

Issues in Defining the Concept of a Marine Cadastre for Australia

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ABSTRACT

Australia's ratification and subsequent implementation of the United Nations Convention on the Law of the Sea has given the government responsibility for the management of a marine environment double the size of the country's land mass. Such a management initiative must take into account the economic, social and environmental needs of marine stakeholders, as well as incorporating international and national tools of governance.

In the terrestrial environment, it is the cadastre and initiatives such as the creation of the Australian Spatial Data Infrastructure (ASDI) that are facilitating greater decision making in areas such as sustainable development. The ability of such tools and initiatives to facilitate effective decision-making and spatial data access mechanisms within the marine environment has given rise to research into a marine cadastre. Such a cadastre aims to define, visualise and realise legally defined maritime boundaries and the rights, restrictions and responsibilities attached to them.

With this in mind, this paper aims to identify and quantify the various themes which are driving the development of an Australian marine cadastre, as well as attempting to define the concept of a marine cadastre through an investigation into the current international research into marine cadastral systems.

KEYWORDS: marine cadastre; SDI; marine rights, restrictions and responsibilities.

INTRODUCTION

Australia lays claim to one of the largest maritime jurisdictions in the world, covering an area over double the size of the country's land mass, and extending up to 200 nautical miles from the coastline. Given the diversity of this area, there is an economic, social and environmental need to effectively manage it. Current policy and institutional frameworks for the governing of this ocean territory are complex, with government legislation and international treaties such as the United Nations Convention on the Law of the Sea (UNCLOS) needing to be considered (Collier *et al.* 2001). Underpinning this legislative framework is the complex relationship and interaction between overlapping and often competing rights, restrictions and responsibilities of stakeholders both in the marine environment and at the land-sea interface.

Based on this situation, a management framework such as a marine cadastre needs to be created, in order to provide the foundation from which management issues, including the global focus on sustainable development within the marine environment, can be addressed. In the terrestrial environment, it is the cadastre and initiatives such as the creation of the Australian Spatial Data Infrastructure that are facilitating greater decision making in areas

such as sustainable development. The ability to utilise such tools within the marine environment is currently being researched through the creation of a marine cadastre for Australia.

Before a marine cadastre can be conceptualised however, it is important to fully understand the sustainable development issues that are driving its development. The current systems in place to manage marine boundaries and rights also need to be assessed, in order to identify the technical, legal and institutional issues and arrangements which are hindering the coordination of effective marine management. The various initiatives being undertaken by government and academia to address such issues are also closely scrutinised, leading to research being undertaken into the concept of a marine cadastre, as a framework to facilitate sustainable management objectives. This includes a review of international research on the topic, and demonstrates the concept of a marine cadastre through the use of a marine cadastre model diagram. The main objective of this paper however is to describe the concept of a marine cadastre for Australia, focussing on current research being undertaken in the Department of Geomatics at the University of Melbourne.

SUSTAINABLE DEVELOPMENT AND THE MARINE CADASTRE

There is an increasing realization that the interests of a nation do not stop at the land-sea interface (Collier *et al.* 2001). The economic, environmental and social impacts that this realization is having on the marine environment are just beginning to be felt, with competition for the vast array of natural resources ever increasing. Added to this is the implementation of the United Nations Convention on the Law of the Sea, which came into force in 1994. This has given rise to the need for more efficient and effective maritime boundary management techniques, such as a marine cadastre, to be put in place within Australia's maritime jurisdiction.

One of the main drivers in implementing a marine cadastre comes from the environmental movement and the effect it has had on politics and society. Issues of pollution, depleted marine resources and increased threat by man to the health of the marine environment are forcing governments such as Australia's to implement sustainable development measures. According to the Australian Fishing Management Authority (AFMA, 2000), 70% of all marine pollution comes from land based activities and many of Australia's fishing zones have been over fished, leaving stock numbers dangerously low. There is also international pressure to implement legal and institutional mechanisms to support sustainable development. For this to be achieved however, new approaches to marine and coastal area management and development are required (Robertson *et al.*, 1999).

