Marine Administration Research Activities within Asia and the Pacific Region – Towards a Seamless Land-Sea Interface

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Abstract

Administering the marine environment is an important topic for discussion and management internationally, especially within the Asia and Pacific Region. This region relies heavily on the ocean as a source of food, for transportation and for income through activities such as tourism and hence it is important to manage such marine spaces effectively. With this in mind, the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) is involved in several international collaborative research projects within the marine environment. The main objectives of these activities are looking at defining the issues to be considered in the context of developing effective and appropriate administrative infrastructure systems as part of national Spatial Data Infrastructure initiatives to manage marine resources in the context of the United National Convention on the Law of the Sea. This includes the facilitation and development of a set of guidelines appropriate to the Asia and Pacific region for the design of such systems.

This paper aims to describe current SDI based research activities within the sphere of marine administration throughout the Asia and Pacific region. The paper provides an overview of the incentive, objectives and principle tasks as well as the results of current research activities being undertaken through Working Group 3 (Cadastre) of the PCGIAP. These activities aim to aid in meeting the sustainable development (economic, environmental and social) objectives of the region through the development of a seamless enabling platform to provide more efficient and effective decision making capabilities across both the marine environment and the land-sea interface.

1. INTRODUCTION

Countries throughout the world have spent considerable time and effort in attempting to effectively manage the economic, social and environmental aspects of land, with management of the marine environment placing second to that of land. For some countries however, the marine environment provides the main avenue for resources ranging from basic everyday needs such as food to economically powerful fossil fuels, and provides avenue for transportation and social cohesion. This is especially relevant within the Asia and Pacific region.

The Asia and Pacific region accounts for some 60% of the world's population and includes 56 nations covering the largest geographic land region in the world. Most of these nations, especially those within the Pacific, have marine jurisdictions that are greater than that of their land mass. Australia for example, has maritime responsibility for twice that of the Australian continental landmass (Kaye 1995) with the ability for the size of area under Australia's jurisdiction to increase under the 3rd United Nations Convention on the Law of

the Sea (UNCLOS). The nations within the region are also at different stages of development and range from the largest archipelago nation (Indonesia) to the largest landlocked nation (Mongolia) in the world.

These large national marine environments also contain a wealth of actual and potential resources, with the demand for exploiting these resources increasing rapidly. Each nation must explore, exploit and manage its ocean territory in a way that will maximize benefit to the nation, while at the same time protecting the delicate ocean environment (Collier et al. 2001). This has not been achieved effectively, with marine pollution as well as over fishing occurring across the region. In 1995 for example, the FAO classified nine of the world's 17 fisheries as being in serious decline, with four depleted commercially (PANOS 1995). Even in wealthier OECD countries such as Australia, poor management and an increase in competition for control over major sources of revenue such as natural gas and oil is causing an exhaustion of natural resources in the marine environment.

There is a need to create a framework for marine administration in order to provide a foundation from which management issues, including the global focus on sustainable development, can be addressed. In order to address this, various research initiatives are being undertaken through the Permanent Committee for GIS Infrastructure for Asia and the Pacific (PCGIAP). This paper aims to describe the research that has been undertaken and is currently being undertaken within Asia and the Pacific under Working Group 3 (Cadastre) of the PCGIAP on facilitating the development of a marine administration framework.

2. PCGIAP COMMITTEE

The PCGIAP was established in 1995 through the efforts of the United Nations Regional Cartographic Conference for the Asia and Pacific Region (UNRCC-AP) following its 13th Conference in Beijing. The aims of PCGIAP are to maximize the economic, social and environmental benefits of geographic information in accordance with Agenda 21 by providing a forum for nations across the region to cooperate in the development of the Asia-Pacific Spatial Data Infrastructure (APSDI) and contribute to the development of the global infrastructure (Rajabifard et al. 2003).

PCGIAP operates under the UNRCC-AP, submitting its reports and recommendations to this conference. It comprises of 56 nations which are represented on the Committee by directors of national survey and mapping organizations or equivalent national agencies. Each member nation participating in the Committee has one vote and decisions of the Committee are taken by a majority of the Representatives present and voting. An Executive Board comprising representatives from twelve member nations, including a President, Vice President and Secretary, coordinates the Committee's work program. The term of the Executive Board is the period between UNRCC-AP Conferences, currently three years.

