An SDI Model to Include the Marine Environment

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Declaration

This is to certify that this thesis:

a) has not been submitted for a higher degree at any other University of Institution
b) Is approximately 30,000 words in length

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Abstract

Currently Spatial Data Infrastructure (SDI) initiatives are mainly focused on the terrestrial environment and have not yet expanded to fully accommodate marine and coastal spatial information. This causes many stakeholders within the marine and coastal environments difficulty in obtaining spatial data or information about these areas. Therefore the aim of this research is to develop an extended seamless SDI model that can apply to coastal and marine spatial data as well as terrestrial data. This thesis explains the need for improved management of the marine and coastal environments, in terms of sustainable development and the importance of spatial information to underpin administration of the various rights, restrictions and responsibilities in these areas. It also discusses the common understanding and views of the nature, concept and components of SDI. Different views about the development and implementation of SDI are explored and the Australian Spatial Data Infrastructure (ASDI) is used as a real-life example of an SDI.

In order to meet the aim of the research, three objectives have been identified. These comprise the different parts of the thesis. The first part of the research was a literature review that examined the current 'state-of-the-art' of the SDI concept and components, and the emergence of the Marine SDI concept. This concept has evolved over the past five years, as many coastal countries realise the importance of their marine jurisdiction and are developing different ways to facilitate sustainable management of these areas. At the same time people in SDI have realised that current SDI models are mainly focused on the terrestrial environment and seen the potential for either expanding or creating new models for the marine and coastal environments.

The second part of this research was to compare the different marine SDI initiatives and the current 'land focused' SDI concept, hierarchy and components. The many different initiatives occurring worldwide in Marine SDI, at national and international levels were documented and their current state of development and issues were analysed. In order to investigate a similar phenomenon at lower jurisdictional levels a case study of a marine area managed at a state/local level was chosen. Within this area the current use, management and sharing of spatial data, for the stakeholders of the

area was investigated, with an aim to discover their common problems and opportunities in using and accessing spatial data.

The last part of this research involved a comparison of the results at each of the jurisdictional levels and identified the main commonalities and differences. These were then compared to the ASDI to find the main differences between land and marine or coastal SDI. The main limitations of the current SDI model for marine and coastal spatial data were highlighted and the opportunities for developing a seamless SDI that can apply to spatial data from the marine, coastal and terrestrial environment was discussed.

The results of this research found that the broad concept of SDI is as applicable in the marine environment as it is on land. There is an increasing demand for improved availability of marine and coastal spatial data. However within the SDI components (people, policies, standards, access networks and data) there are some differences with marine spatial data that will be both limitations and opportunities for implanting a seamless SDI. It was found that many of the limitations are institutional, in that many stakeholders were unwilling or had a perceived inability to make data compliant to standards and policies, while the opportunities were technical, for example the development of marine access networks and fundamental datasets or a marine cadastre. These opportunities and limitations are summarised in an extended SDI model. This model will facilitate the implementation of a seamless SDI through identifying the areas that will hinder its development and the areas that can be built upon to support its development.

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List of Abbreviations

AMBIS	Australian Marine Boundary Information System
AMSIS	Australian Marine Spatial Information System
ANZLIC	Australian and New Zealand Land Information Council
ARC	Australian Research Council
ASDD	Australian Spatial Data Directory
ASDI	Australian Spatial Data Infrastructure
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEH	Department of Environment and Heritage
DFO	Department of Fisheries and Oceans
DSE	Department of Sustainability and Environment
ECS	Extended Continental Shelf
EEZ	Exclusive Economic Zone
EIS	Environment Impact Statement
ERIN	Environmental Resources Information Network
FAO	Food and Agriculture Organisation
FGDC	Federal Geographic Data Committee
GA	Geoscience Australia
GIS	Geographic Information Systems
GI	Geographic Information
GOOS	Global Oceans Observing System
GPS	Global Positioning System
GSDI	Global Spatial Data Infrastructure
ICZM	Integrated Coastal Zone Management
ICM	Integrated Coastal Management
ICT	Information and Communication Technology
IOC	Intergovernmental Oceanographic Commission
ISO	International Standards Committee
NOAA	National Oceans and Atmospheric Administration
NOO	National Oceans Office
NRC	National Research Council
OBIS	Ocean Biogeographic Information Systems
OGC	Open GIS Consortium
OPIS	Ocean Planning Information System
PCGIAP	Permanent Committee on GIS Infrastructure for Asia and the Pacific
PEMSEA	Partnerships in the Environmental Management of the Seas of East Asia
PPB	Port Phillip Bay
SDI	Spatial Data Infrastructure
SDS-SEA	Sustainable Development Strategy for the Seas of East Asia
TSB	Territorial Sea Baseline
UN	United Nations
UNB	University of New Brunswick
UNCLOS	United Nations Convention on the Law of the Sea
VCC	Victorian Coastal Council
WSSD	World Summit on Sustainable Development
W3C	World Wide Web Consortium

Chapter 1: Introduction

1.1 Background

Until recently the SDI concept has largely overlooked the marine and coastal environments, focussing mainly on connecting people with land-related data and information. However the marine and coastal environments play an important role in many areas of human life and thus the ability to access and share accurate and up-to-date spatial information about these areas is also important. Humankind is extremely reliant on the world's coasts and oceans, as a source of food and wealth, as a climate regulator, for transportation, shipping, waste disposal and recreation. There are serious environmental issues such as the threat of sea level rise and natural resource depletion, which need to be balanced with economic development and social concerns. Many countries are reliant on marine industries such as oil and gas exploration, fishing, aquaculture and tourism. Often there is a social attachment to the coastal zone, with many people choosing to holiday and live close to the beach and native title interests in many countries over these areas. As the use and understanding of the marine and coastal environment has increased, so has the need for improvement in the management and administration systems for these areas. This idea is reflected in the number of initiatives worldwide that aim to improve marine and coastal management such as the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA), Integrated Coastal Zone Management (ICZM) and the 3rd United Nations Convention on the Law of the Sea (UNCLOS).

In spite of this, current marine and coastal zone management systems are neither effective nor sustainable (Thia-Eng 2003, Neely et al 1998). Effective governance and administration is underpinned by the need for access to spatial information (Ting and Williamson 2000, Barry et al 2003). This is well understood in land administration and is reflected in the many countries around the world developing spatial data infrastructures (SDI) to improve coordination and sharing of spatial data for that country. SDI covers the collection, management, access, delivery and utilisation of data, aiming to serve the common interests of the spatial data users. It is comprised of the policies and technologies that enable different users to share data. In Australia SDI has been recognised as 'key to planning and sustainable management and development of our natural resources at national, state and local levels' (ANZLIC 1999), however most current SDI models stop at the coastline both spatially and institutionally. The reality is that the need for access and coordination of spatial data does not stop at the coastline.

Research has highlighted the importance of spatial information in improving marine management, and the current lack of coordination and sharing of marine spatial data (Binns 2004, Douven 2003, Pepper 2003, Commonwealth of Australia 1998). Some issues that are often mentioned are a lack of standards for sharing data, different data formats, little to no recording of metadata, different reference systems used, lack of willingness to share data, difficulty is finding data and gaps in data availability (Barry et al 2003, CSIRO 1997, cf. 2004). These issues have been recognised as a barrier to effective marine management in many countries and in response in Canada, Ireland, USA, New Zealand and Australia and at regional and global levels, the concept of a Marine SDI is emerging. While the initiatives within each country have different names and are at a different stage of achievement, they all have very similar aims – to improve marine and coastal zone administration and management through better availability and applicability of spatial data.

Although many countries are now addressing this problem, often the Marine SDI is developing as a separate initiative to the terrestrial one. The uniqueness of the marine environment means that the existing terrestrial system may not be appropriate for use in these areas. Currently in a land based environment, there is a land administration system that is supported by an SDI, as a facilitating framework and a cadastre, as one of the important layers. There are ideas and drivers to support the development of a marine administration system and it is usually recognised that this must also be supported by an enabling platform such as an SDI. The physical and institutional relationships that occur at the coastal zone make it impossible to develop these systems separately (Longhorn 2003, Gillespie 2000). Widodo et. al.(2002) agree, noting that the difficulty in managing rights and interests in the coastal zone has come from the discontinuity in management between the land and marine environments. For an holistic and integrated approach to administration and management of a whole countries jurisdiction, as recommended in Agenda 21 (UN 1992), this research recommends that there is an administration system that can cover the whole area, and that this is underpinned by a cadastre as a layer of information in an SDI that can allow access to and interoperability with spatial data for the whole area.

1.2 Problem Statement

Spatial data is recognised as a critical resource to underpin effective and sustainable management and administration. Spatial Data Infrastructures (SDIs) are developing in many countries to improve coordination and management of spatial data. Recently some countries have started to develop a Marine SDI but often as a separate initiative from their existing terrestrial SDI. To effectively manage the coastal zone there is a need for access and interoperability with spatial information from both the marine and coastal environments. As a result research needs to be undertaken to explore how the SDI model should be extended to create a 'seamless' SDI that can apply to spatial data from marine, coastal and terrestrial environments.

1.3 Hypothesis

Extending and modifying the current SDI model to include a marine and coastal dimension, will provide a framework for a 'seamless infrastructure' that will allow access and interoperability of data from the marine and terrestrial environments.

1.4 Objectives

In order to test the hypothesis the objectives of this research are:

1. To examine, document and compare the needs of marine and terrestrial SDI initiatives;
2. To identify opportunities, limitations and problems for combining the marine and terrestrial components in the coastal zone with a particular focus on Australia's marine jurisdiction; and
3. To develop a model for a seamless SDI that can be applied to marine, coastal and terrestrial spatial data

1.5 Case Study Research

This research adopts a case study approach, which is applicable when looking for information on a broad range of phenomena, rather than studying particular phenomena in their own right (Evans and Gruba 2003). As stated in the objectives (section 1.4), this research examines the concept of Marine SDI across a broad range of countries and jurisdictional levels. It then uses a case study as an example of marine and coastal spatial data use, management and sharing to test the concepts. Most research to this point has been conducted at a National level, with small scale data, however the coastal and near-shore environments, which are under state government management, are more complex with more intense data use and conflicting activities. Therefore this research used a larger scale case study area of Port Phillip Bay, which is located in Victoria, and is one of the busiest ports in Australia.

The overall objectives of the case study are:

- To identify to current use, management and sharing of spatial data about Port Phillip Bay from the perspective of the people involved in managing this area;
- To evaluate the availability and interoperability of spatial data about Port Phillip Bay through collecting all available data, and generating different spatial products;
- To identify the main limitations and opportunities in use, access and sharing of spatial information about Port Phillip Bay; and
- To examine the private sector perspective in accessing and using spatial data, particularly when reporting on a critical environment, economic and social issue, in this case the development of an Environmental Effects Statement.

In order to meet these objectives the main stakeholders in Port Phillip Bay were identified and interviewed. The interview questions covered the use, management and sharing of spatial data. The case study also involved collecting available spatial data from these organisations. The private sector perspective was examined using industry reports developed for an Environmental Effects Statement (EIS) for a proposed project in the case study area. The reports discussed the availability and accessibility of spatial data as it related to their particular environmental research focus for the EIS. The final part of the case study involved verifying the results using related research that had previously been conducted in the Department of Geomatics, at The University of Melbourne. This research is used as it also targeted responses from a similar range of stakeholders in Victoria and then at a National level and thus can confirm the reliability of the case study results.

1.6 Thesis Outline

Chapter 1 of this thesis introduces the research problem, discussing the converging areas of spatial data management and marine administration. It then describes the research hypothesis, objectives and outlines the case study design and methodology.

There are then two background chapters; Chapter 2 discusses current marine management, the drivers for change and the need for spatial information to support marine management. It particularly focuses on Australia, examining marine management in the case study area of Port Phillip Bay.

Chapter 3 gives a background introduction into SDI. The concept, nature, and components of SDI are discussed in general and specifically within the Australian SDI (ASDI). This chapter also looks at the development and implementation of SDI.

Chapter 4 describes the emergence of the Marine SDI concept and discusses the implementation of SDI in the marine environments. It uses examples of various SDI initiatives from around the world, at both national and international levels, to explore the concept.

Chapter 5 then focuses this research specifically on the case study area of Port Phillip Bay, examining the possibility of a Marine SDI within this environment. This part of the research examines the Marine SDI concept at the state and local jurisdictional level, drawing out the current problems and opportunities from the perspective of the main stakeholders responsible for managing Port Phillip Bay.

Chapter 6 presents the overall results of the research, discussing the similarities and differences from the national and international levels, to the state and local scales. It then compares these, as an overall Marine SDI, to the Australian National SDI (ASDI), to assess the limitations and opportunities for extending the ASDI offshore. From the limitations and opportunities identified through the research a model for a ‘seamless’ SDI model is presented, that can accommodate spatial data from marine, coastal and terrestrial environments is developed and presented

Chapter 7 concludes the thesis, summing up the results and describing the possible direction for future research. This thesis flow is summarised in Figure 1.1 (p. 7).