The marine environment is subject to as many pressures as the terrestrial environment and recognition of its actual and potential value as an economic resource is rapidly developing (Widodo, 2003). Industries such as oil and natural gas exploration are just two of the major sources of revenue for both government and private industry, with competition increasing for control over marine areas with vast arrays of natural resources. This makes the effective management and delimitation of Australia's coastal area increasingly important.

There is also a growing awareness of the need to recognize the rights that indigenous people have to both land and sea, with international initiatives and domestic court rulings giving increased focus to the indigenous peoples movement (Robinson and Mercer, 2000). The Common Law of England recognized that all of Australia was in possession of the indigenous people before British settlement in 1788, but property and rights were taken away by the government in Australia, when it pronounced Australia as *terra nullius*, or land belonging to no-one. It was not until the High Court's 1992 decision in *Mabo v. the State of Queensland*,

that it was judged to have been done “wrongfully, without compensation and contrary to the spirit of British property law” (Reynolds, 2000). In 2001, indigenous rights to the sea and sea-bed were formally recognized with the High Court ruling that non-exclusive native title existed in the offshore region of the Crocker Island, off the coast of the Northern Territory. Although a victory for the indigenous people, this non-exclusivity meant that non-aboriginal people and commercial fisherman could still enter native title areas without asking permission and without negotiating compensation over fishing and other developments (Robertson, 2002). The existence of such rights makes it difficult to effectively manage native title areas under Australia’s current system, driving the need to introduce a framework such as a marine cadastre, in order to facilitate a greater degree of cooperation between stakeholders.

Issues and Problems with Australia’s Current Marine Management System

As discussed above, the ability to sustainably manage and develop Australia’s marine environment is of a high priority. The environmental, economic and social dimensions that this entails have forced a review of Australia’s current management systems, to identify issues and areas which need to be addressed or improved, in order to facilitate more cooperative management arrangements between stakeholders and users of the marine environment.

Australia operates under a state/Federal system of governance, with areas such as health, education and land administration managed by the state, and monetary, defence, foreign affairs immigration and trade issues administered by the Federal government (Dalrymple, *et al.* 2003). This division of jurisdictional responsibility also occurs within the marine environment, with the states and northern territory holding sovereign jurisdictional responsibility from the Low Water Mark out to a limit of three nautical miles (called Coastal Waters). The Federal jurisdiction begins from this point and extends out to the Territorial Sea boundary at 12 nautical miles, which is the legal limit of Australian sovereignty (Figure 1). The various maritime zones which Australia has declared under the guidance of UNCLOS are explained in Table 1.

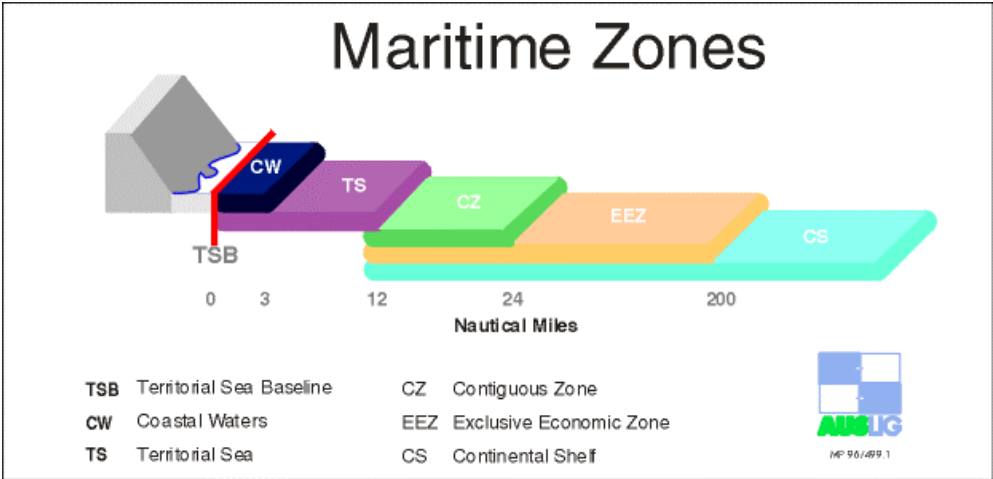


Figure 1: Australian Maritime Zones (AUSLIG, 1999)