Projects are undertaken within the PCGIAP by Working Groups, which are described in Table 1. These working groups help to fulfill the aims and objectives of the Permanent Committee with meetings held both in conjunction with the meetings of the UNRCC-AP and also between these meetings.

Table 1: Working groups of the PCGIAP in the period 2003-2006

Working Group 1 **Regional Geodesy**	Responsible for the implementation of a regional precise geodetic network and coordinating regional geodetic campaigns.
Working Group 2 **Regional Fundamental Data**	Responsible for establishing regional fundamental datasets and mechanisms for sharing these data and fostering an understanding of the benefits in using regional fundamental data.
Working Group 3 **Cadastral Working Group**	Responsible for facilitating discussion on cadastral and land administration issues, and marine cadastres.
Working Group 4 **Institutional Strengthening**	Responsible for facilitating member involvement, education, training and sub-regional programs.

Working Group 3 (Cadastre) was established in 2000 based on the Resolution from the 15th UNRCC-AP in Malaysia. Through that Resolution and as part of the WG3 work plan, it was recommended that the United Nations within available resources, and in cooperation with the Working Group on the Cadastre under the PCGIAP, and with the expert assistance of relevant organizations such as the International Federation of Surveyors (FIG) and the International Hydrographic Office facilitate:

- discussion on marine cadastres, focusing on the issues involved in the establishment of appropriate administrative infrastructures to manage marine resources in the context of the United Nations Convention on the Law of the Sea.

This work in relation to marine administration is seen to be within the context of the development of a seamless land-sea SDI for the region, and is essential to the implementation of the United Nations Agenda 21 and the realization of economic, social and environmental benefits for the region.

3. MARINE ADMINISTARTION RESEARCH IN THE ASIA AND PACIFIC REGION

Work on the marine administration component of the Working Group 3 work plan began in 2002 with research being undertaken in conjunction with the Centre for Spatial Data Infrastructures (SDI) and Land Administration, Department of Geomatics at the University of Melbourne, Australia, into improving the understanding of Marine Cadastres in Asia and the Pacific Region. Research was undertaken in two main areas, however the principle aim of research was the definition of issues currently hindering the development of an Australian marine cadastre, and in that context, the establishment of a direction for future research.

3.1 Development of a Marine Cadastre

The first major research area was the consideration of the similarities and differences between the existing land cadastre and a future marine cadastre and suitability and extension of the Australian SDI to the marine environment, as well as an attempt to sufficiently define the concept of a marine cadastre.

Some of the major issues identified within this research include:

- the ambulatory nature of the coastline;
- the size of the marine areas to be managed
- the complex spatial and temporal interactions in the marine environment;
- the need for mechanisms to facilitate quick and effective updates of marine spatial data;
- the need for a virtual register of interests in the marine environment to support decision making; and
- the wide range and nature of marine activities and stakeholders which need to be taken into account

In an attempt to overcome these issues, the concept of a marine cadastre, as described in Figure 1 (Binns et al. 2003), is being considered by a number of countries including Australia, Canada and New Zealand. In all of these countries, as well as within the Asia and Pacific region, there are a large range of stakeholders and activities that occur within the marine environment, ranging from tourism and recreational activities such as boating and swimming, to the disposal of waste and drilling for oil and natural gas deposits. In order to effectively manage these activities, the administrative and legal boundaries that govern where and when such activities can occur need to be known. The rights and restrictions that go along with such boundaries also must be recorded. For example, marine protected areas have defined boundaries for the purpose of excluding or restricting the rights of other stakeholders within such an area. Knowledge of these rights and restrictions need to be attached to the boundaries, and the boundaries easily displayed and mapped within a GIS in order for them to be effective. This would enable users and stakeholders to "describe, visualize and realize" spatial information in the marine environment (Todd 2001).

