosecurity research and development (R&D) found that full time effective (FTE) staff working in marine biosecurity R&D in Commonwealth and state/territory organisations (including CSIRO) was only 15.4 [11]. The same audit found that annual external funding for marine invasive species R&D in these organisations totalled less than $600K nationally, and concluded the sector was "particularly vulnerable" as the funding sources in question (and staff retention) were largely unstable.

Our current understanding of the impacts that NIMS have on biodiversity remains poor, largely based on correlation and assumptions. More than 60% of global NIMS have not been evaluated for impacts [12] and in a recent review of ecological impact assessments for algal and crustacean invaders [13] it was determined that studies that found no significant impacts consistently had insufficient power to detect impacts even if they existed.

A multi-tiered strategic and adaptable science and research program is critical to ensuring effective marine biosecurity for Australia. Foundation research should underpin our risk analysis and decision making capability, enabling preparedness and identification of biosecurity threats. Responsive research capability is also necessary for rapid response to immediate and unforseen threats as they emerge. Finally, long-term strategic R&D is vital to anticipating future and emerging biosecurity challenges. Importantly, all these R&D approaches must be coordinated, complementary and efficiently managed in order to be effective.

2 Relevance

Australia has an internationally respected reputation in the area of NIMS research and development. Much of this stems from the pivotal work of programs such as CRIMP[1] and CRC Reef[2], both of which are no longer active in this field. Much of the Commonwealth and state/territory policy frameworks governing marine biosecurity and pest management are based upon science and research conducted in Australia. Since the 'closure' of these groups, however, NIMS research in Australia, specifically marine pest research, has lacked direction and drive.

As an island nation, Australia clearly derives many social, cultural, environmental and economic benefits from its marine environment. Its coast is home to some of the most unique and biodiverse hotspots on the planet, containing iconic treasures such as the Ningaloo and Great Barrier Reef systems, the Kimberley coast, the Great Australian Bight and cooler southern marine and subantarctic ecosystems. These systems provide the basis for a myriad of highly productive fisheries recruitment and ecosystem services.

There is a strong history of stakeholder engagement and input to NIMS management in Australia, through the development of national and international policy as well as the identification and facilitation of foundation science and research. Australia has been a leader on the world stage in invasions research, integrating fundamental science into applied outcomes both in developing technological and legal solutions. Australia has played a significant role in raising the profile of marine invasions associated with ballast water at the International Maritime Organisation (IMO)

[1] Centre for Research on Introduced Marine Pests: www.cmar.csiro.au/datacentre/refs/crimp_tech_reports.htm
[2] CRC Reef: http://crcreef.jcu.edu.au/discover/plantsanimals/introduced/index.html

Marine Environmental Protection Committee (MEPC) in the 1980s, resulting in the development of an Assembly Resolution calling for appropriate measures to minimize the likelihood of aquatic bioinvasions by ship's ballast. More recently, Australia has joined a consortium of Parties to raise concerns of biofouling associated introductions, resulting in Guidelines for consideration by Parties.

In response to the realisation of several marine pest risks (eg *Asterias amurensis* spread from Tasmania to Port Phillip Bay; *Mytilopsis sallei* incursion and eradication in Darwin Harbour; *Perna viridis* invasion in Trinity Inlet), the Australian and State and Territory governments, along with marine industries and marine scientists, have implemented the Australian National System for the Prevention and Management of Marine Pest Incursions[3] (hereafter referred to as the National System; [14]. The National System aims to prevent new marine pests arriving, coordinate and support a response when a marine pest does arrive in a region, and minimise the spread and impact of those marine pests already established in Australia [14]. Underpinning and informing the marine biosecurity framework of the National System is a comprehensive body of Australian based research and expertise across a diverse range of disciplines, including risk analysis, environmental monitoring and marine pest biology and ecology [15,16].

While the Commonwealth has an obvious leadership role in NIMS management, specifically pests, a strong and active management system must share responsibility across all levels of government, public sector agencies, primary producers, importers, exporters, transport industries, environmental managers (State and private), non-government organisations, service providers, tourism operators, visitors to Australia, and the Australian public. An example of this is the 1999 black-striped mussel incursion in Darwin [17, 18]. Anecdotal reports suggest that members of the public had observed the black-striped mussel in Darwin's Cullen Bay marina some time before authorities became aware of its presence, but failed to act as they were unsure what to do with the information or of its potential importance. Effective research deliverables such as what impact a pest will have to a marine community, how stakeholders can help in terms of delimiting, eradication etc. and what they could expect from management agencies can aid in improving public awareness of NIMS issues.