Zone	Definition	Coastal State Jurisdiction
Territorial Sea Baseline (TSB)	The line from which the seaward limits of Australia's maritime zones are measured, theoretically the line of Lowest Astronomical Tide (LAT).	
Coastal Waters	Waters from the TSB out to a limit of three nautical miles.	Jurisdiction rests with the states and Northern Territory. Not defined under UNCLOS.
Territorial Sea	Band of ocean adjacent to the coastline, the outer limit of which does not exceed 12 nautical miles from the TSB.	Australia has full sovereign rights within this area, with the exception that it must allow foreign ships the rights of innocent passage.
Contiguous Zone	Band of ocean adjacent to the territorial sea (12nm), with the outer limit of the contiguous zone not exceeding 24 nautical miles from the TSB.	Australia does not have sovereign jurisdiction over this area, although it does have the right to enforce its customs, fiscal, immigration and sanitary laws and regulations.
Exclusive Economic Zone (EEZ)	Area stretching from the limit of the territorial sea (12nm) to out to and not exceeding 200 nautical miles from the TSB.	Australia has the right to explore and exploit the living and non-living resources of the water column, seabed and subsoil.
Extended Continental Shelf	A nation may gain rights to an extended continental shelf beyond the 200 nautical mile limit, up to 350 nautical miles from the TSB, subject to the provisions of Article 76 of the UNCLOS.	Australia would gain seabed and subsoil rights to any areas of an extended continental shelf granted under the UNCLOS.

Table 1 – Australia's Maritime Zones (UN, 1997)

The final jurisdictional area illustrated in Figure 1 and described in Table 1 is the Continental Shelf. A coastal State such as Australia, can apply to the United Nations to extend its rights to the marine environment past its EEZ to a distance of 350 nautical miles. Under UNCLOS, “the coastal State exercises over the continental shelf sovereign rights for the purpose of exploring and exploiting its natural resources”, enabling Australia to increase its economic gain in the marine environment. If such an extension is to be granted however, the coastal State must accurately define the new area, and demonstrate a capability and intent to administer it in terms of sustainable development obligations (Robertson *et al.*, 1999). Having said that, the development of a framework such as a marine cadastre would aim to aid in facilitating decision making in order to meet such obligations. There are however a number of legal, institutional and technical issues which would need to be overcome in order for this to occur.

Legal Issues

The current legislative arrangements for the management of Australia's maritime zones involves not only UNCLOS, but also a complex web of state and Commonwealth legislation, which must take into account over 50 international treaties and conventions that Australia is a party to (NOO, 2002a). Australia also has in place the Offshore Constitutional Settlement (OCS), which is the legal tool that enables offshore jurisdictional responsibility to be shared between the states and Commonwealth. The OCS allows for joint management arrangements to be put in place, which in some cases gives the states legislative jurisdiction beyond their Coastal Waters. An example of this is the management of offshore mining, with the relevant Commonwealth Acts conferring day-to-day administrative responsibilities to the states (Rothwell and Haward, 1996).

The ability of the legislation in place within Australia to effectively govern stakeholder activities in the marine environment is currently hindered by a degree of ambiguity throughout much of it. An example can be found when dealing with the definition of “high

water”, the boundary to which property and council rights extend. Within one piece of legislation, high water is defined as “the mean height of the higher tide at spring tides”, and within another as “the ordinary high water mark at spring tides”, as seen in Table 2 below.