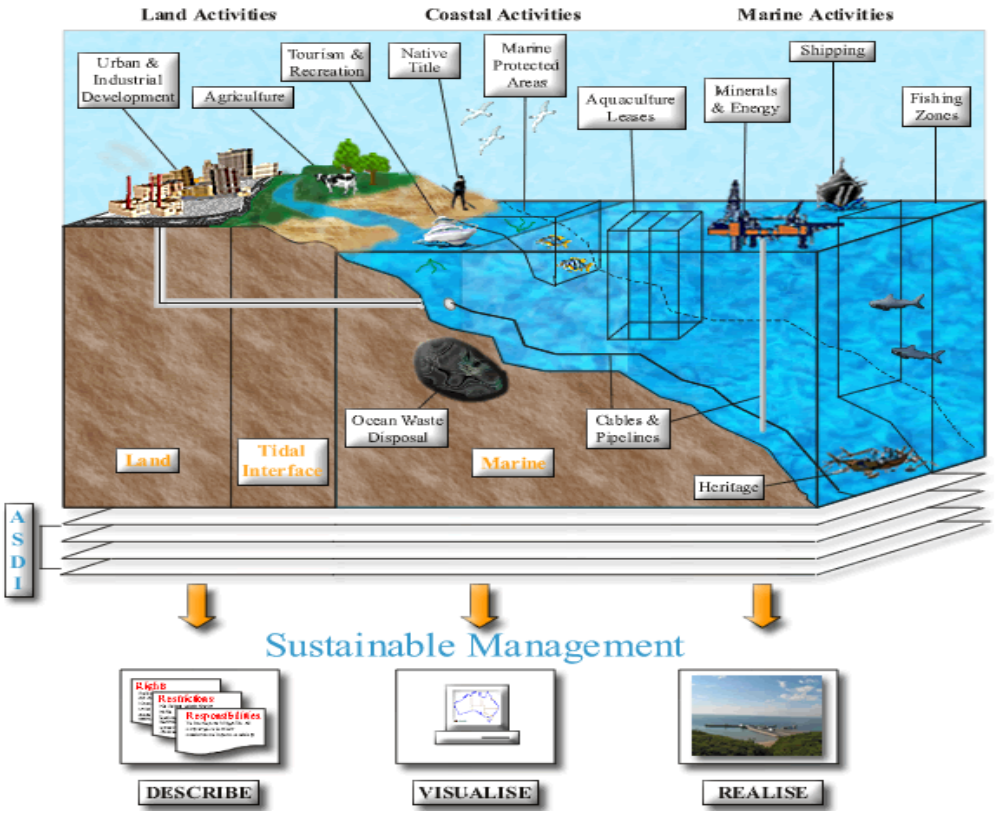

Figure 1: Marine Cadastre Concept (Binns et al. 2003)

The creation of a marine cadastre would also need to include mechanisms to enable spatial information within the marine environment to be continually updated and maintained, in a similar fashion to the terrestrial cadastre. In order to assess the applicability of land based principles, a set of fundamental cadastral and land administration principles and their applicability to the recording of rights, restrictions and responsibilities to aid in marine administration were identified. These include: policy principles; tenure principles; legal principles; and institutional principles.

The policy and institutional aspects were most applicable to the marine environment, as the physical difference between the two environments is not a major concern when applying these principles. This included:

- the need for the creation of a national oceans policy in order to provide direction for the administration of the marine environment. According to Williamson (2001), the development of a policy will drive legislative reform, which in turn results in institutional reform and finally implementation with all its technical requirements, important steps in developing any marine cadastre.
- The need for an overarching governing body to address marine cadastral issues, including the implementation of a marine cadastre at a national level similar to the implementation of SDI initiatives.
- The realization that the marine environment is dynamic. The key to managing it is to start simple, develop a strong marine cadastre framework foundation, and allow the system to evolve and grow as future uses arise.

The ability to apply tenure and legal principles to the marine environment is not as straight forward. Within the marine environment, the need for private transactions is limited, due to the lack of freehold rights. This differs from land, where the ability to transact is the primary aim of the cadastre. There is also a major difference in the description of spatial boundaries. On land, legislation is used to describe how boundaries are demarcated, with monuments used as the primary point of truth for boundaries. In the ocean, the precise location of boundaries is generally embedded in legislation, making statutory regulations the point of truth for boundaries. The physical difference in the two environments also causes issues. Boundaries are delimited rather than demarcated, can be three or four dimensional as opposed to two dimensional, overlap regularly as opposed to rarely and need to be systematically defined, rather than sporadically defined as on land.

The existence of immature institutional arrangements and the lack of an overarching government department to coordinate the collection and maintenance of spatial data in the marine environment creates the need for the utilization of an SDI. This would aid in partnership creation and providing standards from which issues of data interoperability can be addressed. It would also ensure the development of a seamless administration model that covers both land and marine environments, enabling more efficient and effective decision making. The ability to apply the SDI policies and technologies within the marine environment however needed further investigation. This was undertaken as part of a new research initiative, described later in this paper, to examine the ability of using a seamless SDI model to cover both the land and sea environments.

