The threat of non-indigenous marine species towards Tasmanian marine protected areas

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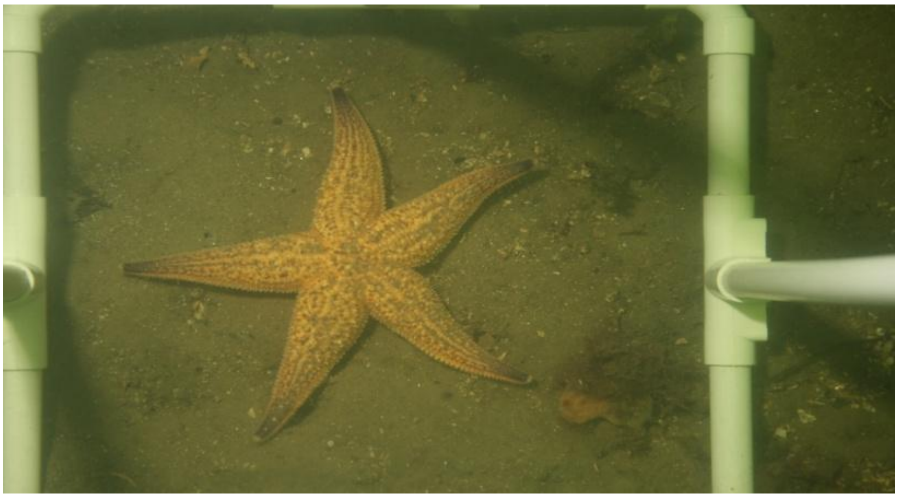
A thesis submitted in fulfilment of the requirements for the Degree of

Master of Philosophy



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Abstract

Marine Protected Areas (MPAs) are one of the most widely used protection methods for vulnerable marine species and ecosystems. An indirect drawback of many MPAs is that they often attract large numbers of people to the MPAs and its surrounds, which increases the potential for detrimental human-mediated impacts. The introduction of non-indigenous species to terrestrial protected areas is a well established hazard directly associated with increased human visitation rates. Similarly, an increased human visitation rate to islands is correlated with higher levels of coastal invasions. Whether this trend exists in marine systems is unknown; with the potential that invasion risk will increase if the people that use the MPA and surrounds are unaware of non-indigenous marine species (NIMS) and their impacts. This thesis aims to explore whether NIMS are a threat to three MPAs in Tasmania, Australia, using two techniques: a qualitative ecological survey to detect NIMS in the selected MPAs; and face-to-face surveys of recreational marine users to see if their activities and their self-rated knowledge of NIMS represents a marine biosecurity issue.

The three MPAs selected for this study were: 1) the Bay of Fires Abalone Research Area (41.11 °S 148.28°E), where collection of abalone is either not allowed or restricted in parts; 2) Governor Island Marine Reserve in Bicheno(41.36°S 148.05.°E), where diving and snorkelling are the only activities allowed; and 3) Tinderbox Marine Reserve(43.11.°S .147.29°E), which is 25.5km south of Hobart and allows diving and snorkelling activities only, but has a boat ramp and boat moorings within the MPA and therefore increased visitation inside the MPA.

A qualitative ecological survey with a nested sampling design was used to detect NIMS within and outside the three study MPAs. There were five haphazardly chosen sites within and immediately outside each MPA; within these sites five randomly placed 10m transects were laid out and on each transect, five 0.10m^2 quadrats were photographed for qualitative analysis upon return to the laboratory. Qualitative methods (photo-quadrats) were selected to minimise impact via destructive sampling, within the protected areas.

A difference between the prevalence of NIMS between MPAs; inside MPAs and outside MPAs; and IUCN categories was found during the photographic survey. Although the sampling methods used covered a large area in order to find NIMS at randomly located sites, a more targeted approach may have been more useful to find NIMS in more vulnerable areas (e.g. boat ramps, moorings jetties etc..) Also more destructive sampling techniques that allow for laboratory analysis of the species in the quadrats would give more certain results for future research on how human could be a vector for NIMS entering MPAs.

A survey instrument (questionnaire) was used to determine the recreational marine activities that occur at boat ramps close to the three study MPAs and to assess the marine recreational users awareness level of four target NIMS (*Undaria pinnatifida*, *Asterias amurensis*, *Maoricolpus roseus*, and *Carcinus maenas*) that are already found in Tasmanian waters. The majority (70%) of questionnaire respondents stated that they are aware of NIMS in Tasmania. Yet the accuracy of identification was very low with the average respondent accurately identifying less than 50% of the target NIMS in the questionnaire. This indicates that there is a potential for recreational marine users to inadvertently transfer NIMS into MPAs because their self-rated awareness was inaccurate, or that they are unaware of the NIMS concept (30% of the respondents). If people are unaware that their actions may be contributing to a problem then the management of this problem needs to address this issue. Therefore, increased use of awareness raising campaigns should be a top priority incorporated into managing the spread of introduced species, especially into areas such as MPAs.

This research aimed to assess the threat of NIMS to three Tasmanian MPAs. After analysing marine recreational user group awareness of NIMS in Tasmania, there appears to be a threat of spread based on the inability of these user groups to accurately identify four well known NIMS that are already well established in Tasmania. Photographic analysis revealed all three sites had been invaded at varying degrees by NIMS. I suggest that a thorough risk analysis that uses semi-quantitative sampling data linked with a vector analysis for each MPA site would provide direction for improving the management of the threat of NIMS entering MPAs in Tasmania.

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Chapter 1: Marine Protected Areas and their vulnerability to the Invasion of non-indigenous marine species

1.1 What are Marine Protected Areas and their role in marine conservation?

Throughout most of the 18th and 19th centuries the ocean was thought of as an inexhaustible resource, in which all marine organisms were immune to extinction from human activity (Agardy, 1994, 1997; Hyrenbach *et al.*, 2000).Yet, this concept has been questioned (e.g., Holman 1952) and subsequently proven to be incorrect (e.g., Weinstein *et al.,* 2007). This late recognition of threats by human activity has left marine conservation ideology several decades behind land-based conservation efforts, which occur in fundamentally different ecosystems (Steele, 1985; Agardy, 1994). Marine conservation efforts have ecosystem services focused on managing the use of marine and coastal resources to protect ecological processes that support biodiversity and human values. This focus is the basis for the concepts of "sustainability" and "sustainable use of resources" that are used by resource managers (e.g. fisheries, oil, development) to ensure the use of a resource today does not compromise its use in the future (Brutland report, 1987; Agardy, 1997).

The concept of sustainable use of resources is poorly defined and its interpretation differs between user groups (e.g. ecologists, economists, sociologists and politicians) that often have conflicting values (Agardy, 1997). The increase of human populations in coastal areas (Agardy, 1997), along with technological advances, has lead to a greater need for resources coupled with an increased ability for removal or extraction. This, in turn, has lead to conflicts between user groups (referred to as stakeholders). For example, there are often disputes surrounding the use of recreational areas between fishers (both commercial and recreational) and nature based tourism groups (such as divers) (Buzan 1978; Agardy, 2000; Jones *et al*., 2001; Kearney 2001; Christie 2004).

