Developing the Concept of a Marine Cadastre: An Australian Case Study

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Abstract

In the terrestrial environment, it is the cadastre and initiatives such as the creation of Spatial Data Infrastructures (SDI) that are facilitating greater decision making in areas of 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.

1. Introduction

The world's oceans cover almost two thirds of the surface of the earth, regulating weather patterns and producing a huge variety of plant and animal life (UN, 2003). 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 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. The term cadastre has not been readily used in the marine environment, but according to Neely et al. (1998), many of the cadastral components such as adjudication, survey, and owner rights have a parallel condition in the ocean. A closer inspection of Australia's cadastral system however shows that there are also many differences that would need to be overcome, if the terrestrial cadastre concept was to be applied to the marine environment.

The continuing development of Spatial Data Infrastructures (SDI) as a tool to facilitate access and maintenance of data within the terrestrial environment is also beginning to spread to the marine environment. Within Australia, the Australian and New Zealand Land Information Council (ANZLIC, the nations peak spatial information body), has recommended that the Australian SDI (ASDI) incorporate spatial information relating to all of Australia, including the marine environment. This would go a long way to aiding the creation of a seamless 'on-land off-shore' cadastre for the country.

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 that are hindering the coordination of effective marine management. International perspectives on the management of maritime boundaries and associated rights, restrictions and responsibilities must also be considered. This paper aims to describe the concept of a marine cadastre through the use of an Australian case study, based on current research being undertaken in the Department of Geomatics at the University of Melbourne.

2. Factors & Issues Driving the Development of a Marine Cadastre

It is accepted that the interests of a nation do not stop at the land-sea interface. 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 to be put in place within maritime jurisdictions.

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 according to the FAO, "nine of the world's 17 fisheries are in serious decline, with four depleted commercially" (PANOS, 1995). 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 two examples of 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 coastal areas 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). Indigenous Australians were in possession of Australia before British settlement in 1788, but property and rights were not recognized by the government, when it pronounced Australia as terra nullius, or land belonging to no-one. It was not until the countries 1992 High Court 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 in Australia with the High Court ruling that non-exclusive native title existed in the offshore region of the Croker Island, off the coast of the Northern Territory (Robertson, 2002). Although a victory for the indigenous people, the existence of such rights makes it difficult to effectively manage native title areas under current spatial management systems, driving the need to introduce a framework such as a marine

cadastre, in order to facilitate a greater degree of cooperation between stakeholders.

The ability to utilise spatial data in managing such environmental and social factors is currently hindered by a focus on data 'silos'. Data management agencies collect and disseminate data individually and without consultation amongst themselves. This encourages marine data to be held in varying formats and at varying accuracies within 'silos'. The integration of datasets thus becomes much harder, hindering the ability of management agencies to make up-to-date and informed decisions.

There are also various legal, institutional and technical issues which need to be addressed in the creation of a marine cadastre.

2.1 Legal Issues

The current legislative arrangements for the management of a nation's maritime zones involve not only UNCLOS, but also a complex web of federal legislation. Within an Australian context for example, the National Oceans Office (NOO, 2002a) has identified roughly 600 pieces of state, Territory and Commonwealth legislation which currently manage ocean use and ecosystem health in Australian waters. This is on top of over 50 international treaties and conventions that the country must take into account. Australia also has in place the Offshore Constitutional Settlement (OCS), a legal tool that enables offshore jurisdictional responsibility to be shared between the nation's states and Commonwealth government. 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 legislation 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 most nations. Within one piece of legislation as an example, 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 1 below. Defining such ambiguous terminology will promote greater understanding of the issues and promote easier communication and enactment of effective legislation. This was highlighted in the recent UNB-FIG marine cadastre meeting (UNB-FIG, 2003).

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 1 – 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 as to where a boundary is spatially. The second fact is that generally, people who write legislation do not have a spatial background. Even when legislation is updated, the spatial data community is not always asked to comment on how to accurately describe boundaries. Both of these factors can result in ambiguous spatial definitions of geographic areas or boundaries in legislation in the marine environment.