Shipping is the primary vector for new NIMS introductions, via biofouling and/or ballast water discharge. Ports and coastal transport hubs serve as conduits or 'stepping-stones' for their spread into nearby high-value areas (e.g. marine reserves [17]) by natural spread or "small" craft movement [18]. Australia's economy is also highly dependent on maritime transport, with 99% of Australia's imports and exports being carried by sea [19]. International maritime trade was calculated to be worth $418.4 billion in 2011-12, exporting 973.2 million tonnes and importing 94.9 million tonnes of freight [19]. Australian research into the mechanisms driving species introductions and spread in ports and harbours [eg 20-25] provides port authorities and environmental managers with tools and strategies to ensure both the ongoing responsible operation of our valuable ports network and the protection of high value natural marine habitats [39].

The increasing global demand for marine resources, increased global vessel movements and large scale factors such as climatic change all affect the likelihood of introduced marine pests entering Australia. The key is preventing introductions as a first line of defence, as it is far easier to prevent the arrival of a species than to eradicate it once it has established. As such, regulatory authorities rely primarily on preventative actions, such as risk identification and mitigation frameworks, education programs, and the good will of vessel operators to ensure the management of biofouling biosecurity risks. Australian research outputs and expertise form an integral foundation for risk assessment and regulatory frameworks managing biosecurity risks for these important vectors both in this country [29-] and overseas [30, 31].

Users and beneficiaries of nonindigenous marine species and marine pest research include ports authorities, the shipping, fishing and aquaculture industries, NGOs, community users of marine amenity and Government Departments regulating environment, transport, fisheries and aquaculture including protected area managers. Many NIMS researchers are engaged with a range of these stakeholders, as outlined in the Shipping Australia contribution to the Senate Inquiry on Biosecurity

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[3] The National System: http://www.daff.gov.au/__data/assets/pdf_file/0004/2059141/national.pdf

and Quarantine Arrangements, involvement of port authorities in national system surveys and other research, the use of substrates for infrastructure that decrease invasive species colonisation [32-35] and the funding through National Biosecurity Committee of a large project to validate molecular tests for marine pest surveillance for implementation at a proposed Australian Testing Centre for Marine Pests.

The control, management and potential eradication of marine pests to protect native systems is heavily dependent upon science. There is a fundamental need for agencies to better understand how pest species behave, aspects of biology that may be exploited, and potential impacts of these species should they become established. Impacts need to be considered across the biodiversity, socio-cultural and economic spheres. Research must therefore include practical applications, management actions and cost effective approaches to control or reduce the impact of each pest. While Australia leads much of the world in its NIMS research, it may not be achieving its true potential in terms of end-user management and application of this science. A more coordinated approach to research and monitoring would be the first step to strengthening our nation's capacity to respond to any NIMS threat and protect our marine biodiversity and ecosystem health.

3 Science Needs, Gaps and Challenges

The *National Priorities for Introduced Marine Pest Research and Development 2013*-2023 [36] provides a comprehensive national research and development plan that was developed by the Marine Pest Sectoral Committee and has had substantive consultation with stakeholders. In delivering to the National System, four priority areas were identified: (1) vector management, (2) species and ecological information for management, (3) monitoring, evaluation and review, and (4) information, communication and education.

This paper assumes a Biodiversity Conservation and Ecosystem Health focus in evaluating gaps and priorities set in the *National Priorities for Introduced Marine Pest Research and Development 2013*-2023 document. While we note that prevention is key – our knowledge of marine invasions in Australia suggests that more than 400 nonindigenous and cryptogenic marine species have already been detected, many restricted in distribution. This suggests that to achieve biodiversity conservation and ecosystem health targets a focus on both preventing new international invasions as well as restricting the spread of existing NIMS is necessary.

3.1 Vector management

The current and on-going focus of the National System is on the international barrier. Preventing new invasions is critical to maintaining a secure national system and best supported by a focus on the ability to predict new invasions, so called 'next pests', and better understanding vector activity and pathways of risk. Unfortunately Australia also currently has a significant number of already established species, many of which have a limited distribution. A focus solely on the next species will fail to protect biodiversity and ecosystem health against species that are already present, but with restricted distribution.

SCIENCE GAPS & CHALLENGES:

Developing better, more predictive tools to assess risks of new incursions requires better evaluation of risk factors including association with and operation of vectors and pathways. While the focus remains on the international border, many of the already existing invaders continue to pose a threat. Our current understanding of domestic pathways (vector connectivity) is poor, both between Australian ports as well as connectivity between ports and high value areas. This lack of understanding, coupled with limited abilities to manage domestic vectors, remain key gaps in the protection of biodiversity and ecosystem health.