Marine Protected Areas (MPAs) act as a conservation tool for resolving disputes between stakeholders while simultaneously safeguarding the critical marine and coastal ecological processes that maintain biodiversity and human values (environmental, economic, social, and cultural values)

(Agardy, 1994, 2000; Lynch *et al.,* 2004). The scientific knowledge about marine and coastal ecosystems is far from complete and therefore MPAs potentially provide a buffer against unanticipated yet potentially disastrous environmental uses and even potential management mistakes (Agardy, 1994; Lauck *et al.,* 1998).

1.1.1 History of MPA initiatives

The first recognised MPA was established in 1935 as the Fort Jefferson National Monument in Florida, United States of America. This park was established to protect historic features but became a national park to protect natural features in 1992 (Gubbay, 1995; Brock and Culhane, 2004). However, international calls for MPAs came much later when they were the subject of special attention at the First World Conference on National Parks in 1962 which was established to promote international understanding of national parks and encourage further development (Adams, 1964; Gubbay, 1995; Sloan, 2002). MPAs were again an area of special attention at the Third World conference on National Parks 1982, which focused on the expansion and strengthening of national parks and protected areas (Scriabine, 1983; Gubbay, 1995). The call for MPAs as a marine conservation tool increased coincident with a number of international initiatives and conventions (e.g., the RAMSAR convention; UNESCO World Heritage Convention; Man and the Biosphere Programme) that were established to help guide governments in designating and managing protected areas in their countries (Gubbay, 1995).

The Convention on Wetlands of International Importance Especially as Waterfowl Habitats, commonly known as the RAMSAR convention was established in 1971 and requires signatories to designate at least one wetland within their territory to the RAMSAR List of Wetlands of International Importance. Wetlands of relevance to this study refer to an area of marine water with a depth of no more than six metres at low tide (RAMSAR, 2006). Currently, there are 1,899 designated RAMSAR sites across the world however not all are marine. Aldebra Atoll in the Seychelles is a more recent (2010) RAMSAR marine designation (RAMSAR, 2010).

The United Nations Educational Scientific and Cultural Organisation (UNESCO) has two initiatives that include MPAs. The UNESCO World Heritage list has sites that are protected for conservation but also stimulate tourism. To be included on the UNESCO World Heritage list, site nominations must be of outstanding universal (*sic* global) value and must meet at least one of ten criteria (Table 1.1; UNESCO, 2008). Nominations for the UNESCO World Heritage list are made by the relevant national authorities and independently evaluated by three advisory bodies: 1) The International Council on Monuments and Sites (ICOMOS); 2) the World Conservation Union (IUCN); and 3) the International Centre for Study of the Preservation and Restoration of Cultural Property (ICCROM) (UNESCO, 2008). The Great Barrier Reef World Heritage Area (GBRWHA) in Queensland (which also encompasses the Great Barrier Reef Marine Protected Area), and Shark Bay in Western Australia are Australian marine examples that are inscribed on the UNESCO World Heritage List (Woods, 2007).

Table 1.1. Selection criteria for UNESCO World Heritage List nominations (UNESCO, 2008).

Criteria	Criterion Number	Selection Criteria Description
Cultural criteria		
	i	Represent a masterpiece of human creative genius
	ii	Exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design
	iii	Bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared

Table 1.1. cont.

Criteria	Criterion Number	Selection Criteria Description
	iv	Be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history
	v	Be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change
	vi	Be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria)
	vii	Contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance
Natural criteria		
	viii	Be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features

Table 1.1. cont.

Criteria	Criterion Number	Selection Criteria Description
	ix	Be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals
	x	Contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation

UNESCO also initiated the Man and the Biosphere Programme (MAB) in 1971 from the Conference on the Rational Use and Conservation of Resources of the Biosphere, which took place in 1968 (Batisse, 1980). The aim of MAB was to set up "biosphere reserves" for: 1) the conservation genetic resources and ecosystems and maintenance of biological diversity; 2) establishing an international network of areas for MAB research and monitoring; and 3) associated environmental protection and land resources development as a governing principle for research and education activities (Batisse, 1980, 2003).

The concept of biosphere reserves was developed by terrestrial ecologists and includes functional zonation patterns that are more applicable to terrestrial environments. These zonation patterns consist of a "core area" for protection, a "buffer zone" where conservational activities may take place, and transition areas which help develop sustainable resource management practices for the surrounding human population (Figure 1.2). The first biosphere reserves were set up in 1976, with 562 being listed in 192 different countries in 2010 (http://www.unesco.org/mab/doc/brs/BRList2010.pdf). The MAB programme has had problems in coastal biosphere reserves, mainly due to the dense human population along the world's coasts and the high value of coastal resources and activities (Batisse, 2003). The marine aspect of a coastal biosphere reserve also needs to be protected from terrestrial based impacts, such as effluent from human activities (Batisse, 1980).

The European Commission in 1992 developed the Habitat Directive and Bird Directive in order to protect animals and habitats which were of European importance and provide for the creation of 'special areas' of conservation throughout Europe (Paavola, 2003/2004). There are 144 Habitat Directive special areas of conservation found in Denmark, France, Ireland and the United Kingdom (http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm). For example, the Isle of May special area of conservation was designated in 2001 (Woods, 2007).

Because there are so many different initiatives that exist for designating and managing MPAs, the World Conservation Union (IUCN) called for the marine coastal, and freshwater protected area sites to be incorporated into a worldwide network of protected areas at the Bali Action Plan in 1982 (Salm and Clark, 1984; Gubbay, 1995). Consequently, the definition for a protected area was developed at the fourth World Wilderness Congress and adopted by the IUCN in 1988, in which protected areas are defined as "*an area of land and/or sea especially dedicated to the protection of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*" (Kelleher and Kenchington, 1992). Many marine sites that fit this definition have been given names more similar to terrestrial protected areas, such as reserve, sanctuary or park (Kelleher and Kenchington, 1992; Gubbay, 1995), due to domestic regulations and terminology that is specific for individual states or countries. However, the IUCN definition is still currently used by many MPA managers and is used as the main definition of an MPA within this thesis.

1.1.2 The benefits of MPAs

The most crucial environmental benefit MPAs offer is increased ecosystem health and resilience, with a rapid increase in density, biomass, individual size, and biodiversity across all functional groups occurring within MPA boundaries wherein extractive activities such as fishing are restricted (no-take MPA) (Halpern, 2003; McCook *et al.,* 2009). A healthy stable ecosystem increases its ability to absorb shocks, resist catastrophic phase shifts and regenerate after natural and human disturbance (Folke and Moberg, 2000; Bellwood *et al.,* 2004). The species that respond most rapidly to protection are often sedentary invertebrates and fish because most of their life history is spent within an MPA boundary (Gell and Roberts, 2003). Within Australia, the network of MPAs with the Great Barrier Reef Marine Protected Area GBRMPA has enabled researchers to measure these benefits at different levels of protection. One result of this research is evidence produced by McCook *et al*., (2009) that revealed fish densities were two times greater in no-take MPAs (Mapstone et al., 2008) and that the out-break frequency of the Crown of Thorns Starfish (COTS) was seven times greater in non-protected, exploited areas (Sweatman, 2008).