2.2 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 in the marine environment can overlap often creating competing rights, restrictions and responsibilities. This creates the need for cooperation between managing agencies that does not always occur. Often, such agencies are in isolation from one another, creating data 'silos' which do not encourage the sharing of spatial information. Hence managing agencies do not have clear spatial certainty of each other's rights, restrictions and responsibilities. According to a report from the FIG-UNB meeting on the marine cadastre in 2003, there needs to be a whole of government approach to the management of marine space, including input from academia, native groups and communities, in order to overcome such competing rights (Sutherland, 2003).

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 can be jurisdictional confusion over the management of the land-sea interface or coastal zone, an example being local governments managing land to High Water Mark (HWM), and state governments managing the marine environment from the Low Water Mark (LWM). 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 a nation's oceans, providing guidance on access to spatial information and addressing issues of both state and national importance.

2.3 Technical Issues

The 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 baselines from which the boundaries between international, national, state and private rights are created. 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. 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 coastal areas.

The Low Water Mark is also the boundary from which a nation'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) is a good example of a system that 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, is maintained and freely available and updated regularly. There is however 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, 2002).

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. The utilization of spatial data through the development of a SDI is one way in which to achieve such certainty.

3. Spatial Data Infrastructure and the Marine Cadastre

Spatial data are items of information that can be related to a location on the Earth, and range from information on natural phenomena issues such as topography and geographic features to administrative and property boundaries (Rajabifard, 2002). The need for spatial data is continually increasing and changing, with more than 80% of governmental data having a locational basis (Rajabifard, 2002). The SDI concept has evolved, in order to facilitate and coordinate the exchange and sharing of such spatial data between stakeholders from different jurisdictions

The concept and components of SDIs are still evolving, however (Rajabifard et al., 2000) state that the important principle of SDIs is that they provide an environment which enables a variety of users to access and retrieve complete and consistent data

sets easily and securely. The common components of an SDI (Figure 1) have been identified as Data, People, Access Network and Standards.

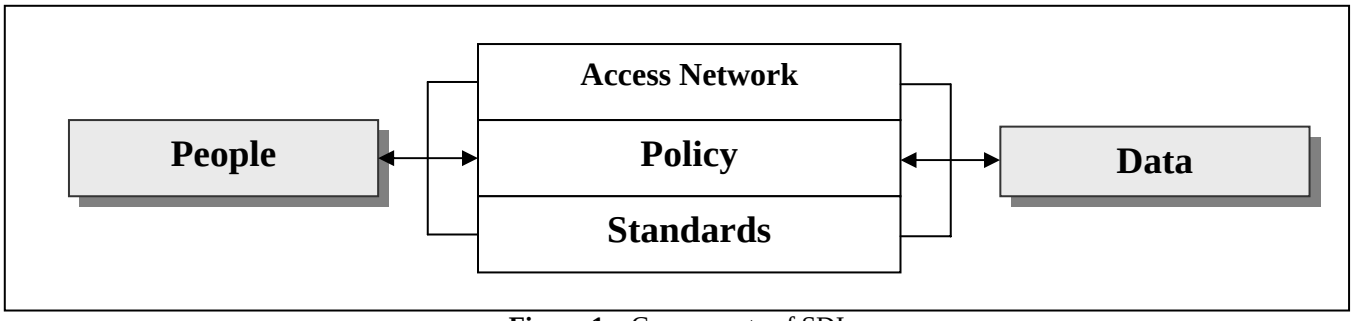

Figure 1 – Components of SDI

In Australia, the objective of developing the ASDI is to create a national infrastructure that enriches the nation's investment in spatial data and improves economic, social, environmental and defence decision making. ANZLIC have welcomed proposals by sections of the marine data community to include marine and coastal data as fundamental data themes in the ASDI initiative. This will provide mechanisms to access spatial data required to support such decision making in the marine environment. It will also maximise the access, use and integration of spatial data, avoid duplication in its acquisition and maintenance, and clearly define custodianship of principle datasets (Warnest et al., 2002).