Thesis Flow

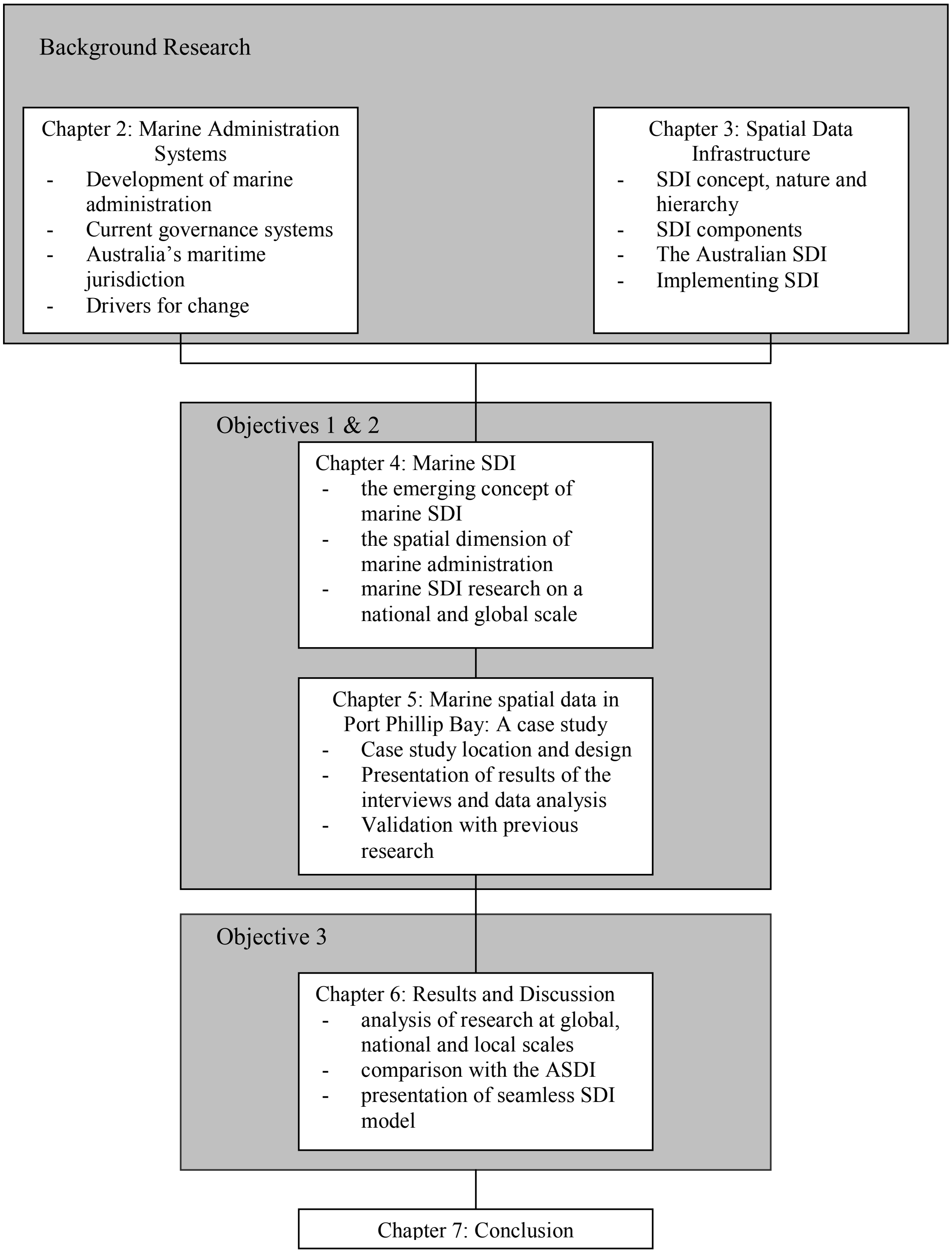


Figure 1.1: Thesis Flow responding to objectives

Chapter 2: Marine Administration Systems

2.1 Introduction

This chapter examines marine management and the administration of rights, restrictions and responsibilities in the marine and coastal environments. In order to understand Marine SDI there is a need to understand marine management and administration systems, their potentials and limitations, drivers and opportunities. This chapter looks both globally and within Australia, at the evolving relationship between humankind and the marine and coastal environments and how it has influenced management of these areas. It then examines current marine governance and the role of spatial information within this environment. Lastly this chapter discusses drivers for improvement of marine and coastal zone management, at global, national and local scales, and how many of these initiatives rely on access to appropriate and reliable spatial information.

2.2 The Relationship Between Humans and the Coasts and Oceans

The coasts and oceans have always provided a source of food and for many thousands of years have also been used for travel and exploration. It is estimated that as early as 3000BC the Egyptians, Polynesians and Mesopotamians were using oar and wind-powered canoes and boats for exploration. As scientific and technical knowledge of navigation and ship building increased the oceans became centres of trade and empire expansion. Even at this early stage the importance of having reliable spatial information was realised as many ships stayed within site of the land, limiting their trade and exploring potential, because they did not have good maps to navigate. Early maps from the Polynesians showed oceans currents relevant to their sailing patterns.

It was not until the 10th Century that the concepts of latitude and longitude were developed, and global ocean voyages of discovery did not occur until the 15th and 16th centuries. At this time many countries were using the oceans for transportation and economic trade. The development and accuracy of detailed navigation charts of landmasses, wind directions and surface currents gave enormous advantage to those nations whose explorers were at the forefront of this technical advance. At this time equal and unrestricted access to the oceans and their resources applied to all, except for the area that could be protected from the coastline. This principle of freedom of the seas was documented in 1608 by Hugo Grotius and became maritime law for the next three and a half centuries (Mitchell et al. 2001).

With the early industrial period came an increase in trading and hence more intensive port and coastal infrastructure development. This also caused an increase in pollution as the oceans became used as a waste disposal site, and increase in conflicts with pirates targeting the trade and transportation ships. The first and second World Wars rapidly developed technology and a better ability to explore and exploit the oceans. Maritime industries such as fishing and oil/gas mining increased dramatically, and many countries began to lay claim over coastal waters realising the economic potential they provided. In 1945 the USA claimed resources in the continental shelf adjacent to the coastline, causing many other countries to lodge similar claims and causing much dispute and disagreement over the jurisdictional rights a coastal nation had over the ocean (Mitchell et al 2001). It was realised that a global oceans policy was needed that documented these rights.

Since the 1950s ocean use has increased dramatically, for example global marine fishing catches have increased from 45Mt/year in 1972 to 90Mt/year in 2000 (Vallega 2003). In the 1950s the first transatlantic telecommunication line was laid, and in the late 1980s the first transatlantic fibre optic cable was laid, supporting the development of improved communication technology such as the internet. Today 44% of the World's population live within 150km of the coastline, which is greater than the number of people who inhabited the entire globe in 1950, and it is estimated that by 2020 three-quarters of the World's population will live on the coast. There has also been increased industrial and exploitative use, for example: there are around 6,000 offshore oil and gas installations. This increased activity has caused many environmental problems, such as oil spills and marine pollution from dumping at sea, species extinction, natural resource depletion and introduced marine pests.

Human use of the oceans now has expanded from simply food and exploration to include: recreation and tourism, energy through oil and gas mining, aquaculture, marine biotechnology, and conservation. However our knowledge of the marine environment is limited compared to the terrestrial environment. Lack of knowledge and understanding is of great concern as this must surely leave the global marine environment exposed to risk. There are many threats to the survival of humankind that can be linked to the oceans – natural disasters, continental plate movement, sea level rise and climate change. Management of each area has evolved separately over time, and the current idea is for more integrated and holistic approach to managing the Earth, including all areas – marine, land, coast, atmosphere etc. This is linked to the concept of sustainable development, first coined at the World Conference on Environment and Development in 1987.

Sustainable development realises the need for balancing economic development with environmental and social concerns. In terms of the marine and coastal environments this encompasses native title, natural resource depletion and marine industries. In the past two decades the understanding and knowledge of the coasts and oceans has increased dramatically. 1998 was the international year of the ocean; in conjunction with this many countries launched their first oceans policies. These generally aimed to improve ocean and coastal management through policies that addressed ocean uses and interests as a whole, instead of focussing on one particular sector. The changing human relationship with the marine environment is shown in Figure 2.1 below.

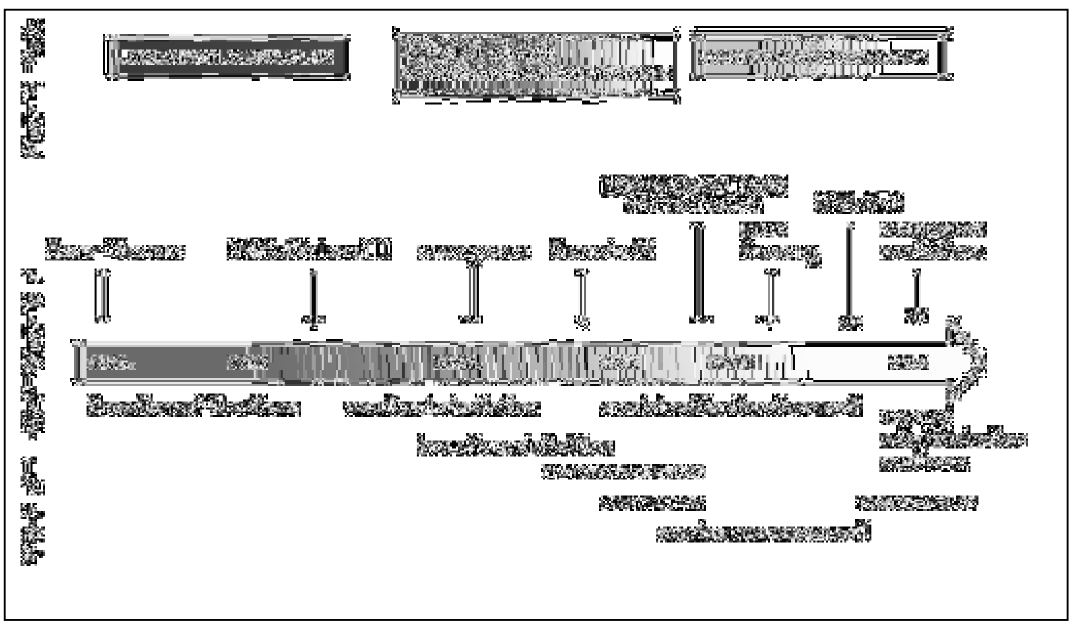


Figure 2.1: The development of marine administration (Strain et al 2005)

As can be seen from Figure 2.1 there are many different ideas evolving to improve marine and/ or coastal zone management. With the development of the various marine administration ideas and the potential growth of marine industries and activity, now is a critical time for a significant change in marine governance.

2.3 Marine Governance

Governance has been defined as the process of decision-making with a view to managing change in order to promote people's well being (Kyriakou and Di Pietro, 2000). Governance is also about providing information to decision makers about the impact that certain decisions will have on the rights and interests of individuals. Governance of the marine and coastal environments involves administrating the different boundaries and their associated rights, restrictions and responsibilities. As described above, the coasts and oceans are home to a large number of different activities that are all competing for space. Governance of these areas therefore must include planning, policy-making, regulation, policing, and conflict resolution for the following sectors:

- shipping and navigation
- living and non-living resource exploration and exploitation
- oil and gas exploration and mining
- conservation, natural resource management, scientific research
- telecommunication, pipelines and cables
- defence and counter-terrorism
- recreation and tourism

Figure 2.2 (p.12) shows the intensity of these uses, particularly in the coastal zone. This shows how marine governance needs to take into account many different and conflicting activities, and the need for integration between them.

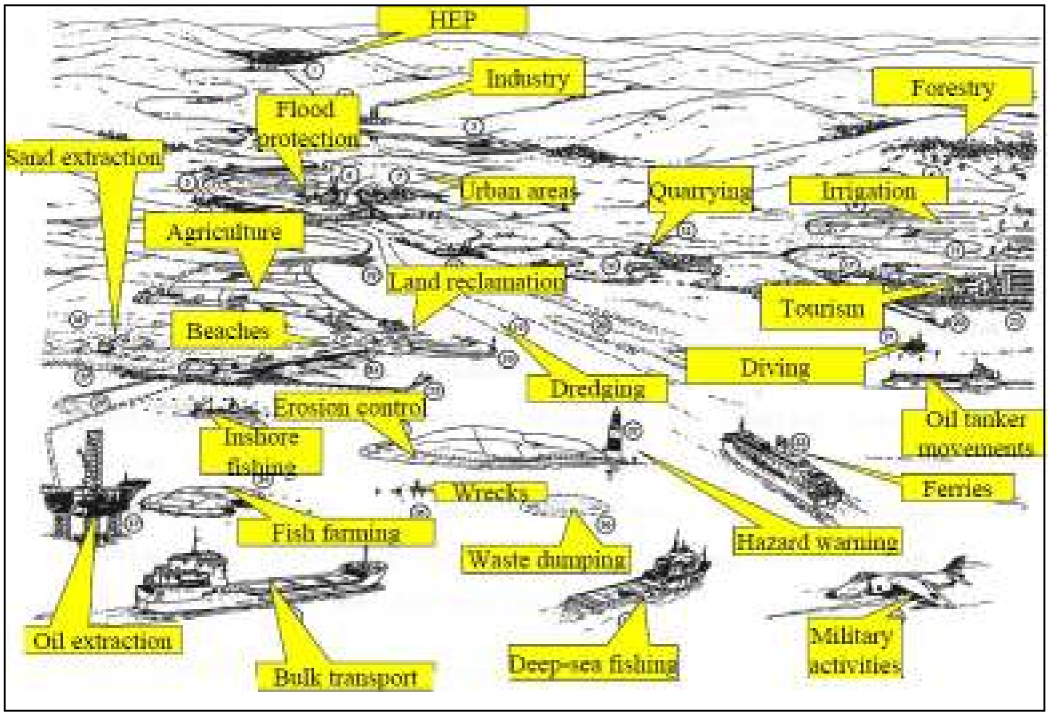


Figure 2.2: The multiple uses of the marine environment (Jolliffe and Patman 1985, as cited in Bartlett et al 2004)

Barry et al (2003) describes management in general as 'the development of overarching systems of philosophy and values, the formulation of policy and strategy and the implementation of strategy'. They further describe marine governance as a balance between '(the) desire to harvest economic resources, desire to use it for waste disposal, desire to maintain pristine environment, and desire for recreation purposes'. The competing uses that need to be governed are clearly shown in Figure 2.2. Good governance of the marine environment has also been described as 'allocation of the rights of use, ownership and stewardship, regulation of these rights, monitoring and enforcement of the regulation, and the prevention and adjudication of disputes' (Sutherland and Nichols 2000).

In terms of the marine environment, there are many different activities associated with good coastal and ocean governance or administration. Some of these and the supporting governance infrastructure are shown in Figure 2.3 (p.13).

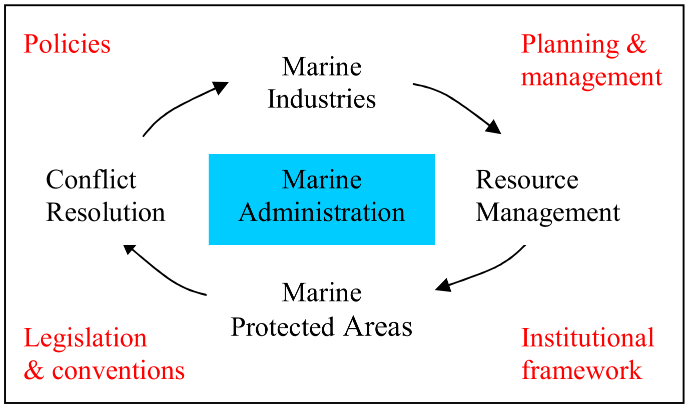


Figure 2.3: Marine administration (Strain et al 2005)

With such a myriad of uses and complex administrative arrangements the need for good boundary definition and a clear understanding of the rights, restrictions and responsibilities attached to the boundary is clear.