MPAs also have positive effects on fish populations adjacent to the MPA boundary, which occur by two mechanisms. The "spillover" effect, which is a term for net emigration of adults and juveniles across MPA borders and the export of pelagic eggs and larvae from broodstock within the MPA (Bohnsack, 1998; Roberts *et al.,* 2001; Gell and Roberts, 2003). Roberts et al (2001) conducted studies in the Caribbean nation of Saint Lucia which found that after five years of protection from fishing, the Soufrière Marine Management Area had catch increases per trap of 36% in big traps soaked overnight and an 80% increase in catch per small lift trap soaked for 1-2 hours.

The integration of 'no-take' areas within larger multiple-use MPAs aims to accommodate differing user expectations, thus eliminating stakeholder conflicts and promoting a basis for responsible use and attitudes (Agardy, 1994; Agardy *et al.,* 2003). This can be important for maintaining traditional customs and uses which have remained as sustainable over long periods of time (Agardy, 1994).

Despite the socio-economic cost from lost fishing grounds, MPAs can offer economic benefits by direct enhancement and diversification of eco-tourism and allowing non-extractive activities such as scuba diving, recreational boating, and glass bottom boat users (Bohnsack, 1998; Lester and Halpern, 2008). These spin-off activities will potentially provide enhances socio-economic benefits to the MPA regions.

1.2 MPA management

The ocean is a public resource and for any marine conservation effort to be successful the management goals and objectives should reflect the desires of all stakeholders, if possible. Therefore, effective MPA designation and management should take biological and ecological characteristics into account, but also be flexible enough to address the social and political atmosphere of the local environment (Salm and Clark, 1984; Salm and Price, 1995; Nowlis and Freidlander, 2004; Weeks *et al*., 2010).

In order to accomplish the broad range of objectives needed to appease all stakeholders and to reduce stakeholder conflict, it is important for MPA planners and managers to clearly define management objectives for MPA networks or individual MPA (Jones, 1994; Kelleher, 1999; Agardy *et al.,* 2003). To help MPA managers and decision makers, the type of protection an area receives can be categorised by the IUCN protected area categories (1994) (Table 1.2). The category of an MPA will likely be based on its primary, secondary and tertiary (potential) management objectives (Table 1.3) (Gubbay, 1995). The management objectives will determine if an area can be managed by a single category of MPA or whether a system of zones should be used (Kelleher, 1999). These zones are often separated by a 'buffer' zone (not to be confused with a biosphere buffer zone) where activities are less strictly controlled than the initial area of protection (Figure 1.1; Gubbay, 1995; Gibson and Warren, 1995). This 'buffer' is used to dilute impacts of activities adjacent to highly protected areas (Day, 2002).

Table 1.2 Protected area categories set out by the IUCN (1994).

Protected area category	Type of protection
I	**Protect area managed mainly for science or wilderness protection** (Strict Nature Reserve/Wilderness Area
II	**Protected area managed mainly for ecosystem protection and recreation** (National Park)
III	**Protected area managed mainly for conservation of specific natural features** (Natural monument)
IV	**Protected area managed mainly for conservation through management intervention** (Habitat/Species Management Area)
V	**Protected area managed mainly for landscape/seascape conservation and recreation** (Protected Landscape/ Seascape)
VI	**Protected area managed mainly for the sustainable use of natural ecosystems** (Managed Resource Protected Area)

Table 1.3. Protected areas management objectives and IUCN protected areas management categories matrix (IUCN, 1994) Primary objectives 1 (green); Secondary objectives 2 (Blue); potentially applicable objective (Tertiary; orange) 3.

Management objective	**Ia**	**Ib**	**II**	**III**	**IV**	**V**	**VI**
Scientific research	1	3	2	2	2	2	3
Wilderness protection	2	1	2	3	3	_	2
Preservation of species and genetic diversity	1	2	1	1	1	2	1
Maintenance of environmental services	2	1	1	_	1	2	1
Protection of specific natural/cultural features	_	_	2	1	3	1	3
Tourism and recreation	_	2	1	1	3	1	3
Education	_	_	2	2	2	2	3
Sustainable use of resources from natural ecosystems	_	3	3	_	2	2	1
Maintenance of cultural/traditional attributes	_	_	_	_	_	_	2

1.3 Global examples of Marine Protected Areas

The Leigh Marine Reserve (LMR) in New Zealand was first established in 1977 for scientific research purposes and is considered an IUCN category Ia protected area. The LMR has strict protection of marine resources, however New Zealand's Marine Reserves Act 1971 reserves the right for all New Zealanders to access coastal marine areas and therefore the MPA is more of an intermediate between category Ia and II (Gubbay, 1995; Walls, 1998). Since its creation there have been positive trophic cascade effects which have caused phase shifts from sea urchin (*Evechinus chloroticus*) dominated reefs to macroalgae dominated reefs (Babcock *et al.*, 1999; Shears and Babcock, 2003).

The Hol Chan Marine Reserve (HCMR) in Belize is an IUCN category II and was established in 1987 (Gubbay, 1995; Gibson *et al.*, 2004). The HCMR is a multiple use MPA with four zones (zone A, B, C and D). Zone A is a no-take zone where non-extractive recreational activities are permitted. Zone B is a seagrass habitat where fishing is permitted with a licence in which only fishermen who traditionally used the area before it was protected are permitted. Trawling is prohibited throughout the zone, and spearing and netting of fish is also prohibited in certain areas. Zone C allows all activities from zone A and B as well as sport fishing boats which are registered. The setting of nets and cutting of mangroves is also prohibited in Zone C. Zone D is a traditional area where fisherman used to clean conch shell before bringing them to market. This has caused a congregation of sharks and rays in the area known as Shark Ray Alley, which is popular with snorkelers. Fishing is allowed in Zone D, except in areas surrounding Shark Ray Alley and wreck dive sites. Scuba diving and feeding fish by tourists is prohibited in the Shark Ray Alley area. The HCMR receives nearly 40,000 visitors a year, paying US$2.50 for access and an extra US$3.50 to enter zone D. These costs help sustain the operating costs of the HCMR which successfully enforces its regulations by having a daily warden on duty (Gibson *et al.*, 2004).

The Monitor National Marine Sanctuary (MNMS) in the United States was the first MPA designated by the National Oceanic and Atmospheric Administration (NOAA) in 1975 (Broadwater and Nutley, 2009). It was originally designated to protect the cultural heritage of the civil war ship the USS *Monitor* from looting and unwanted salvage. The MNMS management objectives make it an IUCN category II MPA (Gubbay, 1995) in which activities are regulated by NOAA. Activities that are prohibited in the MNMS are those which include the removal or injury of historic sanctuary resources and any alteration of the seabed (Broadwater and Nutley, 2009). In general, the United States has developed a National System of MPAs to conserve and manage natural heritage, cultural heritage and sustainable production (http://www.mpa.gov/dataanalysis/mpainventory/).

The Galapagos Marine Reserve (GMR) is a IUCN Category IV MPA designated in 1996 (Woods, 2007). The Galapagos Islands were also inscribed on the UNESCO World heritage list in 1978, meeting criteria's vii, viii, ix, and x (from Table 1.1; UNESCO, 2008). The GMR had a multiple use zoning scheme designated in 2000 with management objectives to reduce user conflicts, protect marine biodiversity, and promote sustainable use of resources. Four zone types were chosen to manage these objectives: 1) no-take areas for scientific use only; 2) no-take areas for tourism, recreation and education; 3) traditional fisheries management; and 4) areas with rotating closures or managed areas in the vicinity of ports and harbours (Edgar *et al.,* 2004a).