NATIONAL BENEFIT:

Prevention of new invasions remains the most cost-effective biosecurity measure. This pertains not only to new international invasions, but also to the domestic spread of restricted distribution high risk species. Through better understanding of domestic transfer risks, particularly with high value areas, biodiversity conservation and ecosystem health will best be managed.

3.2 Species and ecological information for management

The current lack of knowledge surrounding the characteristics of successful invaders and the impacts they cause is of critical concern. In order to understand and predict risks we must first have knowledge of the values that we wish to protect and the likelihood that specific threat species will affect those values. Our current ability to predict high risk species (next pests) is critically constrained by our knowledge of impacts. This knowledge base must not be limited to species not currently present in Australia, but must take into account existing species.

There is now sufficient evidence from overseas that NIMS interact with other drivers of change including climate change, coastal development and habitat alteration. The degree to which these drivers of change interact synergistically remains a critical need.

SCIENCE GAPS & CHALLENGES:

A focus on an international "black-list" of species remains a useful tool to raise awareness and understand our interception abilities; however these will always provide an incomplete coverage of potential threats. It is critical to consider how these lists can remain open-ended with a focus not only on economic values, but also on biodiversity and ecosystem values in identifying next pests. Domestically it is imperative that the current suite of species be re-evaluated to determine which species are most likely to impact biodiversity conservation and ecosystem health values should they spread to high value regions.

A significant lack of knowledge currently exists concerning impact for the large majority of species. More than 60% of global NIMS have not been evaluated for impacts [12] resulting in these species being considered "safe" when developing black lists. Of greater concern is the willingness of scientific research to assume that NIMS cause no harm. In a recent review of ecological impact assessments for algae and crustacean invaders [13] it was determined that negative impact results consistently had insufficient power to detect impacts even if they existed.

Also as identified in other sections, there is a lack of research into the interactions between drivers of change (including social drivers) in the marine environment (eg climate change, coastal development, habitat alteration, social behaviours) and NIMS establishment and impact.

NATIONAL BENEFIT:

Understanding the likely impact of potential and existing NIMS to Australian biodiversity and ecosystems is critical to inform how and where we manage these species domestically. This information will help managers of biodiversity conservation and ecosystem health cost-effectively make decisions about prevention and response efforts.

3.3 Monitoring, evaluation and review

Surveillance for NIMS has traditionally focussed on locations of first entry such as ports, marinas and offshore platforms. The focus for biodiversity conservation and ecosystem health will require a shift to examine outside of these first entry locations such as the National System of Marine Protected Areas. To ensure cost-effective approaches, it would be necessary to leverage off of the efforts internationally to develop appropriate strategies.

SCIENCE GAPS & CHALLENGES:

The current approaches to monitoring and surveillance are focussed on a restricted suite of environments based on species known tolerances (realised niche). Many NIMS appear to not venture beyond these heavily altered and impacted environments into more pristine areas that have higher biodiversity conservation value. Unfortunately many marine protected areas and reserves are themselves attractions for increased visitation, particularly by small boat traffic. These vessels tend to be less maintained and consequently may expose high value areas to greater risk of domestic transfer. Contrary to popular belief high value areas are not immune to invasions [37, 39]. A rigorous focus on new technologies to provide surveillance is critical for early detection, but this also needs to be coupled with a better understanding of response options. In many protected areas, decision-making for response will require substantial consideration and debate, weighing the short versus long-term benefits of action. Of equal importance is an understanding of the social and commercial drivers and the public's risk perceptions of NIMS as managing the vectors (small craft) and pathways (related to peoples behaviours) will necessarily form part of the solution to NIMS impacts in high value areas.

NATIONAL BENEFIT:

Early detection and ready response capabilities will enhance the biodiversity conservation protections currently in place. An understanding of the species and vector risk exposure to individual high value sites, coupled with surveillance regimes that provide early warning will provide managers with greater support to actively monitor and manage potential threats. Engagement with the public will lift the profile of the issue and educate them to reduce risky behaviours that may lead to domestic transfers of NIMS.

3.4 Information, communication and education

Access to current and accurate information on NIMS distribution, ecology and impact is crucial for biodiversity conservation and ecosystem health managers. The ability for these managers to translate this information into action, particularly in the context of citizen-science initiatives will remain a significant gap.