2.3.1 Marine Boundaries

A large part of managing the marine and coastal environments is determining and administering the relevant boundaries. The need for clearly defined boundaries in the marine environment is well recognised and has resulted in the current research in many countries into developing a marine cadastre/ marine GIS/ or marine spatial planning. Each activity takes place within, or is governed by legislation that relates to a certain location. This location is defined by boundaries that can be described in many different ways. All these initiatives aim to provide a clear definition, and an easy visualisation of the boundaries of different rights and interests in the marine environment. There are many different types of boundaries in the marine and coastal environments, such as (Todd 2004):

Sovereign Extents: Queensland and the Commonwealth of Australia based on their individual head of power;

Sovereign Rights: Exclusive Economic Zone for the Commonwealth of Australia, etc;

Jurisdictional Areas: Great Barrier Reef Region, Land Act 1994,

Administrative Areas: Marine Park, Marine Park Zone, Fishing Closures, Inner Adjacent Area under the Crimes at Sea Act (2001), Local Government Area etc;

Tenure: Lease, Estate in Fee-Simple, etc;

UNCLOS III defines jurisdictional boundaries for a country as certain distance out from coastline or Territorial Sea Baseline (TSB). There are several different zones a country may lay claim to, as outlined below in Table 2.1.

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)	Jurisdictional boundaries defined from this line
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 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) 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 2.1 Australia's Maritime Zones (UN, 1997)

The area of the oceans beyond the Exclusive Economic Zone (EEZ) or the Extended Continental Shelf (ECS) of coastal states is known as the High Seas. Here all states have equal rights to navigation, overflight, fishing and scientific research. As can be seen from Table 2.1 all jurisdiction boundaries are defined as a set distance out from the coastline. Other boundaries in the marine environment however, are delimited in different ways. They can be described using natural features such as 'generally south-westerly along the coast' or from the use of physical features 'the southern most point on Cape Otway.' The problem with managing these boundaries in the marine environment is that it is difficult to describe them in an accurate way without using coordinates, and then even with an accurate description it is difficult to locate or realise this boundary both on a map and in the real world.

The other differences between marine and terrestrial boundaries that complicate marine administration are:

- Terrestrial boundaries are 2-dimensional, to account for rights or interests in the sea column, sea bed and surface marine boundaries would need to be 3D;
- The marine environment is fluid and highly dynamic, and many boundaries are time dependant so these may need to be 4D;
- Some boundaries are defined as a set distance from the coastline, which is ambulatory in nature and so how this affects these boundaries is yet to be determined;
- Land boundaries can be demarcated physically, this is not possible in the marine environment with the exception of buoys and other navigation aids;
- Often on land boundaries can be described to a graphical accuracy and still be located, this would be less likely in the marine environment as there is a lack of identifiable features. Boundaries in the oceans would be clearer if they were described using coordinates. These could then be located with greater accuracy providing the technology, such as GPS, is available.

2.3.2 Legislative and Institutional Framework

The legislative and institutional framework that governs the marine environment has evolved over many hundreds of years resulting in a very sectorally focused and complex governance system. This section looks both globally and within Australia at how the governance systems work.

The World's oceans are divided into areas that come under the control of a coastal nation, and the areas outside this jurisdiction – 'the high seas' (see Table 2.1). These all managed by a myriad of legislative and institutional controls. These controls have historically been developed and implemented as single-purpose regimes, with little thought to how they would interact with other resource management considerations. (NRC 1997). The main exception is the 3rd United Nations Convention on the Law of the Sea (UNCLOS III), an overarching global oceans agreement which covers many different activities. There are many other global and regional conventions and treaties, but these are usually more specifically focused, covering just one particular marine activity or industry. For example the 1993 Convention for the Conservation of Southern Bluefin Tuna, and the 1971 Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention). There are approximately 33 of these that apply just to Australia and cover areas from collision prevention to endangered species (NOO 2002). According to the Admiralty and Maritime Law Guide there are approximately 70 International Conventions and Treaties (http://www.admiraltylawguide.com/interconv.html#SC) that govern the global oceans. This section discusses UNCLOS and gives examples of some of the other relevant conventions.

UNCLOS

The 3rd United Nations Convention on the Law of the Sea (UNCLOS) is essentially a global oceans policy. It covers: navigational right, territorial sea limits, economic jurisdiction, legal status of resources, conservation, natural resource management, research and settlement of disputes. It also specifies the jurisdictional boundaries that apply to a coastal States maritime zone, such as the territorial sea, contiguous zone and the extended continental shelf. Each jurisdictional boundary has different associated rights, restrictions and responsibilities, from local and state planning regulations, to international and global conventions and treaties. Under UNCLOS coastal countries are also allowed to claim areas out to the edge of the continental shelf, however as well as defining the boundary the country must also demonstrate 'a capability and intent to administer these new areas in the terms of sustainable development obligations' (Robertson et al 1999). To satisfy this requirement and better manage the different zones many countries are considering the development of a marine cadastre to 'describe, visualise and realise' the boundaries and the rights and interests that go with them (Binns 2004, Mitchell at al 2001).

Convention on Biological Diversity 1992

This convention aims to commit States to conserve their biological diversity, promote the sustainable use of its components, and ensure the benefits of using these resources are shared equitably (NOO 2002). This convention had been ratified by 181 Countries, making it one of the most widely ratified. This convention aims to find the balance between human needs and environmental protection, as such promoting sustainable development. This was agreed upon at the Rio de Janeiro Earth Summit in 1992.

Convention for the Safety of Life at Sea (SOLAS), 1974

The first version of SOLAS was written in 1914 in response to the Titanic tragedy. The current or fifth version entered into force in 1980 after 25 States had agreed to it. It aims to establish common agreed principles and rules that promote the safety of life at sea. These include standards to which a ship must comply, life saving equipment, radios, and maintenance, fire protection and escape routes and other technical requirements.

2.4 Australia's Marine Jurisdiction

Australia lays claim to 16 million square kilometres of ocean under UNCLOS III (Commonwealth of Australia 1998) with rights, restrictions and responsibilities varying over this area. Australia's marine jurisdiction is home to a vast number of activities and interests and while only 3% of the area is within 3nm of the shoreline, the majority of activity occurs in this area. It is an important resource environmentally, economically and socially, with ¾ of the population living within 50km of the coastline and 8% of our Gross Domestic Product (GDP) coming from marine industries (Commonwealth of Australia 1998). Figure 2.4 (p.18) further demonstrates the intensity of use of space within Australia's marine jurisdiction especially around the coastal zone.

Marine and coastal zone management in Australia is characterised by fragmented and haphazard planning, legislation and institutional arrangements (CSIRO 1997, cf. 2004). While most states and Australia as a whole are starting to implement more integrated approaches to management, management frameworks still exist separately for each interest, with different organisations responsible for each activity and different legislative control governing each activity. This has resulted in approximately 200 pieces of legislation that relate to the marine and coastal environments (NOO 2002).

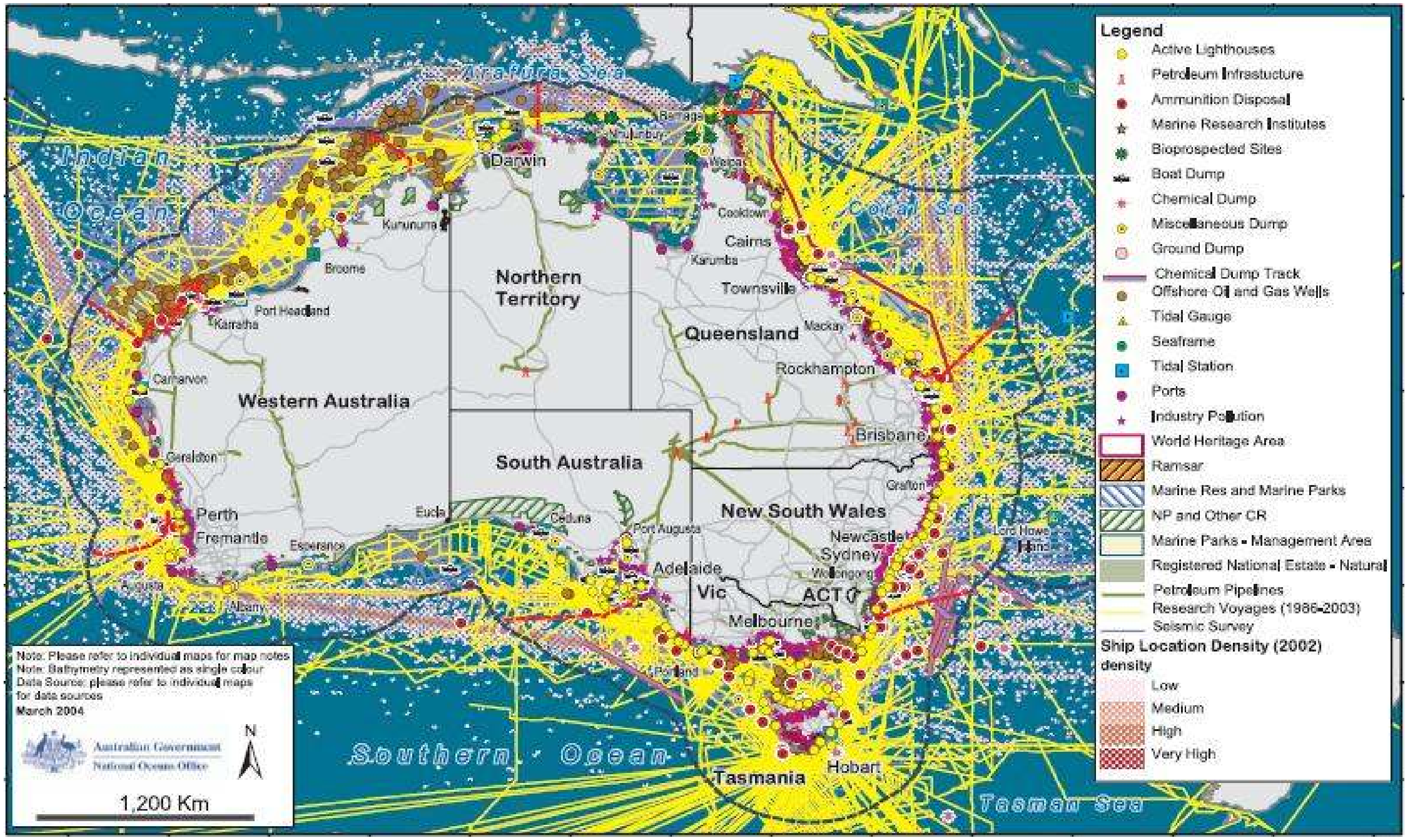


Figure 2.4 Multiple Uses in Australia's South East Marine Region (NOO 2003)

As Australia is a federated country (Figure 2.5) the system is perhaps even more complex, as the legislative framework can operate at different scales from local to global levels both spatially and institutionally. Legislation set at a global scale – for example the 1971 Ramsar convention for Wetlands of International Importance – may need to be implemented at a national level – in Australia through the Environment Protection and Biological Diversity Conservation Act 1999 – however will affect the local and state level as wetlands, spatially, are located on the coastline within state and local government control.

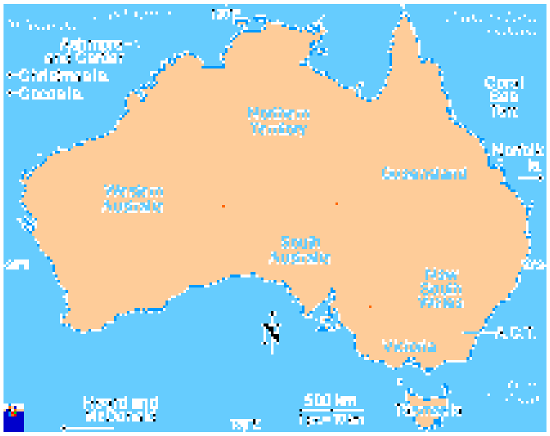


Figure 2.5: Australia's states and territories

Similar to this example each marine or coastal activity or industry (shipping, aquaculture, recreational sailing, oil and gas, navigation etc) will have a different regulatory framework that may have related legislation all the way through from local to global levels. On top of this different organisations are responsible for implementing the planning, regulation, policy and policing roles within each activity, and these also operate on different scales both spatially and politically.

The table below (Table 2.2) shows this complexity of management for marine areas, outlining the various organisations responsible for managing Australia's maritime jurisdiction at local to international scales.

Scale	**Responsible Organisations**
International	UNCLOS, plus approximately 30 other conventions and treaties
National	National Oceans Office, Defense, Department of Environment and Heritage, Shipping, Oil and Gas, Fishing Industries
State	State Governments ie/ Department of Primary Industries, Marine Board of Victoria
Local	Local governments responsible for the Coastal Zone, tourism, recreation industries, conservation

Table 2.2: Who's responsible for managing Australia's maritime jurisdiction

Recognising the segmented approach to national marine management, in 1998 the Australia Government released a National Oceans Policy. This policy aimed to propose an overarching governance framework that would better integrate all the various sectors, as discussed below.

Australia's Oceans Policy

Australia's Oceans Policy recognised that current marine management needed a more integrated and holistic approach and that there was no overarching policy or law in place to govern management from a national level. The Oceans Policy aims to set in place a framework for the integrated and ecosystem based planning of Australia's marine jurisdiction (Commonwealth of Australia 1998). It is predicted that marine industries and use of marine resources will grow, therefore there is a real need to manage different rights and interests to avoid conflict and overuse. The outcome of the policy was for management and decision-making to be integrated across the sectors. This relied on coordination between the states and the commonwealth governments for better management across jurisdictional boundaries.

The issues outlined in the section are clearly limiting the potential of marine management, with overlapping jurisdiction and competing and conflicting interests and responsibilities. The same issues in marine management in terms of sustainable development are driving the need for improvement in this area around the world. In response many countries and regions are trying to implement more integrated and holistic marine and coastal zone management.