The creation of a marine cadastre aims to enable collaboration through the utilisation of SDI principles in addressing sustainable development objectives, pulling together the various technical, legislative and institutional issues discussed in this paper. For this to become reality however, there is a need to foster greater relationships between agencies, governments and countries involved in marine cadastre related initiatives.

4. International Perspective

The nature of the marine environment demands that research initiatives not be developed in isolation. They must be user driven, with collaboration from various governments, the private sector and researchers. The development of marine cadastral systems for the sustainable management of 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 main focus on the USA and Canada.

One of the common threads between all of these countries is the similarities faced in attempting to effectively manage offshore areas. This is particularly so when comparing Australia, USA and Canada. There are multiple and unclear jurisdictional boundaries, various 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.

In order to address this, the USA's Coastal Centre 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 is the first 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 system's major features include:

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

The system draws together spatial components that can be of importance in balancing conflicting uses of resources within the marine environment.

A project undertaken in Canada has focussed on identifying marine limits and boundaries from which a conceptual framework for "good ocean governance" can be developed. According to Ng'ang'a *et al*. (2001), other biological, economic and environmental information could be linked to such a framework, giving it a multipurpose cadastral function.

This concept of a multipurpose marine cadastre was recently presented at a meeting on the marine cadastre in Fredericton Canada. While most participants agreed that the marine cadastre's primary focus should be on legally defined spatial extents and associated rights, interests, restrictions and responsibilities, they also desired greater access to a variety of information, something that a multipurpose marine cadastre would aid in providing (UNB-FIG, 2003).

Although international marine cadastre initiatives are a useful guide to some of the current problems and issues relating to the possible design and implementation of a nation's marine cadastre, it is not possible to simply adapt a blanket model. A

solution which is unique, but also takes advantage of current international research into the marine cadastre is required, as shown within the Australian case study below.

5. Case Study : Australia

5.1 Australia's Current Marine Management System

Australia is a profoundly maritime nation, with approximately 99% of trade carried by ship (NOO, 2002b). Australia's coastline is almost 60,000km in length and the area of the nation's maritime responsibility is over twice that of its continental landmass (Kaye, 1995). The Australian Maritime Jurisdiction (AMJ) – the region to be covered by any future marine cadastre – is the second largest in the world and represents a vitally important natural asses and responsibility.

In recent years, there has been an increasing awareness of the importance of spatial data in managing Australia's offshore area. This has included the need for a structured and consistent approach to the definition and maintenance of offshore legal boundaries. It is in this context that the concept of a national marine cadastre has gained increasing prominence and strong government support (Rajabifard et al., 2003). Healthy coordination of the research effort is being maintained through the nurturing of close collaborative links between the government and academic sectors.

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 countries such as Australia to review their 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 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 Commonwealth (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 2). The various maritime zones that Australia has declared under the guidance of UNCLOS are explained in Table 2.