The National Marine Park of Allonissos, Northern Sporades (NMPANS) in Greece was established in 1992 specifically as a foundation for the conservation of the Mediterranean Monk Seal (*Monachus monachus*), making it a IUCN category V MPA (Gubbay, 1995; Oikonomou and Dikou, 2008). The NMPANS has management objectives to: 1) protect and conserve the terrestrial and marine environments of the Northern Sporades for natural heritage and resources; 2) protection of *Monachus monachus* habitat; 3) protection of rare and endangered flora and fauna that inhabit the islands; and 4) overall support the sustainable development of the rational use of resources. The NMPANS is split in to two zones (A and B), in which zone A is a top priority zone for *Monachus monachus* and special fishing restrictions apply that forbid trawling and purse seine nets (within 1.5 nautical miles from the coast), shell fishing, sponge fishing and scuba diving are also restricted in Zone A. Zone B is a buffer zone to Zone A and the same restrictions apply for trawling and purse seine nets (Oikonomou and Dikou, 2008).

Kiunga Marine National Reserve (KMNR) in Kenya was established in 1979 as a Biosphere reserve under the UNESCO MAB programme, and is listed as an IUCN category VI MPA (Gubbay, 1995; McClanahan *et al.*, 2005; Woods, 2007). The primary goal of the KMNR is to provide a safeguard for biodiversity and the integrity of ecological process for future generations.

1.4 MPAs in Australia and Tasmania

Australia is considered a leader in marine conservation efforts, with their MPA initiatives and National Oceans Policy (Sobel and Dahlgren, 2004). In 1991, the Australian government identified the need to establish a National Representative System of Marine Protected Areas (NRSMPA) in order to help meet Australia's responsibilities and obligations as a signatory to the Convention on

Biodiversity (CBD) (UNEP, 1994; ANZECC, 1998). The primary goal of NRSMPA, which was endorsed by all Australian governments, is to:

> *"establish and manage a comprehensive, adequate and representative system of MPAs to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and protect Australia's biological diversity at all levels"*(ANZECC, 1998).

The secondary goals are designed to coincide with the primary goal and promote and/or provide the following outcomes (ANZECC, 1998):

- "*Promote the development of MPAs within the framework of integrated ecosystem management;*
- *Provide management framework for human activities (recreation, tourism, shipping and extraction of resources (impacts must coincide with primary goal);*
- *Provide scientific reference sites;*
- *Provide special needs of rare, threatened or depleted species, and threatened ecological communities;*
- *Provide conservation of special groups of organisms;*
- *Protect areas of high conservation value; and*
- *Provide for recreational, aesthetic and cultural needs of indigenous and non-indigenous people*" (ANZECC, 1998).

To be included in NRSMPA four key characteristics must be met to set the MPA aside from other marine managed areas (ANZECC, 1998). These four characteristics are: 1) the MPA must be established exclusively for conservation and biodiversity purposes consistent with the primary goal; 2) the MPA must be classified into one or more of the six IUCN protected area management categories (Table 1.1); 3) designation of the MPA must be secure and only be revoked through Parliamentary process; and finally 4) the MPA must contribute to the comprehensiveness (include full range of ecosystems recognised at appropriate scale within and across each bioregion), adequacy (have the required level of reservation to ensure the ecological viability and integrity of populations, species and communities), or representativeness (selected MPAs should reflect biodiversity of marine ecosystems form which they derive) of the NRSMPA (ANZECC, 1998). This is referred to by Australian MPA managers as CAR (Comprehensive, Adequate, and Representative). By 1999 hundreds of MPAs had been developed, with only a small percentage qualifying as no-take zones (i.e., most are zoned multi-use; Sobel and Dahlgren, 2004b).

Within Australia, MPAs occur in Commonwealth and State waters and subsequently are managed at a Commonwealth (Commonwealth government agencies such as the Great Barrier Reef Marine Park Authority (GBRMPA)) level and/or state/territory level (individual state/territory governments such as New South Wales Marine Park Authority (NSWMPA)) (Figure 1.2). State MPAs are located within State waters as designated by the State jurisdiction of coastal areas: mean low water mark to 3-nautical miles offshore (http://www.dpiw.tas.gov.au/internnsf/Attachments/BHAN-5498UA/$FILE/MPABackground.pdf). Commonwealth MPAs are designated within the Australian Exclusive Economic Zone (EEZ), which starts after the 3-nautical mile mark and extends to 200 nautical miles offshore (http://www.environment.gov.au/coasts/mpa/nrsmpa/index.html). Although on occasion an MPA may be managed by the Commonwealth within a State jurisdiction, for example the Great Barrier Reef Marine Park (GBRMP) is located within the 3-nautical miles zone but is managed by the GBRMPA which is run by the Department of Sustainability, Environment, Water, Population and Communities Environmental, Water, Heritage and the Arts (DSEWPC) (http://www.environment.gov.au/coasts/mpa/nrsmpa/index.html).