2.5 Global drivers for improvement

In the past two decades there has been increased focus on the marine and coastal environments and improving management and use of these areas. The start of this chapter has explained current management of these areas and several initiatives that aim for sustainable development of the coasts and oceans. This section describes how sustainable development is driving the need for better marine and coastal zone management and administration.

2.5.1 SDS-SEA

The Sustainable Development Strategy for the Seas of East Asia (SDS-SEA) is an oceans policy which aims to implement the World Summit of Sustainable Development (WSSD) requirements for Coasts and Oceans in East-Asia. SDS-SEA sets out a policy to 'sustain, preserve, protect, develop, implement and communicate' aiming to balance the social and economic reliance of East-Asia on the marine and coastal environment, with the need to preserve and protect these ecosystems. This strategy was prepared by Partnerships in the Environmental Management for the Seas of East Asia (PEMSEA), and covers the 12 East-Asian countries. This policy also highlights the conflict arising from developing separate 'property rights regimes on both sides of the coastal zone' (Thia-Eng et al 2004), understanding the need for a holistic approach on and off shore. H.E. Fidel Valdez Ramos in a keynote address at the East Asian Seas Conference (Thia-Eng etc al 2004) states that 'the land and the sea are so closely interrelated that they should be considered as one whole entity'.

The SDS-SEA recommends the same approach to data management for these areas. Under the theme 'communicate: objective 3' the SDS-SEA recommends improving dissemination of reliable and relevant data, and encouraging organisations to share data. The organising body Partnerships in Environmental Management in the Seas of East Asia (PEMSEA) is developing an 'integrated information management system (IIMS)'to address this recommendation.

2.5.2 ICZM

Integrated coastal zone management (ICZM) is an initiative that aims to 'improve the quality of life of coastal inhabitants' (Thia-Eng 2004). It has become the standard approach to coastal planning and management (Wescott 2004) with nearly 700 ICZM initiatives occurring at international, national and sub-national levels (Chuenpagdee 2004). ICZM has been adopted by the state governments in Australia as the accepted approach to coastal management (Victorian Coastal Council (VCC) 2002). It is based on the idea that the coastal zone is unique, differing from the marine and terrestrial environments, as it is a combination of both. Therefore management needs to consider the multiple activities and interests in the area and provide an integrated approach, horizontally across different jurisdictions and vertically between different organisations and levels of government. Data is seen as an important element in the

ICZM process as shown by Bartlett et al (2004) 'if goals such as sustainable development of coastal zones are to be reached, then coastal researchers from different disciplinary backgrounds require access to a wide variety of marine and coastal databases'. ICZM recognises the need to integrate planning and management over the land-sea interface and so there is a need for data and information that covers both these areas (King and Green 2001).

2.5.3 Sustainable Development

Sustainable development is often described as comprising the economic, environmental and social aspects of development (Figure 2.6). It was first coined at the Rio 'Earth Summit' and at the World Commission of Environment and Development (1987) as 'development that meets the needs of today without compromising the ability of future generations to meet their own needs'. This section discusses the drivers of the various components of sustainable development and also examines some of the recent world conferences on sustainable development as they relate to the marine environment.

Figure 2.6: Sustainable Development (ConocoPhillips 2004)

Agenda 21

Chapter 17 of Agenda 21 from the 1992 'Earth Summit' in Rio applies to the protection of oceans, coasts and seas. It recognises that part of planning and management of activities such as fishing, conservation, shipping, pollution control and living and non-living resources is access to data, observations and information relating to them. Current management is inhibited by the high degree of uncertainty in current information. Since Agenda 21 there have been several global and regional initiatives that aim to continue the sustainable development theme.

World Summit on Sustainable Development (WSSD)

The WSSD was held in Johannesburg, South Africa in 2002. Initially marine and coastal areas were not considered in the Agenda for the WSSD, but pressure from many countries and international organisations saw them included. Although 10 years after Agenda 21, the same issues were raised with respect to oceans, coasts and islands. Mainly that poor management of these areas comes from a lack of understanding and that there is a need for improved collection and sharing of scientific knowledge and data (Cincin-Sain et al 2004). Since Agenda 21 there have been two initiatives to address these issues. These are ICZM for a more holistic approach to coastal zone management, as discussed earlier, and the development of Global Oceans Observing Systems (GOOS) to establish a global reporting and assessment of the state of the marine environment.

Environment

There are many serious environmental threats to the oceans and the living and non-living resources contained within. These include: pollution from onshore, and from waste dumping, introduced marine pests, natural resource depletion and sea level rise. Currently it is estimated that nine out of the World's seventeen fisheries are suffering from overfishing, while four are totally depleted. It is also estimated that 600,000 tons of oil enters the oceans each year from a mixture of normal shipping activities, accidents and illegal discharges. Chapter 17 of Agenda 21 sets out guidelines for the protection of the oceans, all kinds of seas and coastal areas.

Economic

The marine environment is recognised as an important economic resource, especially for many East Asian and Pacific Nations. With UNCLOS III providing the ability to extend jurisdiction out to the extent of the continental shelf the economic area of a country also increases. At the same time the intense use and overlapping and competing interests in these environments makes for inefficient exploitation of the resources. There is clearly potential for improved methods for exploiting the oceans resources. With unclear guidelines over jurisdictional rights there is still dispute over who has the right to use and exploit the coasts and oceans. Tied into this most marine activities and industries rely on a healthy marine environment to give them optimum output. This is particularly true for the tourism/ recreation industry.

Social

Recently there has been growing pressure in many countries to recognise the rights of indigenous people to the land and sea. In Australia there are many native title claims to coastal and marine areas. However the current Native Title Act does not allow for native title to be granted where it is conflicting with some other non-native title right or interest (Bowen 2002) making it impossible to grant native title in these areas.

The other area of concern is the high level of population living close to the coast and the prediction of this trend increasing in the future. Currently out of the top ten largest cities in the World, eight are located on the coast or on an estuary. The coastal zone is being increasingly used for recreation and holidaying, as well as living, making it an intensely population zone. This puts more pressure on this environment and increases the demand for space. With the threat of sea level rise and the possibility of natural disasters such as the recent Indian Ocean tsunami, there are many social issues that will increase without better planning and management for the future of the coastal environment.

2.6 Spatial Information in the Marine Environment

Many of the ideas for improving marine administration mentioned in the chapter have identified the need for accurate and up-to-date information to support a particular initiative. In addition to their navigational value, accurate charts now are considered essential for proper planning in support of the multiple uses of maritime resources within national waters (Butler et al 1987). Figure 2.3 showed some of the different activities that are involved in the management and administration of the marine and coastal environments. Each of these activities will require access to spatial information in order to support their decision-making. Generally this data will be collected, stored and used specifically for the one purpose. Figure 2.7 shows how an SDI can provide access for many organisations to spatial data that has previously been used for only one purpose.

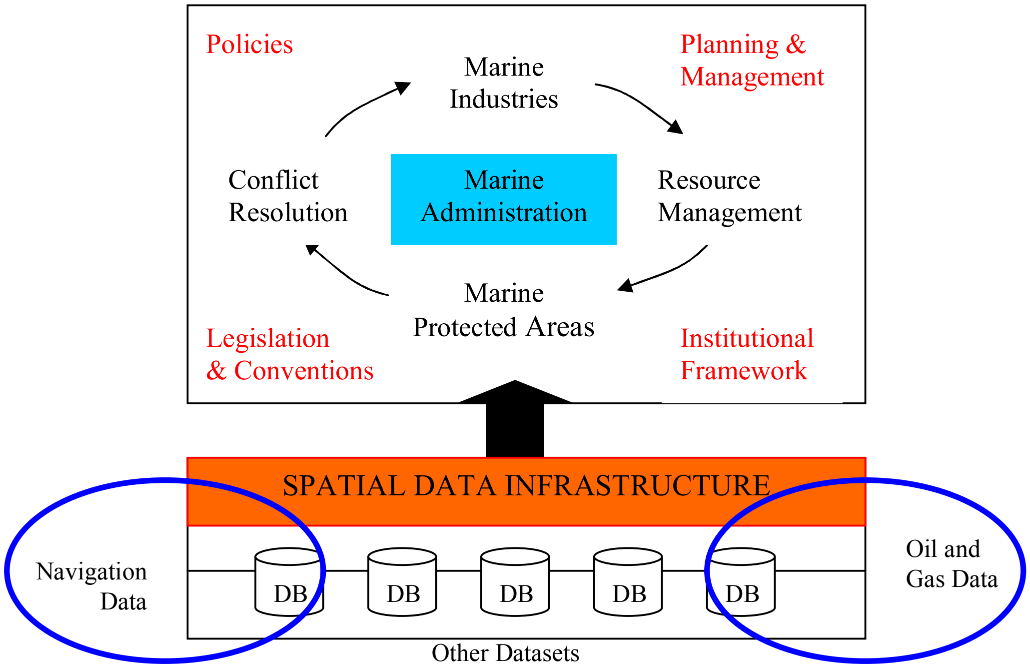


Figure 2.7: The role of SDI in marine administration (Strain et al 2005)

Figure 2.7 describes the role of spatial information in supporting marine administration. The different activities and supporting processes that form marine administration rely on spatial data and information to make decisions. Often the various spatial datasets are collected and stored by different organisations which can make them difficult to find and obtain. CSIRO (1997, cf. 2004) describe the wide range of availability and accessibility of datasets within Australia and state that there needs to be an overarching framework that identifies common access policies, standards and networks. Figure 2.7 shows this framework as an SDI, a concept that is described in more detail in Chapter 3.

2.7 Chapter Summary

A common theme from many of the initiatives that aim to improve coastal and oceans management is the desire for access to appropriate and reliable spatial information to support these initiatives. This was highlighted early in this chapter, as the first sailing ships could not travel far as they did not have accurate maps for navigation. It was not until the science that enabled reliable maps to be drawn, such as latitude and longitude, and a good understanding of oceans currents and winds, that the first long distance ocean explorations took place.

This chapter has also described the need for good governance of the marine and coastal environments. Ocean management was described as about balanced decision making in ocean space. It was shown through all the various drivers and initiatives for improving ocean management that management of resources in the marine environment is greatly dependent on the various types of information that are available to decision makers.

As we increase use of the marine and coastal environments we need a better understanding of these areas and also a better way to manage them. This chapter has shown that spatial information is critically important to managing the marine environment in terms of sustainable development and underpins decision-making and administration. The next chapter will discuss SDI – an initiative that aims to facilitate and coordinate the exchange and sharing of spatial information.

Chapter 3: Spatial Data Infrastructure

3.1 Introduction

Chapter 2 examined the development of marine administration systems and highlighted the need for these to be underpinned by access to reliable and applicable spatial information. This chapter discusses what it is about spatial information that makes it so useful in management and administration, and also the difference between spatial and other types of information. This is an important background into understanding SDI, a tool that aims to promote sharing and open access to spatial information for all potential users. This chapter explores the SDI concept, nature and hierarchy, and then examines the Australian National SDI (ASDI). Finally the implementation strategies for SDI are discussed as the next chapter (Chapter 4) looks at the development of Marine SDI.

3.2 Why is Spatial Information Special?

Chapter 2 demonstrated that spatial information is a useful resource in many marine management and administration initiatives. Spatial information is used in many disciplines, by many different people, for many different reasons. Having information available is necessary to promote a good understanding and knowledge for a particular discipline as described by Doody (2003):

Data + Context = Information

Information + Analysis = Understanding

Understanding + Management = Possibility of sustainable action.

Spatial information is often described as special or essential as it describes the location of resources in a way that gives understanding and relativity to other objects or resources. This ability to visualise the location of resources enables planning and management of the exploitation of these resources, allocation of the rights to these resources, and creation of restrictions and responsibilities for the protection of these resources. This is well described by Butler et al. (1987) ‘inadequate knowledge often results in resources being over-exploited or even destroyed before they are truly appreciated'. In support of spatial data they go on to state 'to derive benefits from a resource, it must first be identified and then managed. The map is the most efficient method of displaying the necessary resource information'.

Some of the oldest disciplines, land surveying and geography, are built on the spatial paradigm (Lees and Williamson 2005). As a country develops most industry and activities are reliant on topological and other spatial information, including (Butler et al 1987, p. 48):

> *road and railway development, improvement in regional agriculture, development of water supplies and hydro-electric power from dam construction, large-scale cultivation of new crops. . . . . . tourism planning and development; census studies; forestry management; industrial plant location; land ownership; land usage; environmental hazards; ecological studies; transportation; archaeological and anthropological studies; investigation, control and use of water resources; cadastral surveys; urban studies; sea defences; soil surveys; economic assessments; health investigations; irrigation systems; land reclamation; mosquito control in marshes; airport siting; housing developments; vegetation classification.*

By examining the list above it can be seen that all of these activities will need access to all different kinds of information. Most of these will be spatial information. It is estimated that 80% of information can be described as spatial as it will have a locational or positional component – all activity occurs at some location (Masser 1998).

Spatial information is different to integer, alphanumeric or symbolic data for a number of reasons: spatial data is scale dependent; spatial queries are inherently complex; all spatial queries, analysis and modelling are dependent on data models which have many and varied dimensions; and integrating spatial data with other data types is particularly difficult due to their different data structures. Using spatial data also relies on an understanding of the collection, scale, orientation, symbols, currency, manipulation, completeness of the data. Knowledge of the location of an activity allows it to be linked to other activities or features, this then allows maps to be made, distances calculated, directions given, data analysed and decisions to be made (Mapping Sciences Committee 1995).

The value of spatial information has increased with the emergence of improved information and communication technology (ICT). The change from paper based maps to digital information and geographic information systems (GIS) has revolutionized the use of spatial information. This is supported by the evolution of measuring technology with satellite positioning, allowing much grater accuracy and range of ability to collect spatial data. Many emergent nations begin by establishing a geodetic survey network to construct an effective topographic mapping series. This has grown to include multitudes of thematic data layers like vegetation, road and rail networks, population statistics (FAO 1997) as the profile for spatial information has increased. This greater profile can be seen through the recognition of the Prime Minister of Australia in 2002 that geo-informatics is one of the frontier technologies for building and transforming Australian industries (Howard 2002).

The improvement of ICT has not only allowed spatial information to be use for a wider variety of tasks and to be present in decision-making for more disciplines, but it also has allowed different users to share their information and results through the worldwide web. SDI is an initiative that acknowledges this desire for access to more and better quality spatial information, and aims to use the improved technology to facilitate people to share their spatial data assets.