3.2 Technical Implementation of Legally Defined Marine Boundaries

The second major area of research focused 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. As a result of the dynamic nature of the marine environment and the human activities that occur therein, the implementation of legally defined marine boundaries is subject to a variety of political, legal and technical challenges. This research has addresses the technical issues which cannot normally be dealt with using conventional land cadastre principles. The key issues identified and addressed under this research are centered upon marine boundary delimitation and positioning, and include spatial uncertainty, maintenance of four dimensional parcels, and the modeling and management of quality metadata.

Accordingly, the outcomes of the research are threefold. Firstly, the research presents the development, implementation and analysis of algorithms and procedures for quantifying uncertainty in the delimitation and positioning of marine boundaries. Conclusions are drawn from tests conducted with real–world and simulated datasets. Secondly, the research has developed algorithms and procedures for constructing and maintaining four–dimensional marine parcels. Thirdly, this research identifies the fundamental quality metadata elements necessary for handling information about uncertainty in the technical implementation of marine boundaries (Fraser et al. 2006).

This early research also aimed to gain a broader understanding of the requirements of those individuals and organizations who use, manage and administer maritime spaces and marine

spatial data. This was achieved through the running of several workshops and a broad based questionnaire.

3.3 Industry Consultation

The questionnaire and workshops enabled researchers to identify the major users, suppliers and producers of marine spatial data, which included mainly government agencies and departments. The major role for spatial data was in environmental issues offshore, whilst also serving an administration and management function. 94% of respondents revealed that spatial information was either essential or important for the management of their offshore functions. The majority of offshore data was supplied to users in digital form, though paper charts were still used by some organizations. It was also interesting to note that most users of spatial data required information in 3D, with many also requiring variations in time. Users of offshore spatial information indicated that they are generally dependent on information being kept up to date, especially boundary information. This can be seen in the dependence on the boundary which is defined by the intersection of a tidal plane with the land, with almost 70% of respondents in some way dependent on tidal plane definitions. (Forse and Collier 2003)

The workshops and questionnaire provide an overview of issues and information on how spatial data is being used offshore. However, to gain a more detailed and higher level picture in order to understand the issues surrounding the implementation of a marine cadastre from a user perspective, industry consultation was undertaken. The major industries consulted included:

- the Queensland Resource Registry within Department of Natural Resources and Mines, State of Queensland, Australia;
- Parks Victoria within the Department of Sustainability and Environment, State of Victoria, Australia;
- National Mapping Division within the Australian Federal Government;
- the Australian Hydrographic Office;
- Spatial Information Infrastructure – Department of Sustainability and Environment, State of Victoria, Australia;
- Environmental Protection Agency Australia;
- Native Title and Indigenous Land Services, Government of Australia; and
- Maritime Safety Queensland - Department of Transport, State of Queensland, Australia.

The outcomes of these consultations enabled current problems and issues effecting major marine stakeholders to be identified. These included:

- The ambiguous nature of terminology within legislation
  - e.g. tidal datum not clearly visualized and realized
  - e.g. marine park boundaries and areas described within legislation as ‘mud maps’
  - Lack of lineage and traceability standards for legislation reference implementation
- Determination of high water
- Lack of political will and poor commitment from government in regards to developing a system such as a marine cadastre
  - Focus is on small scale technical issues, not on realistic whole scale institutional and cultural problems
- Fragmentation of data, varying scales and quality

    - Spatial accuracy/precision of sourced data is unknown
    - Currency of boundary data unknown
- No lead agency to coordinate marine data access, mapping and exchange
- Terms Marine Cadastre, Marine SDI, Marine Spatial Information System etc need to be clarified
- Current focus of SDI is on “data” and “data quality” which limits the potential business and response to market needs
- Need for infrastructure which can manage temporal issues
- Lack of overall strategic policy for infrastructure development in the marine environment

The ability to solve these problems within the initial research focus was limited, however they were considered in the development of further research within the sphere of marine administration. The work achieved through both these research areas and identification of issues through industry consultation enabled four new key research areas to be defined and undertaken. These areas include:

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

3.4 Resolving Issues in the Definition of the Tidal Interface

The coastline is defined by the line of intersection between the land-mass and a nominated tidal place. However, the coastline does not have a concise or unambiguous spatial or legal definition, creating uncertainty and potential conflict in the case of competing interests in the tidal zone. This also makes the delimitation of maritime boundaries dependent on the definition of the coastline somewhat problematic. A new approach for defining the coastline that will remove this current ambiguity in the tidal zone will make it feasible to create a single national cadastre covering the both onshore and offshore environments.