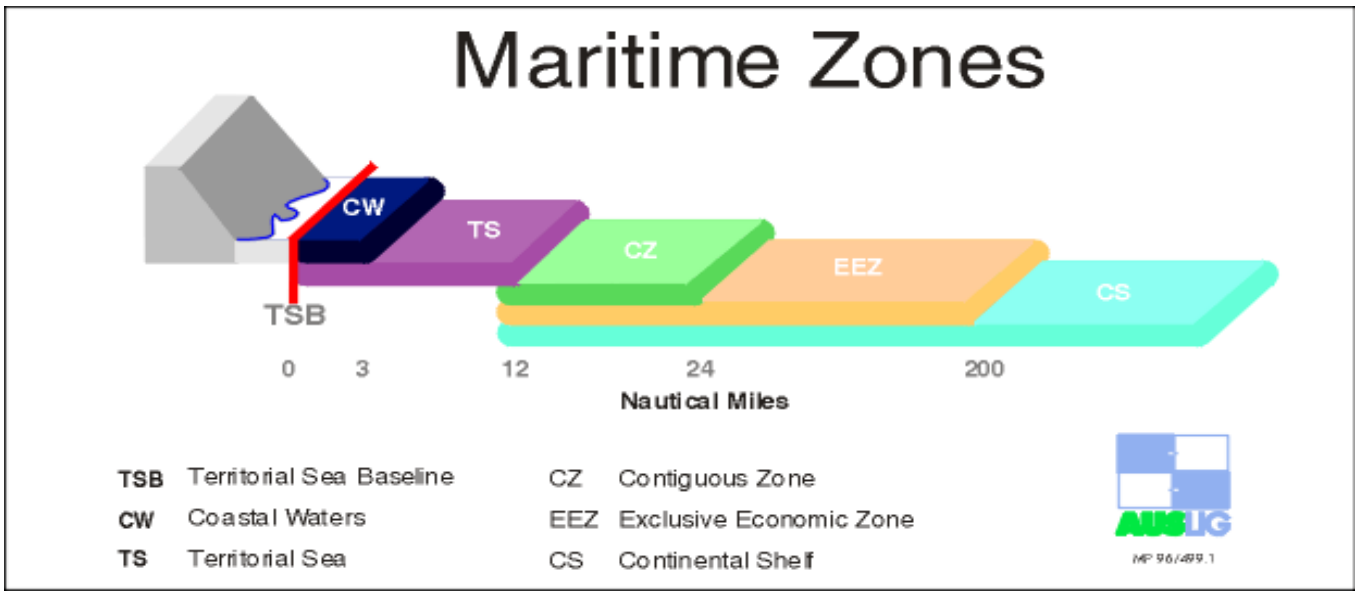

Figure 2: Australian Maritime Zones (AUSLIG, 1999)

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 (defined by the State)	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 is 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) 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 UNCLOS.	Australia would gain seabed and subsoil rights to any areas of an extended continental shelf granted under UNCLOS.

Table 2 – Australia's Maritime Zones (Based on UN 1997)

The final jurisdictional area illustrated in Figure 2 and described in Table 2 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). The development of a framework such as a marine cadastre would aim to aid in facilitating decision making in order to meet such obligations.

5.2 ARC Marine Cadastre Project

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 a marine cadastre for Australia. Such a cadastre is now being recognised as a fundamental initiative utilising an offshore spatial data infrastructure. In essence, the marine cadastre would aim to provide a means for delineating, managing and administering legally definable offshore boundaries and associated rights, restrictions and responsibilities.

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. Work is also being conducted to gain a broader understanding of the requirements of those individuals and organisations who 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.

Current research under this project is focussed on two main areas. The first area of research 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. The second area 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.

Building on the findings of current research and by supporting strategic industry-academic partnerships, a new grant has been provided by the Australian Research Council (ARC) to allow marine cadastre research to continue beyond mid-2004. This research will draw on the body of knowledge and expertise flowing from the first ARC project and aims to provide solutions to four fundamental research problems identified. These four key areas of future research include:

- Resolving issues in the definition of the tidal interface
- The use of natural rather than artificial boundaries in a marine cadastre
- Extension and application of the ASDI to support a marine cadastre

- Marine policy, legal and security issues and the marine cadastre

More information about the current ARC project can be found at http://www.geom.unimelb.edu.au/maritime/index.htm.

5.3 Australian Marine Cadastre Concept

As mentioned earlier, Australia's research into the marine cadastre in not without precedent on the international scene. A significant body of knowledge into the concept and scope of a marine cadastre has been developed, enabling researchers in Australia to build upon and extent this body of knowledge in an Australian context.