3.3 SDI: an enabling platform

As it is now recognised that spatial information is essential to underpin many business and government activities, the use and storage of this information should be as efficient as possible. Previously spatial data was usually collected once for one purpose and stored in data silos by the organisation that had used it. Data was rarely shared or made available for another use. The theory behind SDI is to allow data to be collected once but shared within and between organisations to be used many times.

Spatial data can be expensive and time consuming to collect, for example it is estimated that in developing an Environmental Impact Statement 50-80% of the cost is related to collecting data and information (Gillespie et al 2000). The CSIRO (1997, cf. 2004) states that hundreds of thousands of dollars are spent on marine data collection each year. There is clearly an opportunity for people and organizations to save time, effort and money through sharing their spatial data. SDI has evolved in response to this opportunity. Sharing spatial data would also allow users access to more and potentially better quality data, and better maintenance and integration of datasets (Rajabifard and Williamson 2001).

SDI aims to achieve these goals by providing a framework or system that facilitates the exchange and sharing of spatial data between people. It can be described as the underlying infrastructure, often in the form of policies, standards and access networks that allows data to be shared between and within organisations, states or countries. It has been likened to road or rail infrastructure, which supports transport over land, and comprises roads as well as the rules, maintenance policies, and jurisdictional rights to them. SDI is comprised of 'policies, standards and procedures under which organisations and technologies interact to foster more efficient use, management and production of geospatial data' (FGDC 1997). Some of the benefits of developing SDI include: improved access to data, reduced duplication of effort in collecting and maintaining data, better availability of data and interoperability between datasets.

3.3.1 SDI Definition and Concept

SDI is developing in many different countries and at different levels within each of these countries, and so there are a multitude of definitions for SDI. Some of these are:

> *'the policies, technologies, standards and human resources necessary for the effective collection, management, access, delivery and utilisation of geospatial data'* (Coleman and McLaughlin 1998 p. 131)

> *'SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of*

government, the commercial sector, the non-profit sector, academia and by citizens in general.' (GSDI 2004 p. 8)

There are also many initiatives that are not classified as 'SDI' but have similar aims generally for a specific discipline. For example:

> *'OBIS (Ocean Biogeographic Information System) is a web-based provider of global geo-referenced information on marine species. OBIS strives to assess and integrate biological, physical, and chemical oceanographic data from multiple sources.'* (OBIS website <http://iobis.org/about/>)

> *'The Environmental Resources Information Network (ERIN) is a unit within the Department of the Environment and Heritage specialising in online data and information management, and spatial data integration and analysis. ERIN aims to improve environmental outcomes by developing and managing a comprehensive, accurate and accessible information base for environmental decisions.'* (DEH website <http://www.deh.gov.au/erin/about.html>)

SDI is developed at each particular level or within each discipline to promote better decision-making and therefore better social, economic and environmental outcomes for that particular level (Rajabifard et al 2002 (b)). The way in which data is collected, stored, maintained and used reflects the institutional and technical background of that particular level or discipline. The wide variety of definitions shows the range of ideas in implementing SDI. While there are many different definitions resulting from the different country context or discipline the SDI is intended for, they all have the same overall goal: To improve access and use of spatial data through enabling different people to share their spatial data products. As this research is based within Australia the ASDI definition will be adopted for SDI in general. This definition was coined by the Australian and New Zealand Land Information Council (ANZLIC), Australia's peak spatial information organisation (ANZLIC 2003 p. 2):

'The ASDI comprises the people, policies and technologies necessary to enable the generation and use of spatially referenced data through all levels of government, the private and non-profit sectors and academia.'

These different SDI definitions show the change in attitude and focus of the SDI movement. The first two definitions are less recent than the last two, and it can be seen that these are more data focused. The early view of SDI was that it was about producing, accessing and having spatial data. Another view, which has evolved recently, recognises that while obviously the data is important, developing an SDI needs to concentrate on the infrastructure, in providing the enabling technology and cooperation between stakeholders to allow and promote data sharing. This view is reflected in the later definitions for SDI.

3.3.2 SDI Components

Although there are many different definitions and models for SDI, researchers in SDI have identified some components common to most SDI initiatives (Coleman & McLaughlin 1998; Rajabifard et al.2000 (b)). These are: people, standards, policy, access networks, and data, as shown in Figure 3.1.

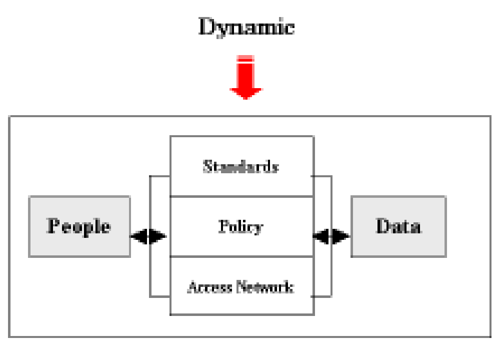


Figure 3.1: Components of SDI (Rajabifard et al 2002)

This does not mean that these are the only components that make up an SDI, or that there is another possible model. It is important to note that the SDI concept is dynamic in that it can be updated or expanded with changing technology or user needs, or to include a new environment. These components will be discussed in greater detail as they apply to the marine environment in Chapter 4; this section briefly outlines each component.

Data

Most SDIs have datasets that are considered fundamental in that they are 'required by more than one government agency and where consistent national coverage is required in order for the agencies to achieve their objectives.' (ANZLIC 1996). These datasets are called fundamental datasets, core datasets or framework datasets depending on the SDI conceptual model. These datasets must comply with the standards and policies defined within the SDI and are made available through the access network. Often the definition for these, and thus the actual datasets defined as 'fundamental' will differ slightly from one SDI to the next. The SDI for Victoria, Australia, for example, has defined framework data as: geodetic infrastructure, address, property, transport, administrative, elevation, hydrography and imagery, while in Western Australia twenty datasets have been deemed fundamental. ANZLIC (1996) has stated that each framework dataset should be 'consistent, to acceptable standards, its existence widely known, and it must be accessible'.

Standards

Consistent standards are required in order for people to access, share and use each others datasets. These standards cover content, access and exchange (ANZLIC 2002). Standards ensure that data is interoperable and intergratable for all users. Standards are generally set at a global level (for example the International Standards Organisation Technical Committee 211 (ISO TC/211) has recently developed a set of 40 Geographic Information related standards) and/ or national level (ANZLIC sets national level standards for Australia and New Zealand, FGDC sets standards for the USA). Content standards cover reference systems, data models, data dictionaries, data quality and accuracy. These are more likely to be national level standards. Access standards refer to metadata, data licensing and pricing, and cover privacy and sensitivity issues of who is allowed to use the data. Transfer standards specify data formats and encoding, facilitating easy exchange between data providers and users.

Policy

Policies are influenced by international best practice in spatial data management and exchange. The current ASDI policies cover access, data custodianship, conformity, quality, content, industry engagement, avoidance of duplication and sensitivity (ANZLIC 1999). This includes data pricing and licensing policies, as well as covering privacy and sensitivity issues. The policy or guidelines component can be considered a governing sector for the other components, as they must comply with this section. The challenge for this component is that the technology and uses are constantly changing causing the SDI to evolve, which in turn creates the need for SDI policies to be rapidly up-dated in order to respond to this dynamic environment.

Access Networks

The access network is the method that data is made available to the community. This is usually over the internet in the form of on-line atlases, web portals or data directories. An access network must comply with the technical, exchange and access standards and the policies set out from the institution that is administrating the SDI. Often the access networks are set up without the supporting back-end infrastructure of the standards and policies. Without this supporting infrastructure the data is unlikely to be interoperable, and there will probably be difficulties with different users obtaining, using, transferring and understanding any data obtained. Generally the aim of the access network is to provide potential data users with a list of available datasets and their metadata that also details the way the user can obtain a particular dataset. Some access networks provide the ability for data to be downloaded from the internet site, but most do not. Data providers often like to have control over who uses their data and what it is used for and so would prefer that people contact them for access to the data. For example the Corporate Geospatial Library maintained by Land Victoria provides a metadata directory for available datasets. When a dataset is requested by a user, Land Victoria then asks the data custodian if they permit the data to be used, before sending the data to the potential user.

People

Spatial data is used in elections, health, statistics, taxation, land administration, counter terrorism, emergency response, defence, natural resource management, environmental impact assessments, market analysis and so on. The people within these disciplines are one of the most important components of SDI. These people are the data users, data producers and value-adders from these disciplines. They form both the responsibility and the drivers for implementing SDI. An important part of the people component is partnerships within and between the people at all different SDI levels. Current SDI research (Warnest et al. 2005, McDougall et al 2005) has shown that collaboration between different people within and between the SDI levels is critical for developing SDIs from global to local levels.

3.3.3 SDI Hierarchy

As the concept and drive for SDI has spread around the world, SDI initiatives are developing at many different levels from local through state, national, regional to global. SDIs at different levels have different drivers that reflect the issues at each particular level. Figure 3.2 shows that SDIs at different levels will be used for different levels of planning and will thus contain different scale and detail of data.

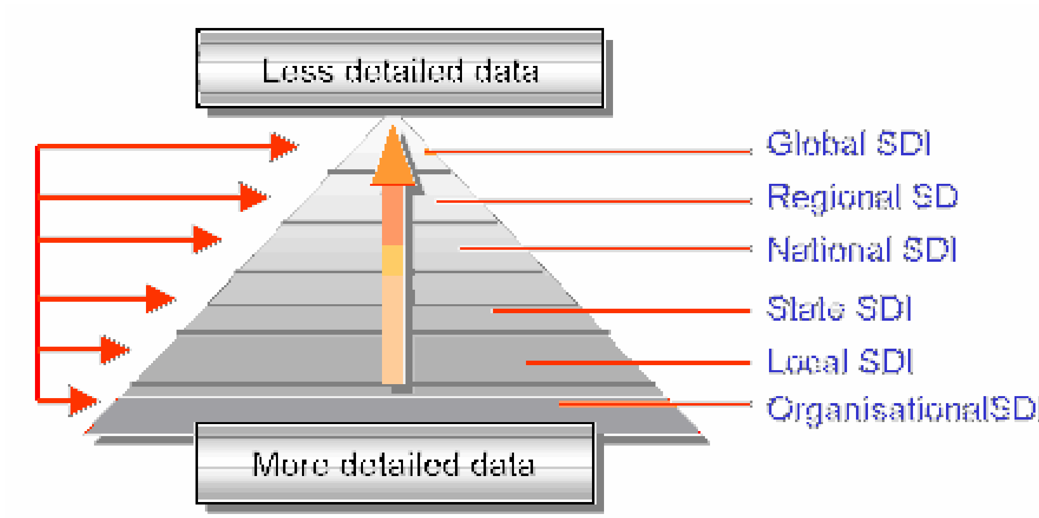


Figure 3.2 Different SDI levels (Rajabifrad 2002)

From this, a hierarchical approach to understanding the complex relationships between the various SDI levels has been developed. This idea is similar to general governance systems, as briefly discussed in relation to the marine environment in Chapter 2, in the scale and responsibility of decisions and the relationships between levels from corporate/ local to global. Rajabifard and Williamson (2001) have proposed two SDI models that examine the nature of the SDI hierarchy. Figure 3.3 shows the SDI as an umbrella, where the SDI at the higher level (such as the global and regional levels) encompasses all the components of the SDI at the lower levels (e.g. State or local). The umbrella view describes SDI as having the necessary standards, policies and technology in place at the global level to support and promote spatial data sharing at all the lower levels from regional to corporate. Figure 3.3 also shows the building block view of SDI hierarchy. In this view SDI at the lower levels provide the supporting spatial data and infrastructure for the SDI at the higher levels. This would mean that a Global SDI is made up of the all the Regional SDIs and a State SDI is made from all the Local SDIs within the state. This is more of a bottom-up approach, where the people and spatial data from the local and corporate levels drive the development of SDI up the SDI chain to the regional and global levels.

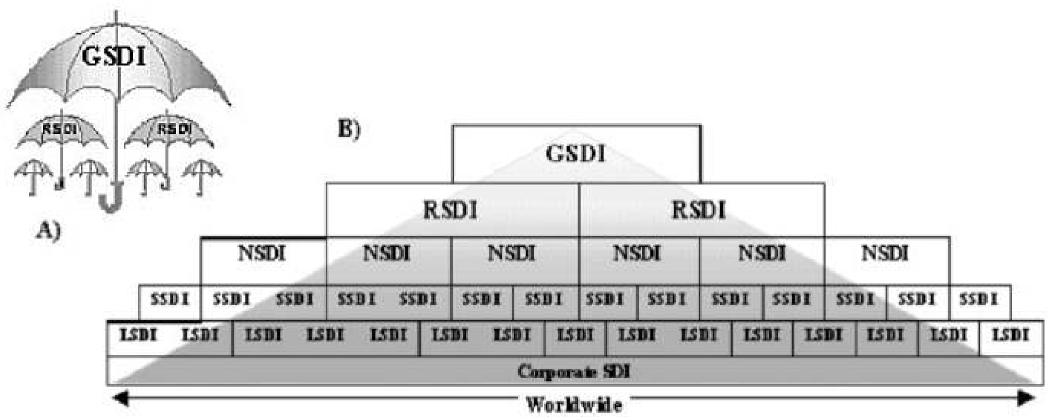


Figure 3.3 Two view of SDI: A) The umbrella view, B) The building block view (Rajabifard andWilliamson 2001)

An understanding of both of these models of SDI hierarchy can help to better design and implement a successful SDI. When the standards, policies and technology are set from the global levels and followed through to the local levels, all the spatial data contained in these SDIs should be interoperable. At the same time if the people are supportive and collaborative from the local levels up, this will enable them to implement the SDI policy and technology that has been set from the top-down. This need for balancing both views is shown in another SDI model from Rajabifard (2002), in figure 3.4. The vertical arrow shows the need for collaboration from the global to the local scale for data sharing between the different levels and at the same time it demonstrates that each level plays and important role in the SDI framework.