In addressing the spatial issues, the research aims to identify and resolve technical issues that impact on the consistent delineation of the coastline. This research uses a technique where by the various tidal datums can be mapped using a mathematical approach. Recent technology which enables coastal terrain data to be captured more accurately at a higher resolution will be supplemented with a harmonic tidal model to derive the required tidal datums (Daw Quadros 2005).

The research has recently developed a system that produces the height of tidal datums (Highest Astronomical Tide, Mean High Water Springs and Lowest Astronomical Tide) at any given position on the Australian east coast. This information is to supplemented with foreshore terrain data from NSW to delineate the relevant coastline. The next stage of the project is going to involve a comparison of the coastline with tide gauge data and current coastline models.

3.5 The Use of Natural Rather than Artificial Boundaries in a Marine Cadastre

The use of traditional and often arbitrarily defined boundaries can be disadvantageous in the marine environment. Naturally occurring boundaries, such as sea floor characteristics, migratory movements of a particular species or the extent of a particular kind of sea grass can be more suitable to the definition of jurisdictional zones, as seen in the delimitation of marine protected areas. This research aims to create a concept for the delimitation and management of jurisdictional boundaries based on natural features and conditions.

This is based on recognition that spatially based management of a resource is not appropriate unless the spatial dynamics (including distribution, density and mobility) of the resource are clearly understood. Where mobile natural boundaries define the spatial limits of a resource, administrative boundaries should only be set at the extremes of the natural variation. This research will look at addressing data format issues, asses seasonal variations in natural boundaries and investigate connections to sea floor topography (Leach 2005).

3.6 Marine Policy, Legal and Security Issues and the Marine Cadastre

All countries face a myriad of both national and international laws, treaties and conventions relating to and assessing their relationship and rights to the sea and sea bed. Not only is this web of legislation complex, but as described by Nichols et al (2000) there is also an increasingly diverse range of actors and authorities active in the marine environment, multiple and unclear jurisdictional limits, various co-management arrangements, and no single agency managing offshore rights and boundaries creating overlapping and competing interests. All of these facets of management need to be related to marine policy. Such a policy must also deal with increasing responsibilities of ensuring safety within claimed maritime zones, issues of illegal fishing and ensuring that a county is kept secure from the risk of terrorism. Hence this component of research aims to analyse the ability of utilising a marine cadastre in resolving maritime security and policy issues.

3.7 Extension and Application of the SDI to Support a Marine Cadastre

The ability for data custodians and data users to have ready access to data which is reliable, complete and current is already becoming available within the terrestrial environment through the development of Spatial Data Infrastructures (SDI). Within the marine environment however, this is far from reality. Recently, ANZLIC – Australia's spatial information council, recommended that the Australian SDI concept be extended to cover the marine environment. This has also occurred in several other nations including Ireland (Bartlett 2004) and the USA (NOAA 2003). The intention of this area of research is to analyse the components of current SDI models and attempt to extend, modify and test these principles in an offshore environment. The ultimate aim is to design an SDI model that seamlessly covers both land and sea, creating an enabling platform for the use and spatial information and services.

One of the major issues in managing and administering activities, be it on land or at sea is having access to relevant spatial data and information concerning the area, as described by Doody (2003):

- Data + Context = Information

- Information + Analysis = Understanding
- Understanding + Management = Possibility of sustainable action.