QLD	Department of Primary Industries	high water	FISHERIES ACT 1994 - SECT 4	"high water" means the mean height of the highest high water at spring tide .
QLD	Department of Primary Industries	high water	MARINE PARKS (CAIRNS ZONING PLAN) ORDER 1992 - SECT 2 Interpretation	"high water" means the mean height of the higher tide at spring tides ;
QLD	Environmental Protection Agency	high water mark	COASTAL PROTECTION AND MANAGEMENT ACT 1995 - SCHEDULE 2	"high water mark" means the ordinary high water mark at spring tides .
QLD	Department of Primary Industries	high water	MARINE PARKS (WOONGARRA ZONING PLAN) ORDER 1991 - SCHEDULE 1	"high water" means the Mean High Water Spring (MHWS) tide level ;

Table 2 – Definitions of high water (Based on Finney, 2002)

The ability of stakeholders to identify which legislation applies to their particular activity is also an issue, as the way in which spatial descriptions are embedded within legislation varies and is often hard to understand. This is due to two factors. The first, is that older legislation which has not been updated uses an outdated system of delimitating boundaries, which is not accurate enough to make an informed decision on the ground, as to where a boundary is. The second fact is that the people who write the legislation do not have a spatial background. Even when legislation is updated, the spatial data community is not asked to comment on how to write in accurately defined boundaries. Both of these factors can result in ambiguous spatial definitions of geographic areas or boundaries in legislation.

The sheer volume of legislation concerning the management of the marine environment is also an impediment to effective management, as the National Oceans Office (2002a) has identified “roughly 600 pieces of state, Territory and Commonwealth legislation [which] currently manage ocean use and ecosystem health in Australian waters”.

Institutional Issues

The volume and nature of stakeholder activity in the marine environment is different to that on land. In the majority of cases, the rights of stakeholders can overlap often creating competing rights, restrictions and responsibilities. This creates the need for cooperation between managing agencies which does not always occur. Often, such agencies are in isolation from one another, and hence do not have clear spatial certainty of each other’s rights, restrictions and responsibilities.

This lack of spatial certainty is compounded by the inability to gain access to up-to-date and accurate spatial information on stakeholder activity in the marine environment. This limits the ability to make speedy and informed decisions. The collection and dissemination of spatial data is often timely and expensive, and without the cooperation of all stakeholders, the same type of data could be collected by a variety of agencies.

The spatial data that is collected in the marine environment also needs to be compatible with data collected from the terrestrial environment. This is due to the fact that there is currently some confusion about the management of the land-sea interface, with local governments

managing land to High Water Mark (HWM), and state governments managing the marine environment from the Low Water Mark (LWM). This means that there are no overlapping arrangements in place to enable efficient coastal zone management. There is also a strip of land between the two boundaries which is not within a management jurisdiction at all. If a marine cadastre is to be implemented, it needs to be compatible with its land based counterpart. This would bridge the gap between the terrestrial and marine environments, aiding in coastal environmental and planning issues such as:

- Development planning for various types of urban, industrial and tourism activities;
- Waste disposal management from local farms, coastal residents, tourist or recreational users, which have outlets or run-off into the marine environment;
- Public health and safety issues involving oil companies, local residents and other marine users;
- Environmental issues between local residents, fisheries and environmental organisations
- Commercial and recreational fishing activities within and around marine parks;
- Commercial harvesting of living and non-living natural resources.

(Widodo, 2003)

The key to bridging this gap and addressing other institutional problems is the creation of a lead agency in the marine environment. This agency would be responsible for facilitating an overarching framework for Australia's oceans, providing guidance on access to spatial information and addressing issues of national importance.

Technical Issues

This discontinuity between the land and marine environments is compounded by the inability to accurately define tidal datums such as Low Water Mark, which are used to determine the boundaries between international, national, state and private rights. This influences the ability to accurately map coastal and shoreline areas, as tidal ranges can vary from almost zero to hundreds of meters in coastline areas such as Western Australia and the Northern Territory. As mentioned in the discussion of legal issues effecting the marine environment, the language used to describe such tidal datums also varies, adding further confusion to the ability to define and map Australia's coastal area.