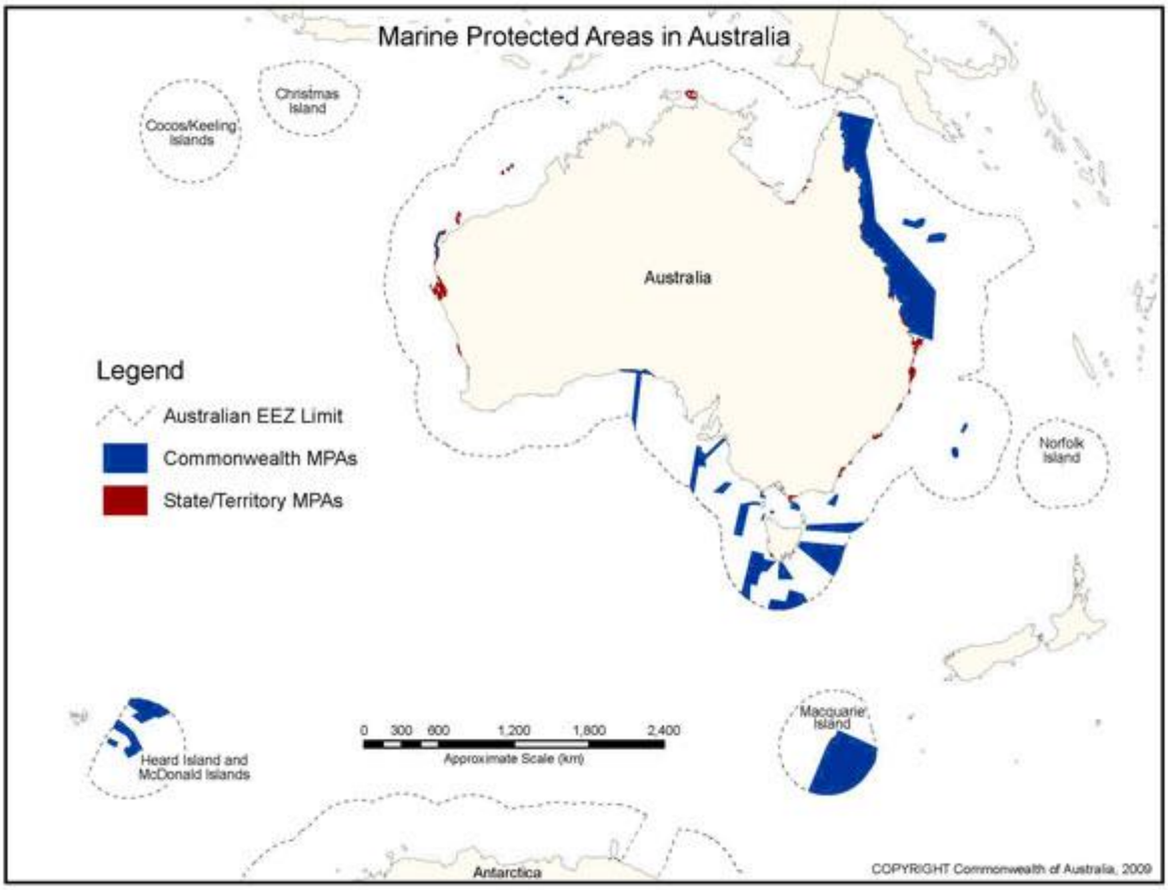

Figure 1. Commonwealth and State/Territory MPAs currently in Australia (http://www.environment.gov.au/coasts/mpa/nrsmpa/index.html).

The GBRMP in Queensland, Australia was first established in 1975 and is a good example of how MPA zoning works (Sobel and Dahlgren, 2004b; Woods, 2007). GBRMPA have used the IUCN guidelines to create a network of MPAs zones with different levels of protection in what is known as a multiple use (or multi-use) MPA. Within each zone certain activities are restricted or allowed with a permit (Table 1.3). They range from general use zones which cover 95% of the Great Barrier Reef (GBR) to scientific research/preservation zones which cover 115,396km² (0.2%) of the GBR (Day, 2002; Woods, 2007).

Within Tasmania (the focus of this study) there are 15 State managed MPAs (Table 1.4), with six MPAs categorised within the NRSMPA. The remaining nine sites are referred to as research areas (DPIWE, 2010) that could be considered to be MPAs by definition, however they do not fall within NRSMPA as they are not secure through parliamentary process and can be revoked at the State

Premier's discretion (R. Koch, Parks Tasmania, pers. comm., 2010). Tasmanian MPAs within and outside of the NRSMPA are summarised in Table 1.4.

Table 1.4. Marine Protected Areas within Tasmanian State waters, year of designation, their IUCN management category designation, primary objectives. *designates MPAs being assessed within this thesis.

MPA	Designated	NRSMPA?	Management Category	Primary Objectives
Tinderbox marine nature reserve*	1991	Yes	IV	Provide a safe, sheltered marine area for education, research and recreation (DPIWE, 2000)
Maria Island marine nature reserve	1991	Yes	II	Protect representative range of marine habitats found in Tasmania (DPIWE, 2000)
Ninepin Point Marine Nature Reserve	1991	Yes	IV	Protect unique assemblage of plants and animals in a unique environment (DPIWE, 2000)
Governor Island Marine Nature Reserve*	1991	Yes	IV	Protection for aesthetics, recreation and biodiversity (DPIWE, 2000)

Table 1.4. cont.

MPA	Designated	NRSMPA?	Management Category	Primary Objectives
Kent Group Marine Nature Reserve	2005	Yes	Ib	Provide marine sanctuary for rich marine life
Port Davey Marine Reserve	2005	Yes	II	Protect unique environment, aboriginal heritage, historic heritage and wilderness
Waterwitch Reef Research Area	2005	No	IV	Protection of species through management intervention (i.e. No taking marine organisms whilst diving)
Inner Sister Island Research Area	2005	No	IV	Protection of species through management intervention (i.e. No taking marine organisms whilst diving)
Swann Island Research Area	2005	No	IV	Protection of species through management intervention (i.e. No taking marine organisms whilst diving)
Bay of Fires Research Area*	2005	No	IV	Protection of Abalone through management intervention
Elephant Rock Research Area	2009	No	IV	Protected for scientific research purposes
North Bay Research Area	2005	No	IV	Protection of species though management intervention
George III Rock	2005	No	III	Protection for conservation of specific natural features

Table 1.4. cont.

MPA	Designated	NRSMPA?	Management Category	Primary Objectives
Doughboys Research Area	2005		IV	Protection of species though management intervention (i.e., No taking marine organisms whilst diving)
Taroona Waters (Crayfish Point)	2009	No	IV	Protection of species though management intervention
Flinders Sanctuary (Commonwealth)	2007	Yes	VI, Ia	Protection of shelf, slope and deep water ecosystems
Freycinet Sanctuary (Commonwealth)	2007	Yes	VI, Ia, II	Protection of shelf, slope and deep water ecosystems
Tasman Fracture (Commonwealth)	2007	Yes	I, VI	Protection of shelf, slope and deep water ecosystems

1.5 Threats to MPAs

The marine environment is fundamentally different to terrestrial environments, with natural processes such as ocean currents having a large influence on the dispersal of organisms, nutrients, and pollutants (Steele, 1985; Palmer, 1996; Allison *et al.,* 1998). Unlike terrestrial protected areas, it is difficult to create physical boundaries for MPAs which can protect what is inside the MPA. The lack of a physical boundary means threats (e.g., toxins, marine debris and non-indigenous marine species) and threatening process (e.g., habitat loss, pollution, phase shifts) can easily spread beyond the boundary of one MPA into many boundaries and that there are no mechanisms to effectively stop a threat or threatening process from entering an MPA. Therefore MPAs are potentially more vulnerable and hence need to be designed in a way which will prevent or reduce both natural and human hazards that may affect the MPAs management objective(s).

Natural hazards such as cyclones and tsunamis are largely unpredictable and unmanageable; however they are typically pulse disturbances that, due to them being a natural process, can have benefits to habitats though enhancing genetic diversity (Glasby and Underwood, 1996). There are other natural hazards to MPAs such as toxic algal blooms (red tides) or the natural range expansion of introduced species (Ling, 2008). These hazards are often synergistic with other human impacts such as runoff from agricultural activity or climate change (Halpern *et al.*, 2008). The management of natural impacts is difficult, but good MPA design and a well planned designation of MPAs can help minimise the impact of natural hazards (Batisse, 1993; Agardy, 2000).

Most MPAs are designed to allow humans to enter designated boundaries for recreational, commercial or cultural reasons. Unfortunately this means the majority of MPAs are not immune to human made impacts which can occur when activities occur close to or within the boundary of an MPA. Many MPAs are either directly or indirectly funded by the stakeholders that participate in activities within the MPA. For example, many MPAs that allow recreational scuba diving charge visitors an entry fee. The GBRMPA, HMMNR are two examples in which the tourism industry funds the management and enforcement of the MPA with a user pay system working in these MPAs. In many cases the designation of an area as an MPA can increase the abundance of visitors to the area because the area is seen as pristine and may contain larger fish due the fishing activity restrictions. Increased use within MPAs can lead to significant damage to reefs, where anchoring from boats and bad diving/snorkelling habits from novice SCUBA divers or snorkelers creates significant habitat loss to reefs (Davis and Tidsell, 1995).