Due to the complex and changing nature of the marine environment, there is currently no definitive definition 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. To aid in this process, a concept diagram was developed, in order to visualise the various aspects of an Australian marine cadastre (Figure 3).

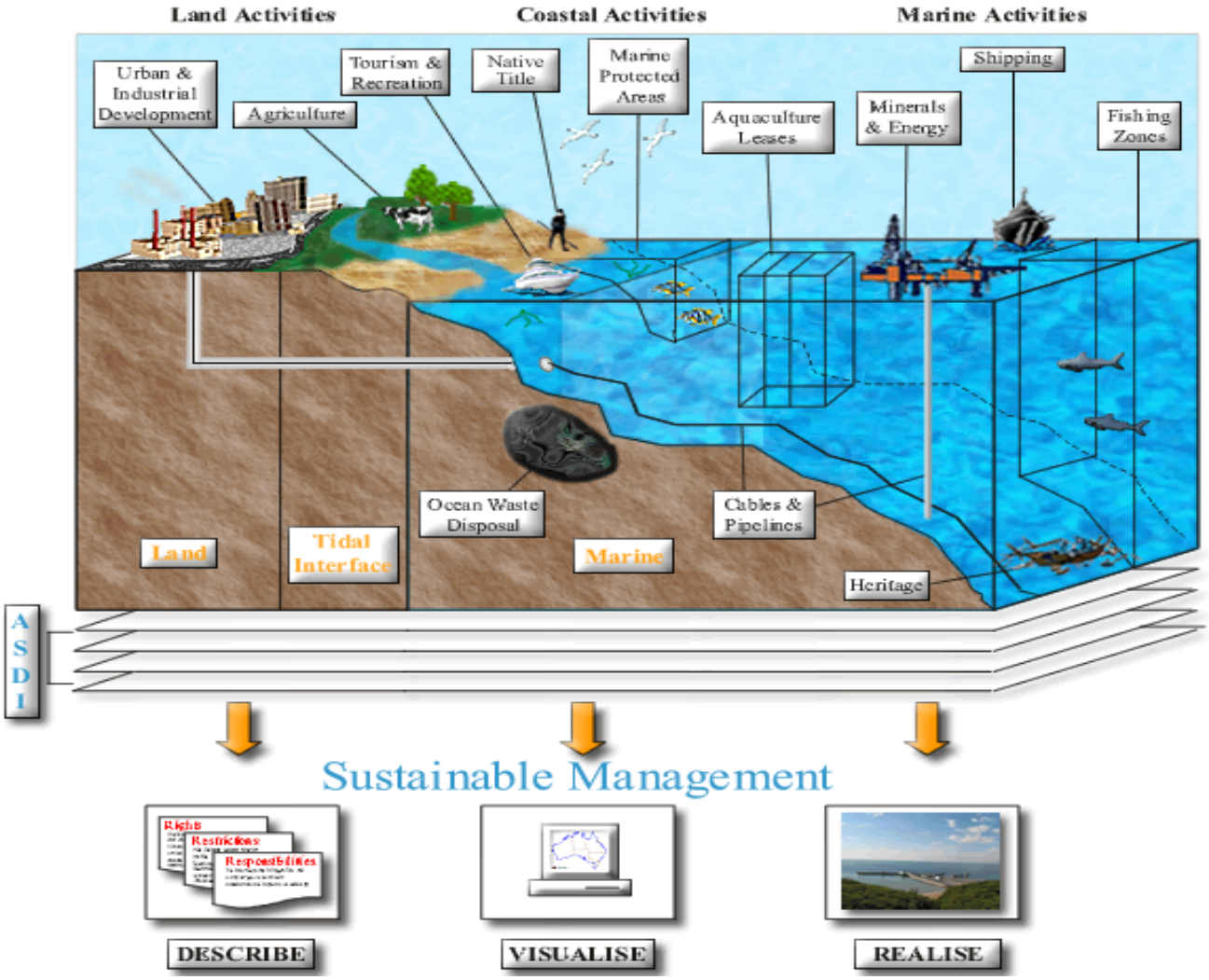

Figure 3 – Marine Cadastre Concept Diagram

The marine concept diagram differs somewhat to other such diagrams developed throughout the world, as it contains areas of the terrestrial environment, as well as the ocean. The aim of this is to demonstrate 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. The development of a marine cadastre will also aid in integrating local, state and federal government interests, facilitating the implementation of more integrated and effective coastal zone management techniques.