The Low Water Mark is also the boundary from which Australia's Territorial Sea Baseline (TSB) is drawn, the line from which maritime boundaries are created. The ambulatory nature of the TSB, due to the constantly changing nature of the coastline, means that it needs to be consistently updated. The Australian Maritime Boundary Information System (AMBIS) provides access to data for Australia's TSB and maritime zones (AUSLIG, 2001, Widodo, 2003) and would need to be part of any marine cadastre initiative. It is the best available information, maintained and freely available, however there is legal uncertainty in regards to the boundaries contained within AMBIS and the quality of the data varies, relative to the capture method and source (Robertson, 2002a).

The other major technical issue is the three dimensional nature of the marine environment, with different activities occurring on the surface of the ocean, across the water column and beneath the sea-bed. There are also instances where a fourth dimension (time) is added. An example of this is in the regulation of seasonal fisheries which open and close during various times of the year. The modelling of such 3D and 4D spatial characteristics is a major hurdle to the development of a true spatial representation of rights, restrictions and responsibilities in the marine environment, which the marine cadastre aims to accomplish.

The issues described above can often lead to competition and conflicting interests between users. In order to address these problems, stakeholders should have clear spatial and legal certainty of their rights, restrictions and responsibilities in the marine environment, something which the current marine management systems do not fully provide.

Current Australian Marine Management Initiatives

There are several initiatives that have been set up to attempt to deal with the legal, institutional and technical issues in relation to the management of the marine environment. The Federal Government has taken the lead by launching the National Oceans Policy in 1999. This is aimed at promoting the strong, diverse and internationally competitive marine industry base through ensuring the long term ecological sustainability of ocean use. The cornerstone of the policy is the development of Regional Marine Plans, which “aim to set in place a framework for integrated ecosystem-based planning and management for all of Australia’s marine jurisdictions” (Australia’s Oceans Policy, 1998). The development of a marine cadastre would compliment such a strategy, helping to create a base layer of information from which sustainable management objectives could be launched.

The issue of access to accurate and up-to-date spatial information in the terrestrial environment is currently being addressed through ANZLIC, the spatial information council. Their role is to facilitate easy and cost effective access to the wealth of spatial data and services provided by a wide range of organisations in the public and private sectors (ANZLIC, 1998). In order to achieve this, nationally agreed policies and frameworks aimed at achieving “best practice” in spatial data management are being developed, through the Australian Spatial Data Infrastructure (ASDI).

Spatial Data Infrastructure (SDI) is an evolving concept which aims to facilitate and coordinate the exchange and sharing of spatial data between stakeholders from different jurisdictional levels in the spatial data community. Australia is one of the leading nations to recognise the important of developing such an infrastructure to facilitate data access and sharing. The SDI initiative at a national level is being coordinated by ANZLIC who have recently updated and expanded their definitions for the ASDI to incorporate both land and marine environments.

As a result of the incorporation of the marine environment into the scope of the ASDI, the Heads of Marine Agencies formed the Australian National Marine Data Group in August 2001. They are responsible for the development and promotion of improved standards and processes for the interchange of marine data. This is the major spatial information initiative in the marine environment. Their program is implemented through technical working groups focussed on data standards and protocols, in the areas of:

- Marine Cadastre;
- Bathymetry;
- Habitat and Species;
- Physical Oceanography and Meteorology; and
- Coastal Zone.

At present the group is working to implement initiatives in order to address each of these themes and to develop data interchange standards and protocols within and across the marine environment (ANMDG, 2002). The ANMDG has established a close relationship with ANZLIC and an outcome of such is the acknowledgement of the need for a common data

access and management framework across both terrestrial and marine environments in the Australian Spatial Data Infrastructure (ANZLIC, 2002). The Intergovernmental Committee on Surveying and Mapping (ICSM) is also working closely with ANZLIC in supporting the development and implementation of the ASDI, as well as trying to resolve the legal and technical tidal datum issues.

The nature of the marine environment demands that each of these marine initiatives are not developed in isolation. They must be user driven, with collaboration from governments, the private sector and researchers. The creation of a marine cadastre aims to enable such collaboration, as it attempts to deal with the overall issue of addressing sustainable development objectives, pulling together the various technical, legislative and institutional issues discussed in this paper. For this to become reality however, further research into the concept of a marine cadastre needs to be undertaken, with the ARC Marine Cadastre Project being undertaken in response to such user demand.