SCIENCE GAPS & CHALLENGES:

The current management and delivery of information supports the National System; however the funding opportunities to enhance our knowledge base of impacts, coupled with a lack of domestic focus on vector and pathway risks, results in the information for NIMS not targeting biodiversity conservation and ecosystem health managers. Other jurisdictions have organised marine protected area managers into a coordinated unit to share information on NIMS threats and to facilitate network research to gain greater understanding. The call for an independent, scientifically focused advisory panel to act as a central overseer of marine biosecurity R&D will potentially provide significant benefit in this regard.

NATIONAL BENEFIT:

Appropriate scaled and accurate information exchange will enhance the ability of coastal managers to achieve biodiversity conservation and ecosystem, health outcomes, as well as meet their public outreach and education responsibilities. This will enhance the ability to engage in larger science initiative to understand how NIMS risks ramify from international entry points to high value areas by linking research across a network of protected areas.

4 Perspective

The Australian marine environment is unique, valuable and less disturbed at a whole-of-continent scale than other marine systems. This leaves it at particular risk to biological invasions, a risk which is increasing with growing global trade and passenger travel, changing climate and ocean currents, and enhanced human mediated alteration of coastal environments. Regulatory systems to manage marine incursions are also immature; the IMO Ballast Water Management Convention is not yet in force, Australian domestic ballast water controls are not in place and biofouling controls are voluntary, so risk management is less comprehensive than in terrestrial and freshwater biosecurity sectors. NIMS invasions pose a risk to freedom of shipping and trade, and information gaps could pose trade barriers if controls are introduced. Science priorities in order to achieve NIMS management (ie biosecurity) centre on a need to improve our understanding and mitigation of risk, surveillance, management of established pests, social drivers and behaviours, and research coordination and governance. This is particularly relevant to protection of high value locations to achieve biodiversity conservation.

4.1 Understanding risk

To optimise use of resources, habitats that are at highest risk of invasion need to be identified and prioritised. This should include periodic review and update of the National Monitoring Network in response to changes in shipping, local industry (aquaculture) and/or visitation. Artificial structures in ports are proximal to arriving vectors and are often the site of first establishment for marine pests, these locations may also have connectivity with high value areas. Disturbance regimes often mean that these environments are dominated by NIMS and developing systems for managing artificial structures and new development to minimise NIMS risk at the point of first entry is a priority. Concomitant with this effort should be a surveillance regime for high value sites in order to detect incursions where biodiversity conservation is paramount.

Models that predict the probability of invasion at a particular Australian port from vessel history and environmental descriptors provide the basis of a cost-effective framework for identifying high risk vessels and surveillance targets. High risk vessels could be subject to scrutiny, including physical inspection and increased precautionary measures [38]. This would provide a tool to prioritise resource allocation and could be implemented at low cost after development. These models should also be applied within a domestic context, with specific attention given to the linkage between ports of entry and high value sites.

The aquarium trade is a little understood vector for marine species. The proliferation of global commerce and popularity of internet trading, however, means this vector poses an increasing NIMS risk that must be addressed. Quarantine frameworks for marine ornamental species lag behind those for freshwater ornamental species and need information to be improved.

Many NIMS are poorly understood, and their biology prior to and after establishing in new environments is often obscure. Improved knowledge of the biology and life history of NIMS, particularly in the Australian environment, would inform managers of the likely impacts of 'next pests', identify habitats and environments for focused surveillance and management, and guide development of eradication strategies in an incursion.

4.2 Risk mitigation

The Australian Ballast Water Management Requirements lack supporting data, education to improve their implementation and are business disruptive. A better understanding of risk incorporating all vessel traffic, to outline which NIMS are likely to arrive, successfully establish and what their probable impacts will be, is required. Modelling techniques for this work have changed markedly in the last decade and are evolving further to include social drivers (vectors and pathways) and social implications (impacts).

Biofouling is universally recognised as a major vector of NIMS introductions, but methods for treating biofouling remain poorly realised. In-water cleaning is an effective vessel biofouling mitigation strategy, but Australian vessel operators and biosecurity managers have few in-water options that are both effective and compliant with Australian Government in-water cleaning regulations. The development of tools and technologies that provide a greater range of effective treatment options for regulators and industry should be prioritised.

The susceptibility of recipient environments to invasion needs to be reduced. Contamination and artificial structures in ports and harbours facilitate establishment of NIMS. The design of marine infrastructure can reduce or enhance the risk of NIMS establishment and spread. It is necessary to improve the design and spatial extent of artificial structures that enhance native species and create port environments that are resistant to biological invasions.