No take MPAs can also be affected by fisherman who decide to fish directly adjacent to the boundary of an MPA in a process known as “fishing the line” (Kellner *et al.*, 2007). The problem with fishing the line of an MPA boundary is that there is no physical structure preventing impacts from outside the MPA getting passed the MPA boundary. For example, a boat that is fishing the line and has an oil spill may inadvertently lead to that oil entering the MPA on the currents. Unlike terrestrial protected areas such as national parks, it is impossible to build an impenetrable fence that prevents the entry of lost fishing gear, pollution and even non-indigenous marine species (NIMS). Apart from being a shipping hazard and expensive, to build such structure would also influence crucial ecological processes within the MPA, which in turn could lead to the failure of management objectives.

1.6.1 Humans as a vector for NIMS transfer into MPAs

Within this thesis I'm interested in examining how recreational users of MPAs can transfer NIMS into an MPA. The transfer of NIMS across the globe is considered one of the most prevalent threats to biodiversity and productivity towards the world's oceans (Bax *et al.*, 2003). Most management of introduced species looks at preventing NIMS entering a country at the pre-border or border through quarantine. However, when these species evade pre-border and border management attempts, post-border management is implemented. Post-border containment or eradication of NIMS relies on successful surveillance and incursion management to prevent further spread of introduced species (Campbell, 2008).

NIMS can also avoid post-border management techniques and be spread unknowingly by recreational marine users. This is referred to as unintentional introductions. Some NIMS can hitch-hike across large distances via attachment to recreational and commercial boating (hulls, ballast water and/or trailers), SCUBA/snorkelling and/or fishing gear (Johnson and Padilla, 1996; Hewitt and Martin, 2001; Bax *et al*., 2003). When combined, the ability of NIMS to spread post-border and the attractiveness of MPAs to recreational users create possible synergistic threat of a NIMS incursion within MPAs. This could possibly lead to a failure of MPA management objectives and a possible decline in biodiversity, ecosystem resilience, and human perceptions of value towards an effected MPA(s).

1.6.2 Human perception of MPAs and NIMS

If MPAs are there to protect human values, managers could rely on recreational marine users to take steps to prevent the spread of NIMS into MPAs. However, often MPAs are not perceived of as being present for human values and the perception of threat that NIMS may pose can differ between individuals (as with all perceptions). Some marine users may have had experiences with NIMS and see them as a threat, whereas some individuals may be oblivious to NIMS and therefore do not consider them a threat to their recreational activities. MPA and NIMS incursion managers need to help stakeholders understand the threat that NIMS pose so that the management of NIMS incursions into an MPA can be controlled and managed to ensure that MPAs efficacy and recreational user activities are not affected.

As well as having an understanding of NIMS threats, a stakeholder (i.e., a user of the MPA or marine environment) must have the ability to identify report and/or possibly remove specific NIMS that are known to have evaded pre-border management attempts and consequently spread regionally. The Australian government has recently started an initiative named the National System for the Prevention and Management of Marine Pest Incursions (NSPMMPI) to educate Australians on how to prevent the spread of NIMS related to various activities, such as recreational boating, and to inform the public on what NIMS are already found in different regions, or may be a threat in their region (http://www.marinepests.gov.au/marine_pests/pest_id_cards). It is yet to be seen if this information has reached the public effectively and whether the public can be relied upon to aid managers and decision makers in preventing post-border spread of introduced marine species.

1.7 Thesis aims

This thesis aims to explore whether NIMS are a threat to three MPAs in Tasmania, Australia, using two techniques:

1) A qualitative ecological survey to detect NIMS in the selected MPAs. This will help determine if NIMS have already spread into MPAs in Tasmania; and
2) Face-to-face surveys (questionnaires) of recreational marine users to determine if their activities and their self-rated knowledge of NIMS represent a marine biosecurity issue. This in turn will provide an indication of the threat humans pose as vectors of NIMS into the three studied Tasmanian MPAs.

A qualitative ecological survey using a nested sampling design was employed to detect NIMS within and outside the three study MPAs. The three MPAs for the ecological study are:

1) The Bay of Fires Abalone Research Area (41.11 °S 148.28°E), where collection of abalone is either not allowed or restricted in parts;
2) Governor Island Marine Reserve in Bicheno(41.36°S 148.05.°E), where diving and snorkelling are the only activities allowed; and
3) Tinderbox Marine Reserve (43.11°S .147.29°E), which is 25.5km south of Hobart (the State capital) and allows diving and snorkelling activities only, but has a boat ramp and boat moorings within the MPA and therefore increased visitation inside the MPA.

A survey instrument (questionnaire) was used to determine the recreational marine activities that occur at boat ramps close to the three MPA study sites and to assess the marine recreational users awareness of NIMS and their ability to identify four target NIMS (*Undaria pinnatifida*, *Asterias amurensis*, *Maoricolpus roseus*, and *Carcinus maenas*) that are already found in Tasmanian waters. Further information about the relevant materials and methods for each technique is provided in Chapters 2 and 3, respectively.

Chapter 2 provides the field sampling and results data on the presence/absence of NIMS within the three target MPAs. An analysis of people's ability to self-rate their skills at identifying NIMS is evaluated and discussed in Chapter 3, with a synthesis and discussion of the implications of the findings being provided in Chapter 4.

These chapters have been removed for copyright or proprietary reasons.

Chapter 4: Synthesis

4.1 Introduction

The attractiveness of marine protected areas (MPAs) for recreational marine users could make them vulnerable to invasion of non-indigenous marine species (NIMS). NIMS can lead negative impacts of ecosystems, such as loss of biodiversity, a reduction in native species, increased competition for food and space. Many MPAs are created with the aim to help preserve biodiversity and ecosystem health as well as help sustain fisheries populations. Therefore if NIMS are able to get into MPAs, they have the potential to jeopardize the effectiveness of the MPA.

4.1.1 Thesis Aims

This thesis aimed to determine the threat NIMS pose to three MPAs in Tasmania, Australia. Within this context the vectoring, from recreational activities, of NIMS into MPAs was explored as a mechanism to improve the management of MPAs and to ensure that MPA objectives are not reduced by introductions of NIMS. This was achieved by undertaking an ecological survey to determine the extent of NIMS in three Tasmanian MPAs and their adjacent areas. This was done in conjunction with an assessment of public awareness (perception) of NIMS in Tasmania using a questionnaire survey. This assessment was used to identify threats from recreational activities due to a lack of the public's awareness and the ability to control the problem posed by NIMS.

4.2 Are NIMS a threat in the three examined MPAS? Thesis outcomes

The first three hypotheses of chapter two were rejected as the prevalence of NIMS was different between MPAs (Bay of Fires Research Area, Governor Island and Tinderbox), inside MPAs and outside MPAs and IUCN categories (IV and VI). Chapter three found although self-proclaimed awareness of NIMS was high in Tasmania, the overall levels of accuracy for indentifying four NIMS was low, therefore indicating a low actual awareness.

The photographic survey found a small number of NIMS had established within the three sampled MPAs and in areas adjacent to the MPA boundaries. Out of the three MPAs the Bay of Fires Research Area (BOFRA) had the least amount of protection (IUCN category VI) but the highest prevalence of NIMS within the MPA. As a site, Tinderbox had an equal prevalence of NIMS as the Bay of Fires, however Tinderbox had more NIMS outside the Tinderbox MPA (IUCN category IV) than outside the MPA boundary. Bicheno contained few NIMS, and Governor Island (IUCN category IV) had smallest of the MPAs selected had only one quadrat with NIMS present.