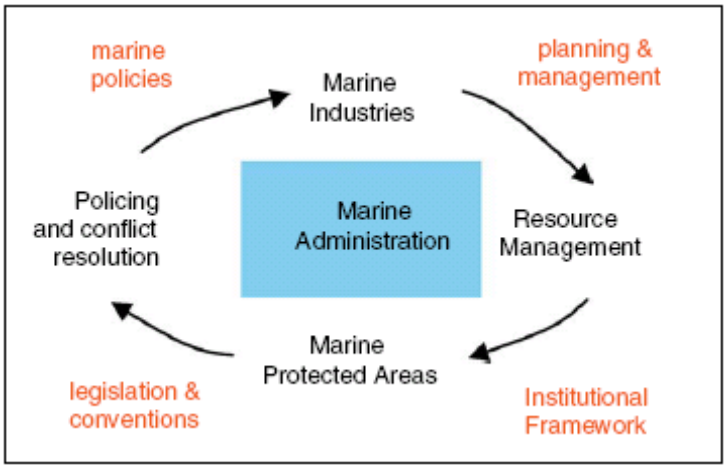

Figure 2: Marine administration (Strain et al. 2006)

Figure 2 shows some of the activities involved in marine and coastal zone administration. Each of these requires spatial data and information such as tide charts, bathymetry, climate, sea surface temperatures and currents, living and non-living resources, property rights in the area, legislation and international conventions in order to be managed successfully. However problems with accessing, sharing and using spatial data related to these areas is often reported. This can be seen in a proposed marine data policy by the CSIRO (1998) which stated that 'present users of ocean and data are faced with a confusing array of datasets and data formats'. This has resulted in the increasing need for the development of an enabling platform to underpin decision making, through the development of an SDI to better manage and share spatial data assets (Strain et al. 2006).

An SDI framework facilitates the exchange and sharing of spatial data between people. It is an underlying infrastructure in the form of policies, standards and access networks that allow data to be shared within and between organisations, states and countries. It has been likened to road or rail infrastructure over land, and comprises roads as well as the rules, maintenance policies and jurisdictional rights to them (Strain et al. 2006). Research has been undertaken to attempt to apply the SDI concept to the marine environment in order to aid in the development of a decision making platform across the land-sae interface. The development of such as enabling platform will aid in the use of decision making tools such as GIS and break down the silos of information held by various agencies in the marine environment.

The use of decision making tools such as GIS within the marine environment is increasing, but there is a need to improve the underlying framework for access to up-to-date data and spatial information. Currently, the ability to provide consistent and accurate spatial information on the wide range of rights and spatial boundaries in the marine environment is hampered by the fact that interests overlap and information is held in silos by various agencies.