4.3 Surveillance

Technology offers tools for surveillance for marine pests that improve specificity and sensitivity, and decrease costs. Molecular methods offer rapid, accurate identification of species and can be combined with ecosystem health tools. Longer term development of autonomous and remote surveillance platforms is vital to address time, cost and safety issues that currently prohibit broad-scale implementation of using conventional techniques.

The ongoing decline of taxonomic expertise is a major impediment to NIMS programs worldwide. Parataxonomic approaches and molecular identification are a viable solution to this problem, but require studies to maximise their reliability and utility.

4.4 Management of established NIMS species

The consequences of most marine invasions are poorly understood and this prevents effective allocation of response resources. Impacts of established NIMS need to be understood so management actions can be prioritised.

Frameworks for robust decision making about responses when NIMS incursions occur are lacking. Cost effective options for responding should be identified and mechanisms to understand economic returns of management actions taken at different points of the invasion curve. Mechanisms to minimize spread of NIMS should be identified and ways to maximize their use put in place. Of critical import is the development of methods for "pristine" areas with a clear understanding of trade-offs between short and long-term benefits of action. These decision frameworks must include the ability to inform biodiversity managers when small losses associated with eradication are of greater benefit over long term control. Some international work is not relevant for Australian environments and local research to identify appropriate responses is required.

4.5 Governance and coordination

For Australian marine biosecurity research and management to be effective there must be coordinated and unambiguous communication of The National System to stakeholders and users, to ensure longevity and a sense of 'ownership' across all relevant sectors.

A centralised integrated approach to Australian marine biosecurity research and development is needed to identify gaps in capability and expertise, while coordinating research effort minimises duplication. Establishing a research network, involving academia, industry, government and industry is crucial to ensuring visibility and interaction between complimentary research areas and communication of research outcomes for evaluation and uptake.

A mechanism for cost recovery from risk creators and beneficiaries for funding applied marine biosecurity work should be identified. Neither Research Development Corporations (RDCs) nor Caring for Our Country fund marine biosecurity or NIMS research. The often piecemeal, uncoordinated approach to recent NIMS research is largely because of a lack of coordination applied through directed funding, and much of the resultant work is often not incorporated into governance frameworks. This has resulted in marine pest controls lagging substantially behind marine disease management frameworks.

A nationally coordinated approach would also provide a central contact point to facilitate communication with international bodies tackling similar issues. National biosecurity is an inherently international problem, and free flowing communication between international parties is vital for effective management. For example, the detection of a NIMS incursion at an international port is relevant to other ports connected by shipping, and ports and other pristine areas within the region that might also be infected. Although Australia has much biosecurity expertise, the absence of a coordinated front is an impediment to sharing information at an international level. There needs to be national repository of information and expertise in order to readily engage with international efforts.

5 Realisation

5.1 Key infrastructure and capability requirements/impediments

The current marine research infrastructure and capabilities provide an excellent framework to effectively manage NIMS effects on biodiversity conservation and ecosystem health. The current and planned development of the observation platforms and existing infrastructure is of sufficient breadth to encompass the concerns raised above.

Our capabilities however are not currently aligned to address the challenges associated with NIMS impacts on biodiversity conservation and ecosystem health. Insufficient focus on the diminishing capability for taxonomic identification has resulted in a critical gap for the majority of phyletic groups. New technologies may facilitate our understanding of biodiversity, as well as aid early detection of undesired NIMS, however this capability requires substantial investments and a focussed effort to address these concerns. Similarly, the need for eradication and control options in "pristine" environments will require new directions for research. This may involve developing viral agents, transgenic capabilities, altering natural processes and traditional biological control mechanisms which are currently considered too risky for use in the marine environment by the general public.

5.2 Funding and coordination requirements/impediments

The current funding environment for research on nonindigenous marine species is fragmented, particularly in relation to biodiversity conservation and ecosystem health outcomes. The call for a coordinated approach to Australian marine biosecurity research and development with participation across the research sector (eg Universities, Museums, State based research departments and research institutes, NGOs and private industry) is critical to understanding capability within the system. This coordinated approach will necessarily require attention to meet the needs of multiple outcomes, including biodiversity conservation and ecosystem health.

As indicated above the opportunity to work collaboratively with the international network of researchers and managers will significantly enhance our capabilities. This should include attention to information sharing agreements, mutual database development, and an explicit orientation towards gap filling including a network approach to research questions which could best be undertaken overseas or across a latitudinal gradient.

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