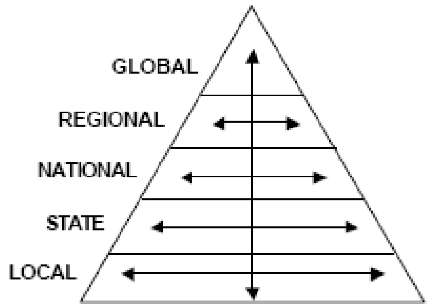
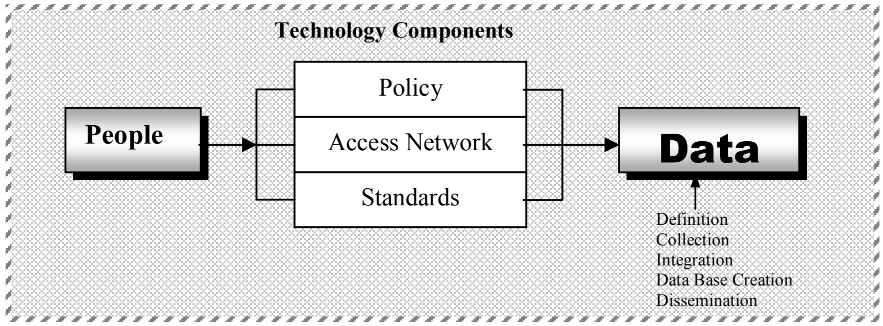


Figure 3.4 SDI hierarchy (Rajabifrad 2002)

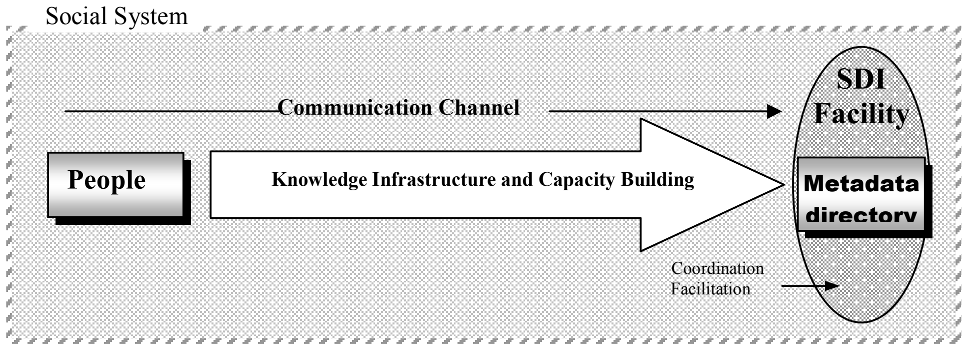
The SDI hierarchy highlights the importance of communication within and between the different SDI levels. The idea of developing and implementing SDI using an umbrella view or a building block view is also dependant on the scale of the proposed SDI.

3.4 SDI Implementation

SDI nature, concept and hierarchy are all influenced by the development and implementation of SDI. The SDI hierarchy model shown in Figure 3.2 and the relationship between the different levels shown in Figure 3.4 emphasises the need for communication both within and between SDI levels. This is to allow data to be shared between different jurisdictions and organisations working at a particular level, but also between organisations working at different levels in the SDI hierarchy. If state government need data at a local scale, they can obtain it from local government. Building on this model it is then clear that SDIs at different levels will need to be working from the same standards, policies and access networks, to enable the data to be shared. The difficulty is then determining at which level these policy and technical components should be set. There are two different models that answer this question. These have been called the product-based and processed based approach to SDI development (Figure 3.5).



A) Product-Based Model



B) Process-Based Model

Figure 3.5: Product and Process based models for SDI development (Rajabifard 2002)

1) The product-based approach

National SDIs first began developing in some countries in the early 1980s; these have been called the first generation of SDIs. These SDIs can be categorised as using a mainly product-based approach. The product-based approach is about developing a common infrastructure, focusing on linking different data-sources and providing access to these. This approach is most appropriate for the lower SDI levels because it can be built upon already existing processes and databases.

The product-based model can be likened to a bottom-up approach which recognises that the history of spatial data from paper maps through to complex 3d digital data will influence SDI development, as will the culture and level of development of a country and the people and activities in a jurisdiction (Georgiadou et al 2005). The bottom-up approach is SDI developing in response to particular user needs, however it is also SDIs developing in isolation from one another. Bottom-up SDI succeeds in responding to the needs of users, however the challenge then is that different data, standards and access networks are used between different jurisdictions and different people. Sharing data between the SDIs created from a bottom-up approach relies on cooperation between the people at each level or jurisdiction. Partnerships have been recognized as an important way to enable data sharing between people in SDIs at different levels (Warnest et al 2002).

2) The process-based approach

The difference between the product-based approach and the process based approach is that the latter is focused towards providing better communication channels, through which a community can access and share their spatial data assets (Rajabifard and Williamson 2003). The process based approach was more noticeable in the second generation of SDI development. The process-based approach is about building on previous experience and from this developing 'best practice' for SDI implementation. This approach aims to define a framework that will facilitate the management of spatial data assets, through coordination networks, capacity building and knowledge sharing (Figure 3.5).

The process-based approach can also be seen as similar to a top-down approach to implementing a framework or system. The top-down idea is often likened to SDI designed from scratch. It involves an overarching framework that defines key goals, implementation plans, core funding, fundamental data, policy, standards and access networks. These are set at the higher SDI levels and should filter down to the local and corporate levels; therefore the process-based approach is a more appropriate view of SDI for national, regional and global SDI levels. This approach often succeeds in the funding, commitment and technology aspects as these are often derived from national, international and global initiatives, organisations and research (Georgiadou 2005).

The overarching aim of the process-based approach is for SDIs to develop together following the same path, which would allow interoperability between them at all levels. If this approach worked, it would result in one SDI definition and set of components, so that all countries and jurisdictions had a generic SDI approach, allowing data to be shared all over the world. However for this approach to work it relies on the lower level SDIs to adopt the common SDI framework that is set from higher levels and as discussed in the bottom-up approach this may not always be the case.

These two approaches have been shown as two separate methods of SDI development. In reality they are also two different views that can be used to portray the implementation of SDI. However in implementing SDI both of these approaches need to be present. The top-down approach fails in that it does not build upon the existing spatial data use and sharing (Georgiadou et al 2005). It is difficult for the lower levels to adapt to standards, technologies and policies that are set at the higher levels and that may not relate to them and may not be easily integrated into their existing practices. The top-down approach relies on 'someone' setting the overarching framework and as Georgiadou (2003 p. 2) states

> *'there cannot be one organisation responsible for SDI. It needs to a web of partnerships and integrated organisations evolving development pushed by technological developments and pulled by user needs.'*

However the bottom-up approach builds SDIs for each level or jurisdiction in isolation from each other which limits interoperability between them. This is described in the SDI cookbook (GSDI 2004 p. 6):

> *'SDI initiatives develop in harmony with each other in order to maximise the impact of these programmes. In reality, many initiatives are working in isolation, not necessarily developing in harmony with others and consequently unable to reap the benefits of working together.'*

While one approach may be better suited for a particular country or jurisdiction, the challenge is to benefit from both these two approaches to SDI implementation, as for an SDI to 'succeed' a combination approach can be present. It is clear that there needs to be both an overall SDI framework to promote interoperability through common standards, policies and technologies but this also need to be user driven, responding to user needs and business drivers.

3.5 The Australian SDI

ANZLIC is Australia peak spatial information council, responsible for developing 'best practice' guidelines for the use and sharing of spatial information in Australia and New Zealand. The ASDI was defined by ANZLIC in November 1996. It then comprised four components:

Institutional Framework: defining the policy and administrative arrangement for building, maintaining, accessing and applying the standards and datasets;
Technical standards: defining the technical characteristics of the fundamental datasets;
Fundamental Datasets: spatial data produced within the institutional framework and fully complying with the technical standards; and
Clearinghouse network: the means by which the fundamental datasets are made accessible to the community, in accordance with policy determined within the institutional framework, and to the agreed technical standards.

These components are very similar to the ones shown in Figure 3.1, the only difference being 'people', which the definition of the ASDI has now included.

ANZLIC arose from the need to better manage land information (Clarke 2001). It was realised that within Australia each organisation was collecting data and storing it separately or in 'data silos' that prohibited other people from using it. This silo approach to collecting and storing data was not efficient and sharing this data could reduce costs for many organizations and could provide access to a valuable resource. This realization formed the initial policy for the ASDI, which is that (ANZLIC 1999 p. 2):

'*all users should have easy, efficient, and equitable access to fundamental spatial data where technology, data formats, institutional arrangements, location, costs and conditions do not inhibit its use'.*

From this beginning the ASDI began with a land administration focus but has since expanded to include the spatial information that will support many other initiatives such as emergency response, natural resource management and now the marine environment.

National SDI aims for a national coverage of data through a distributed network of databases with datasets listed in a data directory and complying with standards and policies. This is a top down infrastructure that ensures all jurisdictional efforts comply with the national interest. ANZLIC (1996) believes that this will support sustainable development through helping to achieve better environmental, economic and social decision-making. Five themes of fundamental datasets have been created including primary reference, administration, natural environment, socio-economic and built environment. In 2002 ANZLIC expanded its definition of the ASDI to include the marine environment.

The organisational structure of ANZLIC reflects the governance structure of Australia. There is one representative from each state and territory, one from the Commonwealth and one from New Zealand. The representative is usually the head of that particular jurisdictions spatial information agency.

Access to datasets is provided through the Australian Spatial Data Directory (ASDD), this lists metadata and contact details for the data custodian for all available data. The ASDD allows disparate agencies to make available for sharing the spatial data that they keep and potential users to search for the data they require. The latest audit of the ASDD (GA 2005), listed it as containing 39,373 metadata records and a broad range of users from the private sector, government and academia (Clarke 2001). Current ASDD statistics (GA 2005) show that the ASDD has approximately 500 visitors a day, which has been gradually increasing over time. ANZLIC has also achieved a nation-wide pricing, copyright and access policy and has formulated national guidelines for access and management of spatial data across different jurisdictions (ANZLIC 2002), although this has not been implemented across all the states and territories because the policies cannot be mandated (Clarke et al 2003).

The design for the ASDI developed by ANZLIC is for a distributed network of databases linked by a common registry of spatial data. In addition, however, users will be able to view, query, search, print and download spatial data in both vector and raster formats (Warnest et al 2002). In order to achieve this vision it will be necessary for the ASDI to embrace global open standards such as those developed by the Open GIS Consortium (OGC) and the World Wide Web Consortium (W3C). The standards and protocols allow consistent communication and transfer of spatial data, promote interoperability, and hence provide better access to the wide range of spatial information held within Australia (Warnest et al 2002). ANZLIC recognises that this is just the beginning of the ASDI and that in the future for a fully functioning SDI existing open protocols and standards such as OGC and W3C standards need to be accepted and implemented by the data providers and uses of the ASDI.

3.6 Chapter Summary

SDI aims to facilitate the exchange and sharing of spatial information. The SDI model needs to be examined in the marine environment from the perspective of both the data users and producers to ascertain how appropriate this model will be for marine spatial information. A marine administration system will be only as good as the information available and decisions are only as good as the information available and analysis of that information (Ting and Williamson 2000).

This chapter has examined the theory and concept behind SDI and discussed the current research in terms of SDI components, nature and hierarchy. The ASDI, as the National SDI for Australia, was used as an example of an SDI initiative and in Chapter 6 this thesis compares Marine SDI research with the ASDI. The last section of this chapter then looked at SDI implementation. Whether Marine SDI is a separate SDI to the existing SDI model, or can be integrated in to form a 'seamless' SDI that covers both areas, the implementation of SDI is critical in its development. SDI implementation reflects culture of society in which it's developed and is influenced by the purpose for which it's designed (ie emergency, conservation, land administration, or even marine and coastal management).

Chapter 4: Marine SDI

4.1 Introduction

Chapter 2 discussed the need for improved spatial data access and sharing in the marine environment. Chapter 3 examined the development of SDI, a framework that facilitates the exchange and sharing of spatial data, but is currently mainly focussed on land-related data. The 3rd UNCLOS brought international attention to the environmental, economic and social opportunities of the marine environment. Around the world countries began to consider how they could prove a 'capability and intent to manage their maritime jurisdictions in terms for sustainable development' (Robertson et al 1999). The idea of using spatial information management tools has occurred in many countries including Australia, Canada, New Zealand, USA, and in the UK (Binns 2004). As mentioned in Chapter 3, SDI development reflects the level of development, culture, location and other factors of the country/discipline that is developing it. This is the same with Marine SDI with every country at a different stage of achievement in their initiatives. However they all have very similar aims – to improve marine and coastal zone administration and management through better availability and applicability of spatial data.

This chapter discusses the emergence of the Marine SDI concept as it has responded to the drivers mentioned in Chapter 2. It then looks at the various initiatives in several countries and also at regional and global scales that are developing a spatial dimension to marine administration systems. The aim of the chapter is to examine Marine SDI from a 'top-down' approach, looking at the ideas and drivers from the national and international levels. The end of the chapter highlights similarities and differences of all these initiatives.

4.2 The Emerging Concept

The concept of a Marine SDI to support the spatial dimension of marine administration has been evolving since the late 1990s, in conjunction with the International Year of the Ocean. Very recently there has been a great deal of activity internationally into these concepts, with several collaborative events that have specifically focussed on them. For example: the 2003 Marine Cadastre meeting in New Brunswick Canada, the 2004 Workshop on Administering the Marine Environment – the Spatial Dimension in Kuala Lumper, Malaysia and the 2003 GeoCoast Conference on Integrating Information in Coastal Zone Management in Genova, Italy. Common at these events has been international reports from the different countries developing different Marine SDI or marine cadastre projects. The main countries that are investigating a Marine SDI or cadastre are: Australia, Canada, the USA, and the UK, as well as the Asia-Pacific region through the Permanent Committee for GIS in the Asia-Pacific (PCGIAP) and globally through the International Oceanographic Commission (IOC).

4.3 Australia

The CSIRO (1997, cf. 2004) stated that within Australia millions of dollars a year are spent on collecting marine and coastal spatial data. The CSIRO believe that considerable savings in time, money and effort could come from data users sharing their datasets. The current obstacle to marine and coastal spatial data sharing within Australia is the lack of a framework or system that promotes and provides access to data for potential users.