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:
Tourism & Recreation	Diving Boating Fishing Swimming
Marine Protected Areas	Marine National Parks Marine Sanctuaries
Shipping	Commercial Shipping Freight Haulage Passenger Ferries
Heritage	Shipwrecks Indigenous Artifacts
Cables and Pipelines	Oil and Gas pipelines Telecommunications Electricity Cables

Activity	Includes:
Aquaculture Leases	Mussle Farms Abalone Farms Spat Gathering Areas Oyster Farms
Minerals and Energy	Mineral Exploration Oil and Gas Exploration Resource Extration
Native Title	Non-exclusive access to the sea and sea-bed.
Ocean Waste Disposal	Ammunition Dumps Chemical Dumps Jarosite Dumps Scuttled Vessels Land-based sources

Table 3 – Range of Activities and Interests 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.

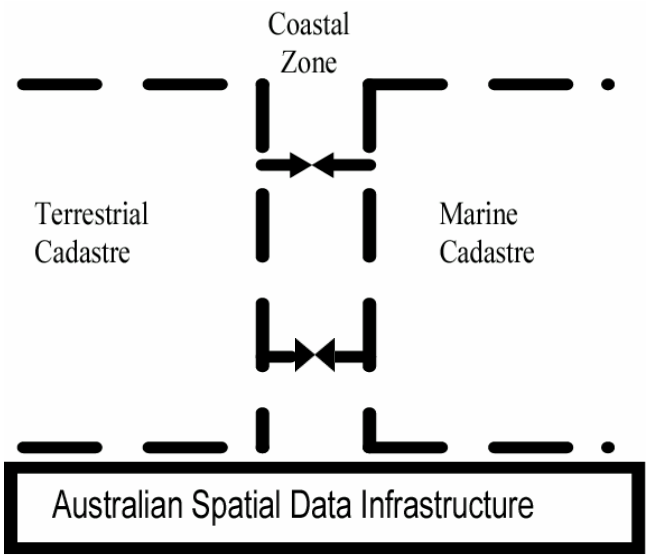

Figure 4 – Integration of the terrestrial & marine environments through the utilisation of the ASDI

The ability to visualise the concept of a marine cadastre also aids in showing the three dimensional nature of legally defined boundaries. Aquaculture leases, fishing zones and marine protected areas are a prime example of boundaries in which depth, as well as sea surface topology is needed, in order to sustain effective management.

Another factor which a marine cadastre needs to address is that the wide range of interests shown in Figure 3 are currently managed by a number of organizations and agencies within 'solos', with each responsible for the collection, collation and updating of spatial data relating to their own particular interests. This data needs to be available 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 (Figure 4).

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.

6. Future Direction and 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. The concept proposed within this paper aims to deal with a range of legal, institutional and technical issues identified as barriers to the efficient management of legally defined boundaries, within an Australian context.

It is important to understand the link between the terrestrial and marine environments and recognise that they should not be treated as separate entities. The cadastre and ASDI enable the efficient management of spatial boundaries in the terrestrial environment and are tools that should be utilised in the development of a marine cadastre. The underlying principles that facilitate such management need to be identified and applied in the creation of a marine cadastre. This is especially so in terms of the ASDI, as it will be the underlying framework for the distribution of spatial data in the marine environment. The marine cadastre would also link local, state and federal government interests within the marine environment, enabling efficient management across Australia's entire 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 that will facilitate the implementation of such a marine cadastre.

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