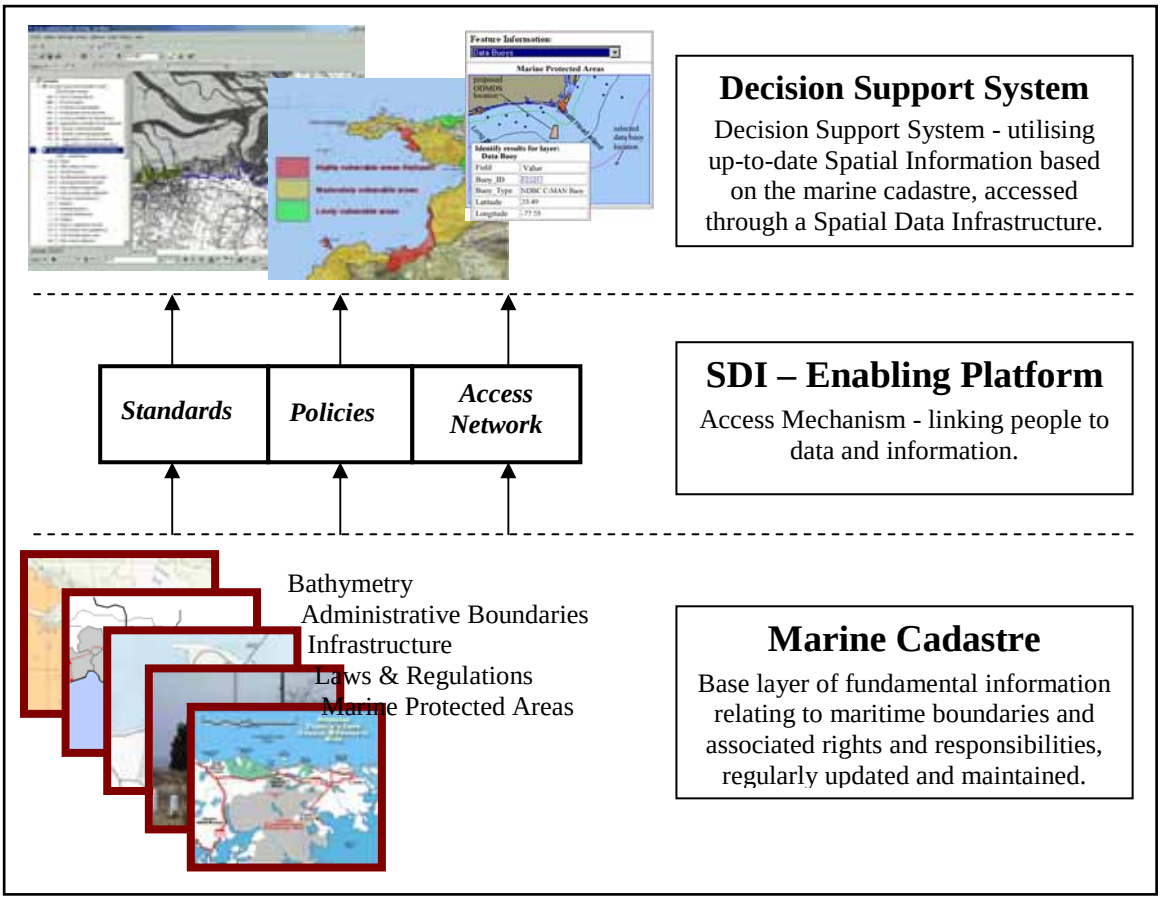

Figure 3: Underlying infrastructure for more effective marine administration

As seen in Figure 3, research into marine SDI and the development of a marine cadastre is aiming to increase this underlying infrastructure by providing an access mechanism to more up-to-date and accurate information regarding maritime boundaries (Binns et al. 2005). As a result of research, a seamless SDI model has been proposed which has used the major SDI principles of people, data, access network, standards and policy. This model now needs to be refined and tested, with barriers effecting possible implementation needing to be identified, from both an individual jurisdictional perspective (e.g. individual country) as well as internationally. This will help in achieving the PCGIAP's goal of establishing a regional SDI for Asia and the Pacific.

4. INTERNATIONAL WORKSHOP ON ADMINISTERING THE MARINE ENVIRONMENT – THE SPATIAL DIMENSION

As part of the PCGIAP WG3 work plan a four day international workshop on Administering the Marine Environment was conducted in Malaysia, 2004. The objective of the workshop was to better understand the spatial dimensions of administering the marine environment in the Asia and Pacific region and in particular, to facilitate:

- an understanding of the needs of an SDI in the marine context;
- better understanding and appreciation of the administration of marine rights, restrictions and responsibilities and to agree on terminology; and

- documentation of issues in establishing a marine dimension as a key component of National SDIs.

Over 100 people from 11 countries attended the workshop, with a representative of each country presenting a report on the marine administration activities in their jurisdiction, based on a common marine administration template. This workshop was facilitated by identifying common problems, issues, similarities and differences in SDI; institutional arrangements; the administration of rights, restrictions and responsibilities; technology; and human resource and capacity building. The PCGIAP-WG3 is continuing to promote countries to complete the Marine Administration Country Template in order to have a wider view of the management of the seas of Asia and the Pacific region. Completed templates can be found online with the information collected helping in the research being undertaken (www.marineadministration.org).

The main discussion areas of the workshop focused on:
- issues in administering the marine environment
- definition of marine SDI and marine cadastre; and
- administration of marine rights, restrictions and responsibilities.

Key outcomes of these discussions took the form of resolutions, concentrating on issues in the region and particularly the role of marine SDI and marine cadastre in aiding more effective marine administration (Rajabifard et al. 2005).

Two of the key resolutions stemming from the Workshop include:

- ***Resolution 1*** *– Spatial Dimension of Administering the Marine Environment*
  The workshop recommended that all countries in the Asia and Pacific region with an extensive marine jurisdiction and administrative responsibility be encouraged to include a marine dimension in their NSDI as part of their obligation to meeting their responsibilities under the United Nations Convention on the Law of the Sea (UNCLOS). It was further recommended that countries cooperate with other countries to ensure technical, operational and policy consistency in the marine elements of NSDIs developed in the Asia and Pacific region (PCGIAP-WG3 2004).

- ***Resolution 3*** *– Defining the Spatial Dimension of the Marine Environment*
  The workshop recommended that the term “marine administration system” is adopted for the administration of rights, restrictions and responsibilities in the marine environment, with the spatial dimension facilitated by the Marine SDI, and further recommends that a marine cadastre is defined as a management tool which spatially describes, visualizes and realizes formally and informally defined boundaries and associated rights, restrictions and responsibilities in the marine environment as a data layer in a marine SDI, allowing them to be more effectively identified, administered and accessed (PCGIAP-WG3 2004). This is described in Figure 4.