ARC Marine Cadastre Project

Marine cadastre research in Australia has gained strong government support. Healthy coordination of the research effort is being maintained through the nurturing of close collaborative links between the government and academic sectors.

The major Australian marine cadastre research initiative is currently an Australian Research Council (ARC) funded two year project based in the Department of Geomatics at the University of Melbourne, which aims to define and develop a marine cadastre for Australia. A marine cadastre would provide a comprehensive spatial data infrastructure whereby rights, restrictions and responsibilities in the marine environment can be assessed, administered and managed.

As part of this collaborative initiative, two pilot project areas have been adopted and are currently supporting the development and testing of research findings and are also helping to demonstrate the concept and complexities of a future marine cadastre.

Current research under this project is focussed on two main areas. The first is a consideration of the similarities and differences between the existing land cadastre and a future marine cadastre and the suitability and extension of the ASDI to the marine environment. The second research area focuses on issues of 3D and 4D parcel definition, the application of uncertainty in maritime boundary delimitation and coastline definition, and the integration of uncertainty within a multi-dimensional cadastral object model.

In parallel with these detailed areas of research, work is also being conducted to gain a broader understanding of the requirements of those individuals and organisations that use, manage and administer maritime spaces and marine spatial data. This is being achieved through the running of workshops, the conducting of a broadly based national questionnaire and the execution of detailed industry consultation.

Further to this, it has been noted that the international research into the marine cadastre must also be taken into account, as it is a good guide to the current global ability to deal with marine resource management issues.

International Research into the Marine Cadastre

The term cadastre has not been used often in the marine environment, but according to Fowler and Treml (2001), “many (and some may argue all) of the cadastral components such as adjudication, survey and owner rights have a parallel condition in the ocean”. The

development of such a cadastral system for the sustainable management of marine resources is evident in a range of countries such as Canada, the United States of America, New Zealand and the Netherlands (Nichols *et al.*, 2000; Fowler and Treml, 2001; Grant, 1999; Barry *et al.*, 2003), with the major research initiatives of the USA and Canada discussed below.

United States of America

The USA's marine resource management methods have been described as "fragmented, complex and poorly understood" (Neely *et al.*, 1998) and in order to address this, the Coastal Services Center of the National Oceanic and Atmospheric Administration (NOAA), in conjunction with various industry, government and academic collaborators have developed a prototype Ocean Planning Information System (OPIS).

This system is the first of its kind to apply cadastral data toward integrated ocean planning, with the overall goal being "to provide easy access to comprehensive ocean-related data and information that will enhance regional, integrated approaches to coastal and ocean resource management" (NOAA, 1998a). The OPIS was developed as a web-based regional tool, with both federal and state policy frameworks considered. A link between the policy and the geography was created through the formation of a marine cadastre (NOAA, 1998a). The system's major features include:

- an interactive mapping application;
- marine and coastal spatial data download tools;
- associated metadata; and
- legal summary pages.

It can be seen from this, that the OPIS draws together spatial components which can be of importance in balancing the conflicting uses of resources within the maritime environment, not only within the USA, but also Australia.

Canada

The main focus of research in Canada is on identifying marine limits and boundaries which would aid in the "good governance of Canada's oceans" (Nichols *et al.* 2000), with the main objectives including:

- identifying and evaluating boundary information requirements for good ocean governance;
- investigating spatial data uncertainty and its impact on data integration and boundary delimitation; and
- developing and enhancing prototype visualisation tools for marine boundary delimitation.

(Ng'ang'a *et al.*, 2001)

From the information gathered on these boundaries, a conceptual framework for "good" ocean governance will be developed. According to Ng'ang'a *et al.* (2001), other biological, economic and environmental information could be linked to such a framework, to give it a multipurpose cadastral function. The Canadian project commenced in 2000 and has provided guidance to research in Australia, due to the similarities faced by both nations in attempting to effectively manage offshore areas. These include:

- multiple and unclear jurisdictional boundaries;
- co-management arrangements between state and federal governments;
- no one agency managing offshore rights and boundaries;
- indigenous title rights, and
- enormous maritime areas to manage.