NIMS that were found during the surveys are in fact a serious threat within MPAs. The presence of introduced kelps such as *Undaria pinnatifida* can lead to increased competition for light and substrate, leading to a decrease in other native kelp species (DeWreede, 1996). A mature *Undaria pinnatifida* plant attached to an anchor out of water will partially dehydrated, if undetected and deployed to the water again, the plant is likely to release spores dude to the rehydration of reproductive sporophyll (Forrest and Blakemoore, 2006; Acosta and Forrest,2009). In its non native range *Maoricolpus roseus* can reach very dense numbers leaving its dead shells to have a habitat altering effect on ecosystems (Probst and Crawford, 2008). *Asterias amurensis* are highly efficient bivalve predators and are known to aggregate in very high numbers during “outbreak” phases (Byrne et al., 1997).

4.3 Linking the ecological and human factors

The results from this thesis show that there is a threat of NIMS spreading around Tasmania and into its MPAs. Even though the results from the ecological survey on NIMS indicate MPAs have NIMS present within them, there are indications that more NIMS are encroaching into MPAs based on observations of local boat ramps, artificial structures and moorings, which have well established NIMS populations of *Undaria pinnatifida* (pers. obs.), *Crassostrea gigas* (pers. obs.), and *Grateloupia turuturu* (pers. obs.), for example. Although these species did not show up in the ecological survey their presence is known from personal observations and publications.

Having NIMS within such close proximity to these recreationally used structures increases the threat of a marine user taking on board NIMS, especially when their awareness levels are low (Johnson *et al.*, 2001). Upon picking up hitchhiking NIMS a recreational fisher, for example, may decide to fish or set a trap right on the boundary of the MPA and therefore facilitate the dispersal of

NIMS directly on or close to the invisible boundaries of the MPA. This may explain results in Tinderbox, which has an established *Undaria pinnatifida* population. Paradoxically, Tinderbox had the lowest percentage of marine users that could identify *Undaria pinnatifida* out of any of the other questionnaire sites. Also *Undaria pinnatifida* was found at a site which was next to the Pierson's point boundary. The site where *Undaria pinnatifida* was found in the survey had no artificial structures and was found at a depth of 5-8m. It is feasible to think the species had been transported via human vectors such as recreational boating, fishing or SCUBA diving.

The questionnaire revealed that although the recreational marine users of Tasmania appear to be aware of NIMS as a problem, they did not possess a strong capability to identify NIMS. This makes it difficult for MPA managers to rely on self- management by the public. In fact, a lack of awareness has the potential to contribute to the NIMS problem via people unknowingly spreading NIMS across the state on their recreational gear.

4.4 Strengths and weaknesses of this thesis and ways for improvement

The strength of this project lies in the use of social surveys to gauge the public's perception and their ability to self-rate their knowledge of NIMS. Improvements to the surveys would include using a Likert scale (a composite measure used to standardise response categories in social research; Babbie, 2010) for respondents to rate their level of awareness. This would give the interviewer a better idea of self-perceived awareness.

The questionnaire could have been more user friendly by being shorter in duration and thus ensuring that respondents weren't inconvenienced by a long questionnaire. At present the administered questionnaire took ten minutes to complete, which resulted in some people not completing the questionnaire. Shortening the duration could have been achieved by grouping types of marine activities together (underwater capture, surface capture, both). Yet, getting respondents to specify what activities they undertake provides a clearer idea of what marine activities are taking place within each site.

The use of pictures to test respondent's knowledge was successful to test the ability for respondents to identify NIMS. The use of photographs, as identification sheets or booklets, is a common practice within marine biosecurity in both Australia and New Zealand (http://www.marinepests.gov.au/marine_pests/pest_id_cards; http://www.biosecurity.govt.nz/pests/salt-freshwater/saltwater). Perhaps using multiple choice questions to ask respondents what they should do if they encounter NIMS, how they could prevent NISM spreading across the state, or even asking them to identify what parts of gear are vulnerable to help facilitating NIMS dispersal, may also provide some useful insights to the public's perception and ways forward for the management of this problem.

There were a few faults in sampling design, which if improved upon could have given a more certain outcome of the threat of human vectors moving NIMS into MPAs. The most obvious fault was the qualitative methods used, which did not take into account size heterogeneity and mobility of species and therefore led to a lack of certainty in identifying most of the NIMS. This could have been avoided by using semi quantitative methods and taking scrapings of the quadrats for further analysis in the laboratory with taxonomic keys. To do this, permits would obviously be required to take species out of an MPA. These methods would also give an idea of species diversity and composition in and outside the MPAs, which could be used to give MPA managers a better idea of the biodiversity and ecosystem health of the MPA.

Another weakness in the sampling design was the random placement of dive sites and transects. The project aimed to determine threats of NIMS invasion via human vectors. It may have been better to not only do the random sampling design as an ecological survey, which would compare NIMS compositions against native species. It would have been useful to target areas which are vulnerable to NISM invasion, such as artificial structures (boat ramps, moorings, break walls). As mentioned NIMS have been found in high numbers at each site, around these areas but as they were not in randomly selected sites, they did not show up in the ecological survey data.

In order to determine the threat or, even the risk of NIMS spreading into MPAs, an analysis of vector strength (number of boats entering MPA or doing activates near the boundary) is vital to provide an idea of likelihood of invasion. To adequately determine the vector strength of each MPA the number of activities at each site must be recorded at the same day and time or record visitation each site for multiple days over a long enough sampling period to get robust data.

4.5 Conclusions and future questions

Two important pieces of information were found in this study. Firstly, NIMS were present in all MPAs that were sampled. This suggests that management of MPAs needs to be improved to better address the issue of MPAs. Secondly, the public lacks the ability to accurately identify NIMS. This infers that there is a knowledge gap between NIMS researchers/managers and the recreational marine users, or between researchers and managers of Tasmania. This information could be used by NIMS managers to help direct efforts in education/outreach of NIMS in Tasmania.

This project provides the basis for a risk assessment by providing one of the foundational steps in the risk assessment process – the elucidation of a threat to MPAs. A risk assessment that includes a vector analysis within MPAs could take this study further. The risk assessment could address questions like: what is the vector strength between MPAs that allow different activities based on zoning? Or, what is the vector strength between remote and more urbanised areas?

Analysing the number of NIMS found around vulnerable areas close to MPAs would also determine what species are more likely to establish within the MPA and what ecological impact their establishment is going to have within the MPA. Combining the vector strength and assessment of vulnerable areas will give a clearer understanding of the likelihood and consequences of invasion into MPAs. Also knowing what species are in the area will give a better idea of the potential consequences of a NIMS incursion; especially if the ecological impact of the particular NIMS involved is already known.

Once a risk assessment of NIMS establishment in MPAs is performed, a fully quantitative ecological survey would have to be performed to deem the risk assessment true or false. If the risk of invasion was thought be very high, but there were no invasive species found in the MPAs concerned. Table 4.1 summarises the main threats related to NIMS spreading into MPAs, including the human and ecological components of those threats, and remedies which could help minimize each threat.

Table 4.1. Summary of threats of NIMS spread, human and ecological components, with suggested remedies to minimize the threat of spread.