4.3.1 Marine Cadastre Project

A two year research project began at The University of Melbourne in July 2002 that aimed to define the concept of a marine cadastre. It was funded by the Australian Research Council (ARC) and was supported by The Department of Natural Resources and Mines, Land Victoria and Geoscience Australia (GA). There were two research aspects to the project, one focused on the similarities and differences between the existing land cadastre and a future marine cadastre. The second looked at 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.

Following the success of the first ARC Marine Cadastre project a new ARC grant was awarded in July 2004 to run until July 2007 for a second project on 'Addressing key scientific and policy issues for an Australian marine cadastre' with industry partners including Department of Land Administration Western Australia, Department of Lands New South Wales, Department of Sustainability and Environment Victoria and Land Information New Zealand. There are four research areas within this project:

1. Resolving issues in the definition of the tidal interface
2. The use of natural rather than artificial boundaries in a marine cadastre
3. Extension and application of the ASDI to include a marine dimension
4. Marine policy, legal and security issues

A marine cadastre has been recognised in Australia as a fundamental offshore dataset. It will essentially provide an ability to define, manage and administrate boundaries and their associated rights, restrictions and responsibilities in the marine environment, as an important layer in a Marine SDI. The overall aim of this project is the policy and technical basis upon which a marine cadastre can be built. Each research area aims to provide one aspect, the boundaries, the coordination of spatial data or the legal, policy and security implications. It is believed that these areas represent current major impediments to an Australian marine cadastre. The end result of the project will be to facilitate the development of a Marine SDI and a marine cadastre in Australia.

4.3.2 National Oceans Office – Oceans Portal

Australia's National Oceans Office (NOO) is aiming to develop the marine component of the ASDI through their proposed Oceans Portal. The idea of the Oceans Portal is to provide 'an Internet-based, customer focussed view into data and information of interest to users of the marine environment (Finney and Mosbauer 2003)' through three different components. These are: a Marine Portal, a Marine Catalogue and a network of interoperable service and content providers. The portal aims to be user driven, recognising that unless it is, it will not succeed. In order to ensure that the portal would meet user requirements, the NOO held a workshop inviting potential users and data providers. From the workshop the users identified the following datasets as those they most desired: oceanography, bathymetry, biodiversity, restricted areas and other boundaries, and access to this data, both in real-time and archived, was the most required function of the portal. Users also required the ability to search, access and display metadata and to visualise data to assess fitness for use. Data contributors volunteered that they would be able to provide similar datasets to those requested and also included fishing data and infrastructure.

The Oceans Portal is still under development with the workshop identifying the main obstacles to its development to be both technological and institutional. NOO aims to comply with standards set by ANZLIC for the ASDI, so that the portal could be included in the ASDD (Finney and Mosbauer 2003). However it is unclear if these standards will be applicable for marine spatial data. Also these standards for data and metadata still need to be defined, so that contributors know the standards their data must conform to. Regarding policy issues, there is still a level of institutional unwillingness to share spatial data both for 'not with my data' and capacity and ability reasons. This is also a challenge because the Oceans Portal, and the standards and policy that go with it, are not compulsory for data providers and there is no funding to encourage them. The NOO is relying on awareness raising, being able to identify business drivers, and possibly establishing mandates at a federal level.

The other issue with the Oceans Portal is that it only deals with spatial data from national jurisdiction (from 3n.m. to 200n.m.) and so doesn't include state marine or coastal spatial data. The NOO, because of this, is also considering building the Oceans Portal from scratch instead of using the ASDI framework that already exists (Finney and Mosbauer 2003).

4.3.3 Geoscience Australia

GA has two marine information systems currently underway. These are: an Australian Marine Spatial Information System (AMSIS) and an Australian Marine Boundary Information System (AMBIS). AMBIS is a dataset that delimits the marine jurisdictional boundaries out from Australia's coastline. This includes the coastal waters, the territorial sea, and boundaries shared with other countries. It also includes the TSB, an approximation of the coastline that defines all the other boundaries. The data this representation is based on is dated at 2001. As the coastline is dynamic these boundaries need to be re-computed every couple of years to adjust for the changing baseline. AMBIS has a metadata layer that lists this currency, as well as the completeness, standards, spatial extent and other attributes of the dataset.

AMBIS would form one of the datasets to be contained in AMSIS. AMSIS has similar aims to the Oceans Portal in that it will provide access to consistent spatial data and information and conform to current spatial standards, policies and technologies. GA believes that ocean management and planning is hindered by the current lack of information, especially which relates to boundaries, administrative areas, rights and interests and marine features. The database will firstly contain data that GA is the custodian of, which is sediment characterisation of the seabed, biophysical information on Australia's estuaries, and maritime boundaries. GA envisages that other data custodians will also be able to contribute data and information to AMSIS, providing they can conform to the standards and policies.

In developing these systems, GA has considered the following issues: data standards, dictionaries, format, structure, quality and datum, data maintenance, metadata and data gaps. GA also aims to make this data accessible through the internet using interoperability standards so that the system could be linked to the NOO Oceans Portal.

4.3.4 Australia's Marine Science and Technology Plan

Part of Australia's Oceans Policy was a marine science and technology plan. Under Objective 4 of Program three titled: Infrastructure for Understanding and Utilising the Marine Environment, the science and technology plan aims to achieve better coordination of marine spatial data. This objective recognises that 'increasingly larger volumes of marine spatial data are being collected, analysed and stored by government and the private sector' and that there are obvious benefits in terms of resources saved if there was a better ability to share this data. The NOO (1999) states that the main impediment to achieving better sharing and coordination of marine spatial data are is the lack of an agreed framework of standards, policies, and coordination mechanisms that would enable different users to exchange their datasets. National standards are set from the Commonwealth Spatial Data Committee (CSDC) and ANZLIC, however these are not rigorously followed by all organisations that collect and store marine spatial data, leading to the current situation of data with a wide variety of formats, datums, levels of completeness and consistence and often an incompatibility of these datasets.

At a national level there have been several groups that aimed to improve coordination and set national level standards. The strategy recommended in the marine science and technology plan is to establish a National Marine Data Group (NMDG) to oversee the implementation of common standards and policies that encourage organisations and industry to adopt this framework, and to share their marine spatial data resources. This has inspired the development of the Oceans Portal and AMSIS that were discussed previously, however at this point these initiatives are still underway with little to show in terms of implementation.

4.4 The United Kingdom

The House of Commons Environment, Food and Rural Affairs Committee released a report discussing the state of the marine environment that described similar problems for the UK as outlined in Chapter 2. That is, the current regulating framework for marine and coastal management is complex, fragmented and unable to adequately handle the pressure of all the different activities that take place within these environments. One of the main challenges to solving this problem is the current lack of knowledge, especially of a single location where all the information is available. The House of Commons (2004) believes it is difficult to 'achieve a complete picture of the seabed' because many of the existing databases 'for example hydrological, geological and geographical mapping exercises, are not in the same format' and there are institutional barriers to the different department working together to share data. Other problems regarding spatial data were 'disparate data, incomplete data, inconsistent data, lack of coordination, lack of metadata, ad-hoc approach to data collection and maintenance (Longhorn 2003)'. The committee recommended initiatives to address these problems and to improve use and sharing of marine and coastal spatial data.

4.4.1 Irish Sea Pilot Project

The concept of marine spatial planning has been developed in the UK with the aim to respond to the need for better access to information to manage the complex and conflicting rights and interests. The concept is being tested through a pilot project in the Irish Sea involving England, Ireland, Northern Ireland, Scotland, Wales and the Isle of Man. Marine spatial planning has been described by Tyldesley (2004) as a ‘strategic plan for regulating, managing, and protecting the marine environment that addresses the multiple, cumulative and potentially conflicting uses of the sea’ (CMS 2003).

The Irish Sea pilot project will examine how existing legal, administrative and enforcement systems will support the marine spatial planning concept and through this evaluate the efficiency and effectiveness of current governance and enforcement regimes. The current challenge recognised is the sectoral nature of marine management in this area, similar to the description of marine governance in Chapter 2. In addition, the administration of the Irish Sea is divided between five countries, but the aim is to have one governance framework. To enable this Tyldesley (2004) believes there needs to be a single leading body or government department in charge of spatial plan-making.

The spatial component of the plans comes from the recommendation that the plans include the physical and spatial dimension of all management strategies, plans, uses, resources, and legislation. In terms of spatial data, the marine spatial plans would contain the following:

- biological and physical characteristics of the sea
- ecosystem, natural processes
- historic shipwrecks etc
- current uses and pressures for change
- future uses and opportunities
- value of marine resources
- threats
- economic, cultural and social and environmental values
- monitoring and management arrangements
- performance assessment

The main challenges with the spatial dimension of the plans are issues with the spatial scales of data, especially coordination and integration between the hierarchy of national, regional and local spatial scales.

Marine spatial planning aims to promote better understanding of the area and thus better decision-making and planning however it is not supported by House of Commons Environment (2004).

The marine spatial planning concept is similar to the marine cadastre concept in that marine spatial planning aims to promote a more integrated approach to the planning and management of uses, rights, interests and restrictions in the marine environment by having them spatially defined. This is similar to the aim of the marine cadastre in the Australian example (Section 4.1), which is to 'describe, visualise and realise rights, restrictions and responsibilities in the marine environment'. The main challenge highlighted with marine spatial planning in the Irish sea is the disjointed approach to managing the coastal zone, with different planning systems operating on either side of the coastline. It was recognised that management should cover the whole jurisdiction of a country. However this also raises other issues in the Irish Sea, as this area is shared by five countries, but shouldn't be managed by five different governance systems (CMS 2003). Therefore, an integrated approach is suggested and being tested in this pilot project.

Also similar to the Australian project, the Irish Sea pilot project recommends that access to spatial data and information should form an integral part of marine spatial planning. While the idea of a Marine SDI is not mentioned, Tyldesley (2003) states that currently there is 'no coordination of geographic information or other mapping systems to collate, interpret, and use information or to form a basis for spatial planning at sea'. There are Marine SDI initiatives underway in Ireland and the UK, but these are currently in the vision stage and not part of the Irish Sea pilot project.

4.4.2 Marine Geospatial Data Infrastructure

In 2003 the United Kingdom Hydrographic Office (UKHO) launched the Marine Geospatial Data Infrastructure (MGDI). The UKHO wants to promote a joint approach to data collection and dissemination, as the current situation does not meet the needs of government, data users or data providers (Pepper 2003(b)). In the UK a MGDI is defined as 'an electronic based service for geographic and geo-referenced data which when combined becomes geospatial data' (Longhorn 2003). It will provide data to users about:

- water depths
- currents
- tides
- channel widths
- seabed textures
- temperature
- wrecks
- pipelines and cables
- seabed obstructions
- fish stocks

In order to implement the MGDI, the UKHO is going to firstly evaluate the currently available and existing data and then develop mechanisms for exchange of marine and coastal spatial data. The development of the MGDI will support marine spatial planning as Pepper (2003(a)) states that available and accessible marine spatial data through a MGDI is essential to marine spatial planning.

4.4.3 Marine Irish Digital Atlas

According to Dwyer et al (2003) Ireland has a significant amount of data related to the coastal and marine environments, collected and held by 18 different agencies in 6 different government departments. Currently the main problems in accessing data are awareness of the existing data and ability of different users to share data. This makes it difficult for potential users to find and access even the most basic of datasets relating to marine areas. The Marine Irish Data Atlas (MIDA) aims to improve the accessibility of spatial data to potential users through the creation of a web-enabled spatial data portal. In order to enable many different users access to MIDA and the data contained within, MIDA aims to use open source technology and standards – for example the ISO 19115 geospatial metadata standards, and xml for storing and displaying this metadata. To also encourage use, and meet the objective of improving the accessibility of marine and coastal spatial data, MIDA aims to be user driven, providing the data and information that will be of most relevance to users from government, research, conservation, education and private industry.

The data in MIDA will be divided into four categories: administration, environment, biological and socio-economic data. The main datasets will be:

- boundaries
- water quality
- protected areas
- planning information
- tenure
- bathymetry
- infrastructure
- oceanography

The main challenges that MIDA has come across in providing access and integration of these datasets are: sourcing and acquisition of data, data quality including scale, accuracy, precision, consistency and completeness, lack of metadata, cost and licensing and institutional willingness. Dwyer et al (2003) believes that the success of MIDA depends on the cooperation of data owners in supplying data and information, and the adoption of common standards and data formats.

4.5 Canada

Canada has two projects that are contributing to developing a spatial dimension to Canada's marine administration. These are driven by the need for 'good governance' of Canada's maritime jurisdiction and the need for better management of the rights and interests in these areas. Canada has the largest maritime jurisdiction in the world, and 25% of the world's coastline. It is also the first country to have created one piece of legislation to govern the National Oceans, the Canadian Oceans Act, which became law in 1997.

4.5.1 A Multipurpose Marine Cadastre

The University of New Brunswick (UNB) has a project on 'the good governance of Canada's Oceans' (http://gge.unb.ca/Research/OceanGov/). This project aims to answer three questions: 1) what resources (living and non-living) there are to govern; 2) who holds the rights and responsibilities for their safe and orderly conservation, distribution and exploitation; and 3) what are the spatial limits (boundaries) of those rights and responsibilities. The answer to these three questions forms the basis for a multipurpose marine cadastre. A marine cadastre that provides a record of all the different rights, restrictions and responsibilities in the marine and coastal environments will enable a clear understanding of the nature and extent of these interests leading to better decision-making and better management.

Under this project a multipurpose marine cadastre has been described as 'an information system that not only records the interests but also facilitates the visualisation of the associated rights, restrictions and responsibilities in the marine environment' (Nichols et al 2000). However the main challenge comes from identifying these boundaries, as currently marine boundaries exist in a variety of different media, produced by a range of authorities, for example: existing maps and charts, lines extracted from images, legal wording from legislation, common law or international law, regulations, historic or habitual usage and title claims. As well as having a large variety of boundary types, many of these are under dispute, and/or are open to an array of interpretations (Nichols et al 2000).

As part of this project the UNB, in conjunction with the International Federation of Surveyors (FIG) held a Meeting on Marine Cadastre Issues in September 2003. Delegates from all over the world attended the meeting to discuss marine cadastre development from their particular area. The main priorities common to most initiatives discussed at this meeting were:

- Obtaining the cooperation of stakeholders in providing datasets
- Developing common datasets, standards etc across jurisdictional boundaries
- The lack of a legal mandate in all countries for stakeholders to cooperate
- The need for common data and information management for all

The meeting highlighted that the basic technology and data already exist to build a marine cadastre; the main challenge is in institutional unwillingness to adapt current practices to common data and information management frameworks and to share their data.