Although international marine cadastre initiatives are a good guide to some of the current problems and issues relating to the possible design and implementation of an Australian marine cadastre, it is not practical to simply adapt these models to the Australian environment. This demands a solution which is unique, but also takes advantage of current international research into the marine cadastre.

Australian Marine Cadastre Concept

Due to the complex and changing nature of the marine environment, there are currently several different definitions of what comprises a marine cadastre. Robertson *et al.* (1999) describe the marine cadastre as:

- A system to enable the boundaries of maritime rights and interests to be recorded, spatially managed and physically defined in relationship to the boundaries of other neighbouring or underlying rights and interests.

Nichols *et al.* (2000) have a slightly varied understanding of the marine cadastre, introducing concepts of ownership and the need to record rights and responsibilities in addition to the recording of boundaries.

- A marine cadastre is a marine information system, encompassing both the nature and spatial extent of the interests and property rights, with respect to ownership and various rights and responsibilities in the marine jurisdiction.

The ARC marine cadastre project has used such definitions of the marine cadastre, along with various issues and research described within this paper, as a starting point in the development of an Australian concept of a marine cadastre. In this respect, the research aimed to develop a concept diagram for Australia, as can be seen in Figure 2.

The first aim of the diagram is to demonstrate the fact that the marine cadastre should not be developed in isolation from the terrestrial environment. As mentioned earlier, the majority of maritime activity occurs in and around the coastal zone. This area straddles both land and sea and is the public access point to the marine environment. Urban and industrial development and other land based activities are also a source of pollution in the marine environment.

The linking of the marine and terrestrial cadastres will enable a more seamless integration of spatial data at the land-sea interface, facilitating more integrated and effective coastal zone management techniques to be implemented.

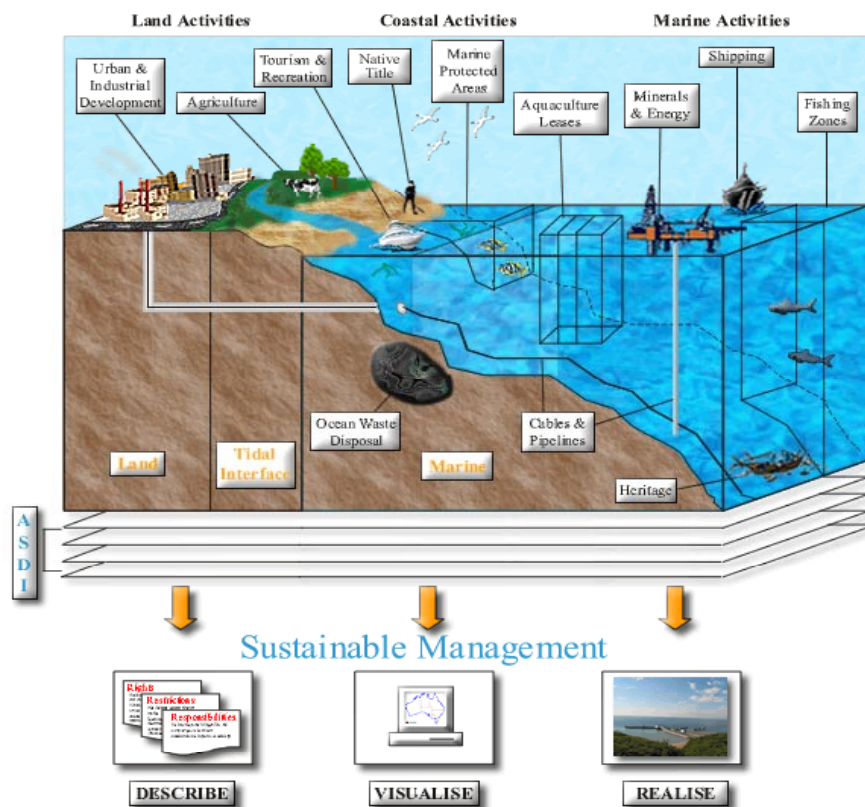


Figure 2 – Marine Cadastre Concept Diagram

The diagram also shows the range of stakeholders and activities that occur within Australia’s oceans. Table 3 summarises the diversity of interests ranging from tourism and recreational activities such as diving and swimming to the disposal of waste such as jarosite and chemical dumps.