Threat of NIMS Spread	Human components	Ecological components	Remedies
Recreational activities as NIMS vectors (e.g., boat hulls/bilge, trailers, gear)	• Attraction to MPAs • Awareness of NIMS • Ability to identify NIMS • Ability and willingness to act on minimizing spread	• Establishment of NIMS into MPAs • Biodiversity loss • Increased competition for space and resources for native species • Loss of MPA gazetting due to biodiversity impacts	• Increased regulation on access to MPAs • Risk nodes (signage) at boat ramps and jetties • Education/outreach activities for recreational marine users • Cleaning stations at boat ramps with appropriate facilities for discarding NIMS.
Artificial structures	• Artificial structures used by recreational marine users (increased threat of establishment on artificial structures) • Threat of users inadvertently picking up "hitchhikers" and spreading NIMS to new locations	• Provide an empty niche for NIMS establishment • Building a structure will cause a disturbance, which can cause a loss of native species, increasing threat of NIMS establishment.	• Inspect and clean artificial structures regularly • Moorings should be checked and cleaned by owners regularly • Biofouling organism should be removed from structures and discarded appropriately
Natural spread of NIMS	• Awareness of NIMS at country/state/city(town) levels • Ability to identify foreign species • Ability to report and/or remove threat	• Spread due to natural dispersal mechanisms (e.g., currents, wind driven swells, wind, etc)	• Risk nodes (e.g., signage) in areas that could be threatened by potential NIMS • Effectively train the public to recognize NIMS and report any suspected threats

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Appendix A- The survey instrument (Questionnaire)

To whom it may concern,

I am a postgraduate student at the National Centre for Marine Conservation and Resource Sustainability at the Australian Maritime College, UTAS. I am assessing the risks posed to Tasmanian Marine Protected Areas (MPAs) by Introduced marine species already found within Tasmanian waters. This research will be conducted in accordance with the National Statement on Ethical Conduct in Research Involving Humans. If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on 03 6226 7479 or human.ethics@utas.edu.au. Part of my thesis involves assessing human activity within and around MPAs and you participation (which I anticipate will take approximately 10 minutes) in this questionnaire would be greatly appreciated.

Aim of questionnaire: To find out if public awareness of Introduced marine species and Marine Protected Area (MPA) can be correlated to the risk and impacts posed to Tasmania MPAs from Introduced species.

Boat ramp you visited today:

a. Tinderbox	b. Triabunna	c. Bicheno
d. St Helens	e. Mt. Williamson National Park (Eddystone point)	f. Other ________________

Other:

Section 1- Demographics. ***These few questions are required to analyse the results of this survey by comparing your responses with others. All answers are kept completely confidential***

1. What is you postcode?

2. What is your Age? (Circle one)

   16-25 26-35 36-45 46-55 56-65 65 and over

3. What is your gender? (Circle one)

   Male Female

4. What is your yearly income (Circle one)?

    a. AU$1-6000
    b. AU$6001-34000
    c. AU$34001-80000
    d. AU$80001-180,000
    e. AU$1800000+

5. What is you highest level of education?

a. Primary	b. Secondary	c. Tertiary	d. Postgraduate

Section 2-Activities

6. Please tick all marine activities you participate in.

Boating	Line & Rod fishing	Spearfishing	Gill net fishing	Rock lobster & Crab pot fishing
Scuba diving	Snorkelling	Photography	Abalone fishing	Rock lobster (diving)
Kayaking	Surfing	Waterskiing	Jet Ski	Scallop fishing

Other(s): ____________________________

7. Which activities are you planning on using today?

Boating	Line & Rod fishing	Spearfishing	Gill net fishing	Rock lobster & Crab pot fishing
Scuba diving	Snorkelling	Photography	Abalone fishing	Rock lobster (diving)
Kayaking	Surfing	Waterskiing	Jet Ski	Scallop fishing

Other(s) : ____________________________

	Once a week	Once a Month	Once every six Months	Once a year

8. How often do you come to this boat ramp for marine activities in a year?				
9. How often do you undertake any marine activities a year?				

Section 3-Equipment maintenance

10. Do you own a boat (including jet ski's)? (if no go straight to question 14)

YES/NO

11. Where do you store your boat, if your answer is c or d where?

   a. Dry docked at home
   b. Moored near home
   c. Dry docked in a marina/yacht club. Where? ____________________
   d. Moored at marina/yacht club. Where? ____________________

	Once a week	Once a Month	Once every six Months	Once a year
12. How often do you clean your recreational gear? (Including dive, fishing, kayaks)				

	Fresh water	Soap and water	Products to prevent biofouling (unwanted marine life on hull
13. How do you clean your boat			

14. Does your boat have any anti fouling paints on the hull?

YES/NO

	Rinse with freshwater	Soak in freshwater	Clean with soapy water	Clean with disinfectant then rinse
15. How do you clean your gear	●	●	●	●

Section 3- Marine Protected Area (MPA) awareness

16. Do you know the MPA(s) in this area

    YES/NO

17. What activities are allowed in the MPA closest to this boat ramp?

    a. Only diving
    b. Diving and restricted fishing
    c. Diving, fishing, but no take of Rock Lobster
    d. Diving Fishing, but no take of abalone

18. Would you have come to this area if this was not an MPA?

    YES/NO

Please rate the following MPA questions from strongly disagreeing to strongly agreeing.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
19. Do you agree with the designation of MPAs?					
20. MPAs protect biodiversity					
21. MPAs sustain fisheries within the MPA					
22. MPAs sustain fisheries adjacent to the MPA					
23. MPAs protect the aesthetic value underwater within the MPA					
24. If coastal MPAs protect the aesthetic value of the coast within the MPA					
25. MPAs ruin the culture of recreational marine activities in Australia					
26. MPAs ruin indigenous marine cultures of Australia					

27. Please rank (1=most important, 4=least important) the benefits of MPAs that are important to you.

Protection of biodiversity	Protection of fisheries	Protection aesthetics	Protection of culture

Section 4- Invasive species awareness

28. Are you aware of introduced species in Tasmania?

YES/NO

	A	B	C	D
29. Which of the following is Japanese kelp “wakame” (*Undaria pinnatifida*)?				Don’t Know
30. Which of the following is the Northern Pacific sea star (*Asterias amurensis*)?				Don’t Know
31. Which of the following is the New Zealand screw shell (*Maoriocolpus roseus*)?				Don’t Know
32. Which of the following is the European green crab (*Carcinus maenus*)				Don’t Know

33. Have you seen any invasive species in this MPA?

YES/NO

34. If so which ones? Please List

35. What did you do about it?

a. Remove only	b. Remove & Report	c. Report only	d. Nothing

36. If you answered d(nothing) to Q35, why?

a. Too busy	b. Did not know where to report	c. I thought it was already know to be there	d. Was not a big deal

Please rate the following Introduced species questions from strongly disagreeing to strongly agreeing.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
37. Introduced species increase biodiversity?					
38. Introduced species can lead to a reduction of native species?					
39. Introduced species out compete native species?					
40. Introduced species can reduce the aesthetic value of an area?					
41. Introduced species are health and safety risks?					
42. Introduced species can ruin the cultural value of an area?					
43. MPAs keep introduced species out of the MPA boundary					
44. Boats do not transport introduced species from one place to another					

45. Please rank (1=highest impact-5=least impact) the impacts introduced species have on your marine activities?

Loss of biodiversity	Reduction in native species	Out competing native species	Loss of Aesthetic value	Loss of cultural value

Thank you for your time in answering this questionnaire.