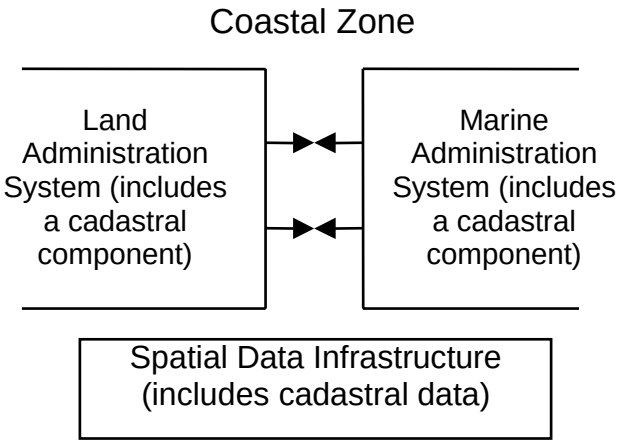

Figure 4: The spatial dimension of the marine environment

Other important issues and points of discussion raised within the workshop included:

- that an SDI should facilitate access, management and sharing of spatial data in both the marine and land environments at any jurisdictional/political level;
- that a marine cadastre component of marine administration can include components of the land-based cadastre and in addition it must take into consideration the fuzzy nature of boundaries as well as a 3D (volume) and sometimes 4D (temporal) nature of interests in the marine environment;
- the need for collaboration between FIG Commission 4 and PCGIAP-WG3 on issues relating to marine SDI and marine cadastre;
- the lack of a single organisation capable of coordinating issues on marine management;
- importance of institutional reform and capacity building in administering marine rights, restrictions and responsibilities;
- the legal and security issues affecting both the creation of effective marine policies and hindering the creation of a culture of data sharing within the marine environment;
- that any marine SDI should relate to natural boundaries as well as administrative boundaries;
- the importance of the link between land and marine environments – they cannot be treated in isolation; and
- the need for international cooperation as maritime actions transcend national boundaries.

(Rajabifard et al. 2005)

Although the discussions and points raised were in relation to the Asia and Pacific region, these points are also relevant to the wider international community. It is important that the issues discussed within the workshop are addressed through collaborative measures, with research and development across nations needing to be shared. This will enable the development of mechanisms and structures for governance of marine territories that are sufficiently flexible to allow integration of global and international objectives with those of local communities and interests. It must be remembered that there is a need to effectively manage the land-sea interface as well as the terrestrial and marine environments themselves. Research within the Asia and Pacific region under the PCGIAP WG3 is attempting to do this.

5. CONCLUSION

There is now a call to move toward a virtual world and create an enabling platform to support such as initiative. This is not limited to the terrestrial environment, with the marine environment, as demonstrated in this article, playing a vital role in day-to-day tasks of countries, especially within Asia and the Pacific. Research is being undertaken to create more effective mechanisms for decision making to help administer the marine environment more effectively and efficiently. This includes the development of a marine cadastre, in order to provide the ability to define, visualize and realize boundaries within the marine environment as well as resolving issues in the definition of the tidal interface in order to more accurately define boundaries.

The need to effectively manage the coastal zone as well as the need for integration of data between the land, coast and marine environment requires a management system that incorporates them all. Currently, many countries have a land administration system and some kind of marine management system, but these generally operate as separate entities. This can cause conflict within the coastal zone or land-sea interface.

Interoperability between technologies and spatial data, as well as incompatibility of data formats, coordinate systems, geodetic parameters and other aspects of data pose problems in the ability to share and exchange data in the marine environment. Research into the development of a seamless SDI model across the land-sea interface aims to address these issues both at a national level and through the development of the Asia-Pacific Regional SDI through PCGIAP. The development of such an overarching infrastructure also aims to more effectively manage the fragile land-sea interface.

The key to success in the marine environment is to start simple, develop a strong marine cadastre framework as a foundation, and allow the system to evolve and grow as future demands arise. Using common SDI standards, policies and access networks can ensure that spatial data is interoperable not only within the marine environment but across the coastal zone, facilitating the design of a seamless SDI to improve decision-making and administration.

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