Activity	Includes:	Activity	Includes:
Tourism & Recreation	Diving Boating Fishing Swimming	Aquaculture Leases	Mussle Farms Abalone Farms Spat Gathering Areas Oyster Farms
Marine Protected Areas	Marine National Parks Marine Sanctuaries	Minerals and Energy	Mineral Exploration Oil and Gas Exploration Resource Extration
Shipping	Commercial Shipping Freight Haulage Passenger Ferries	Native Title	Non-exclusive access to the sea and sea-bed.
Heritage	Shipwrecks Indigenous Artifacts	Ocean Waste Disposal	Ammunition Dumps Chemical Dumps Jarosite Dumps Scuttled Vessels Land-based sources
Cables and Pipelines	Oil and Gas pipelines Telecommunications Electricity Cables		

Table 3 – Range of activities in Australia’s marine environment

It is not the actual activities which the marine cadastre must take into account however, but the administrative and legal boundaries which govern where and when such activities can occur. The rights, restrictions and responsibilities that go along with such boundaries must also be recorded. For example, marine protected areas have defined boundaries for the

purpose of excluding or restricting the rights of marine stakeholders within such an area. Knowledge of the rights and restrictions needs to be attached to the boundaries, in order for them to be effective. In essence, the marine cadastre would provide the means for delineating, managing and administering such legally definable offshore boundaries.

Another factor which a marine cadastre needs to address is that the wide range of interests described above are currently managed by a number of organizations and agencies, with each responsible for the collection, collation and updating of spatial data relating to their own particular interests. This data needs to be provided to all stakeholders in the marine environment at its most accurate and up-to-date. For this to be achieved, the ASDI must be in place in the marine environment to underpin and facilitate the availability and reliability of spatial data. This would also provide the basis for the integration of the marine and terrestrial environments, helping to facilitate sustainable management objectives across Australia's entire jurisdiction.

The tangible outcome of the marine cadastre concept, as described by Todd (2001) is the ability for users and stakeholders to "describe, visualise and realise" spatial information in the marine environment. The marine cadastre will describe the location and spatial extent of rights, restrictions and responsibilities in the marine environment, including management boundaries, coastal planning guidelines, ocean parcels and legal definition. Such spatial extents should then be able to be visualised through the continual updating of accurate digital spatial data through the use of a maintenance environment, and includes the three dimensional nature of the marine environment together with the advent of time over this space. This ability to describe and visualize maritime boundaries will enable users to realise them 'on the ground'. This aids in managing and creating new fisheries or aquaculture leases, policing marine protected areas, exploration, and the laying of cables and pipelines, enabling an integrated and practical approach to the management of Australia's maritime extent.

CONCLUSION

The need for a marine cadastre is increasing, being driven mainly by the need to address the environmental, social and economic issues of sustainable development. For this to occur, accurate and up-to-date spatial information concerning the administrative and legally definable boundaries of rights, restrictions and responsibilities of marine stakeholders needs to be available. The marine cadastre will provide such a means, and in this context will form a fundamental component of marine spatial data and a layer in the ASDI that covers both the terrestrial and marine environments.

The holistic concept of a marine cadastre for Australia has been described within this paper, in an attempt to tackle the major legal, institutional and technical issues effecting the effective management of Australia's offshore jurisdiction. The marine cadastre concept diagram presents the view of a marine cadastre as a spatial boundary management tool, which describes, visualizes and realizes the rights, restrictions and responsibilities of maritime stakeholders. The task now is to attempt to develop the tools and principles which will facilitate the implementation of such a marine cadastre.

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