4.5.2 Marine Geospatial Data Infrastructure

The Canadian Marine Geospatial Data Infrastructure (MGDI) began in 1987 with the Inland waters, Coastal and Ocean Information Network (ICOIN), a project to develop an integrated marine based information infrastructure. The ICOIN was planned to be built upon common standards and networking allowing simple third party access (Gillespie et al 2000). The current MGDI has been built upon this idea, and has the same basic underlying principles.

The Department of Fisheries and Oceans (DFO) is building on this previous work to develop a marine node in the Canadian Geospatial Data Infrastructure (CGDI). The DFO (DFO) defines a MGDI as 'a spatial and temporal data infrastructure comprising a system of data and enabling technologies that are critical to sustainable development, management and control of national marine, coastal and freshwater areas'. The DFO recognised that in order to be successful the MGDI would have to respond to the needs of the potential users. Therefore they undertook eight workshops all over Canada, with representatives from all marine sectors, at which the potential users were briefed on the CGDI and MGDI, and were asked for their feedback. The results suggest that user recommendations are:

- most users want information not data, however some want both
- single portal where all information/ data is available
- two-way infrastructure where they can contribute or update data
- MGDI to be part of global Marine SDI
- access to more and better quality data
- want interoperability of datasets
- metadata that particularly lists currency and accuracy
- seamless land and water digital elevation model

The workshops also highlighted that there are framework datasets that the majority of users want access to, such as bathymetry, boundaries, and shoreline. From these workshops the DFO also noted that compared to terrestrial data there was a greater focus from users on the currency of the data, as the marine environment is more dynamic and older data is less likely to represent the real world.

The challenges that have been noted in moving forward with the MGDI are:

- different users wanted slightly different needs from MGDI
- copyright, ownership, privacy and licensing
- diversity levels in currently collected and available data, interoperability
- pricing, coast recovery
- capacity building, funding
- building partnerships
- adoption of common standards

Many of these issues are tied up with the technical implementation of the MGDI. It is acknowledged that the technical 'supply' side that consists of applications, data, tools, methods, standards etc, needs to be balanced with the demand side, that is: information, knowledge, people, decisions etc. Developing the MGDI in a way that is both useful and affordable is vital for the sustainability of the system.

4.6 USA

The USA has a similar marine jurisdiction to Australia, as it is also a federated country. The Pew Oceans Commission (2003) reported on the state of the marine environment and the future for marine and coastal management in the USA, recommending a new oceans policy. Ocean management in the USA has been described as 'fragmented, complex and poorly understood' (Neely et al 1998). The Pew Oceans Commission recognised the stresses on the marine and coastal environments and recommended a new oceans policy that encourages regional and multi-sectoral marine planning and governance. It also recommended improved and more information availability.

4.6.1 Ocean Planning Information System (OPIS)

OPIS is a marine cadastral information system that aims to enable users to visualise property rights, regulations, laws and management system in the oceans. It recognised that many of the same components of land administration are applicable offshore, for example: adjudication, survey and owner rights. The main difference is in the boundary definitions and delimitation, already described in this thesis. In order to test this idea the National Oceanic Atmospheric Administration (NOAA) Coastal Service

Centre (CSC) is testing three types of ocean management: 1) regional through OPIS, 2) state and 3) no management system. OPIS covers the states North and South Carolina, Georgia, and Florida (Fowler and Treml 2001). It is the first application of its kind that is examining cadastral data in the offshore environment.

OPIS is an interactive web-enabled GIS that allows users interactive mapping tools, data and metadata download, and legal summary pages. Users can examine significant issues and then look at related spatial data and legislation (Figure 4.1). It also has standard GIS functions such as query, analysis and information.

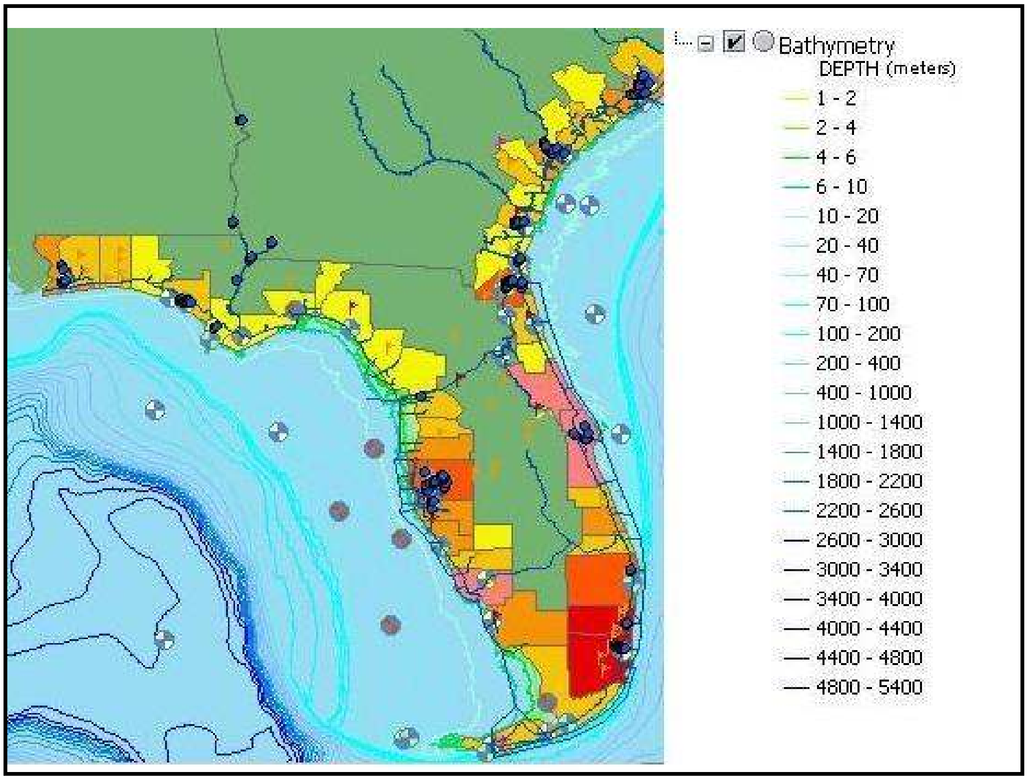


Figure 4.1: OPIS Map of Florida showing bathymetry data
(OPIS 2005)

OPIS tests the different management types by providing information on existing boundaries and their spatial accuracy, regulatory data and natural resource data. This allows managers more and better integrated information with which to make their decisions. The main difficulty that OPIS has is in obtaining information. Currently the spatial concepts of scale, resolution, accuracy, datum and projection are not considered, which may cause problem with integrating data and the reliability of the data. NOAA CSC recognises the greatest challenge for OPIS being the need to be adaptable to changing political and legal situations, and to be able to respond by updating reference datums, or the addition of data categories, or with new technology (Fowler and Treml 2001). The system needs to be dynamic and flexible. OPIS aims to respond to some of these problems through complying with the NSDI framework.

4.6.2 Coastal Spatial Data Infrastructure (CSDI)

Bartlett et al (2004) states that 'US ocean observation efforts are limited temporally and spatially' and the US needs a better mechanism for data collecting, sharing and exchange. The Federal Geographic Data Commission (FGDC) is responsible for the USA National SDI (NSDI) and is also discussing the development of a Coastal Spatial Data Infrastructure (CSDI). The FDGC describes the aim of the CSDI as 'to assist coastal managers in data acquisition, processing, storage, distribution, ease of use, and inclusion in decision-making'. The CSDI has four goals from the FGDC, being:

- the coastal management community understands and embraces the vision, concepts and benefits of the NSDI
- geospatial coastal and marine framework data are readily available for use by the coastal management community
- innovative practices and technologies that facilitate the discovery, collection, description, access and preservation of geospatial data are widely available to the coastal zone management community
- foster, develop and implement geospatial data applications in response to the needs of the coastal and marine communities

Currently the only data that is definitely considered fundamental are bathymetry, the coastline, and boundaries within a marine cadastre (Longhorn 2003). The FGDC lists the steps to a CSDI as establishing standards, defining fundamental datasets, and policies that cover collection, publication, licensing and privacy. As the coastal zone is made up of the marine and terrestrial areas combined, the end aim is for a seamless marine and coastal spatial data clearinghouse.

4.6.3 Multipurpose Marine Cadastre

The USA's multipurpose marine cadastre is being developed by the Department of the Imterior's (DOI) Mineral Management Service (MMS) Mapping and Boundary Branch (MBB). The DOI MMS (2004) has described this cadastre as 'a comprehensive spatial data infrastructure whereby rights, restrictions and responsibilities in the marine environment can be assessed, administers and managed'. Its objective is to provide marine managers with the best information available to meet their management, enforcement and research goals. Currently many different organisations or agencies are responsible for the same area or the same activities. The multipurpose marine cadastre will provide a clear outline of who is responsible for what and the spatial limits of these rights or responsibilities. It will also aid in enforcement by outlining the restrictions that apply to certain areas.

The cadastre needs to contain a number of datasets necessary to properly administer rights and interests, such as legislation and boundaries. Therefore implementing the multipurpose marine cadastre relies on partnerships and cooperation between the different agencies that have this relevant information. This data or information may be held by many agencies. The DOI MMS (2004) believes the implementation will have to be at state or national level to promote and encourage this collaboration and data sharing.

4.7 Regional and Global

There are several initiatives occurring at regional and global levels. For example at the regional level Working Group 3 (Cadastre) of the PCGIAP held an International Workshop in April 2004 in Malaysia, to discuss the spatial dimension of administering the marine environment. Many countries in the Asia-Pacific region are dependant on coastal and marine industries and so the development of a framework to enable clear understanding of rights and interests in these areas is vital. An example of global Marine SDI is the OBIS that was mentioned in Chapter 3. While OBIS does not call itself SDI, it aims to facilitate the sharing of biogeographic data and information about the oceans, using common standards and policies and a web-based information portal.

This section discusses two other global ideas: the United Nations – Global Oceans Observing System and Oceans 21.

4.7.1 Global Oceans Observing System (GOOS)

Chapter 40 of Agenda 21: from the United Nations Conference on Environment and Development, recommended improved methods of data collection, analysis, dissemination, use and sharing, to promote a better understanding of our Earth and its environmental processes (Bernal 2002). In response the United Nations has proposed three separate Global Observing systems, the Global Terrestrial Observing System (GTOS), the Global Oceans Observing System (GOOS) and the Global Climate Observing System (GCOS). These observing systems are being implemented to improve availability of general scientific data, through better networking of existing data collection systems. For example GOOS aims to establish a global reporting and assessment of the state of the marine environment. It is building on existing ocean observations systems, for example the Voluntary Observing Ship (VOS) program that takes meteorological observations and tide data from the global sea level observing system. The primary output of GOOS is global or basin scale datasets at real or near real time (IOC 1998), and it is currently focussed on physical data such as sea surface temperatures, currents and salinity observations.

The main challenge that GOOS faces is in data coordination and harmonisation of observations to improve interoperability between all possible users (Le Tissier and Kremer 2004). It aims to comply with existing national and international standards, and information systems using open technologies and standards. Looking at GOOS through the SDI components, it can be seen that while the data component of GOOS is well developed and researched, the backend infrastructure, particularly the standards and policies still need some work. With issues such as spatial data coordination highlighted at presentations from the Coastal Zone Asia Pacific Conference 2004 (Le Tissier and Kremer 2004), the need for common standards, policies and technology is evident. GOOS is described as a ‘shared observation network’ (Bernal 2002) and as such has similar aims to a global SDI – sharing spatial data on a global scale. The joint committee of management is promoting communication and networking between separate GOOS projects – Indian Ocean GOOS, Coastal GOOS and others. This involves integrating existing systems and promoting the use of similar standards and technology to allow interoperability on a regional and global scale. The aim is for one system that contains fundamental datasets – bathymetry, sea surface currents, wave height etc – covering the oceans.

4.7.2 Oceans 21

Oceans 21 is a coordinated initiative between IOC and the International Geographic Union (IGU). The current Oceans 21 framework is based on recommendations from CoastGIS'03 which established that geographic information and spatial technologies are essential for achieving the goals from the Global Conference on Coasts and Oceans Rio +10. Oceans 21 recognises that geographic information is 'the 'glue' that helps integrate information from numerous sources and disciplines helping to improve quality of life for all citizens' (IOC-IGU 2004).

The Oceans 21 plan has six themes, which are:

1) accumulating coastal knowledge for sustainable development: concepts and methods
- tools, best practise guidelines, case studies, reviewing existing situation

2) GIS Implementation of Coastal Information Systems for ICM
- better understanding of GI and GI technology – spatial understanding

3) Coastal Urbanisation and Coastal Landscapes
- identify data and decision support systems, same outputs

4) Science and Technology of coastal information systems for ICM
- implementation of coastal information systems, open technologies, data models for implementing SDI

5) Training awareness and assistance on GIS-assisted ICM

6) Extending National, Regional and Global SDIs from Onshore to Offshore
- partnerships with SDI organisations, data and metadata standards, case studies such as Mediterranean Basin, cross discipline data integration

The outcomes of these themes and their associated activities and research are:

- open source information systems based on GIS technology aiming to respond to the differing needs of decision-makers, planners, managers and educators
- methodologies and tools for improving and using coastal GIS particularly focussing on interoperability
- integration of researchers from SDI at all scales with coastal zone geographic information research
- more participation within oceans-coasts research with SDI initiatives

In order to achieve these objectives Oceans 21 is forming partnerships with the Global Spatial Data Infrastructure (GSDI), the European Regional Spatial Data Infrastructure (INSPIRE) and PCGIAP. Data collection and modelling research is also being conducted with initiatives such as Land-Ocean Interaction in the Coastal Zone (LOICZ) and the Coastal Oceans Observation Panel (COOP).

4.8 Common Limitations or Opportunities

All these initiatives described above share similar aims, and similar methods for achieving these aims. They each described the need for improved marine and/or coastal spatial data sharing and in response to this each is developing an SDI or similar spatial data sharing initiative. Most have also described the need for a better and clearer understanding of the various rights, restrictions and responsibilities in the marine and coastal environments and in response are developing a framework that describes the different boundaries and their associated rights or interests. The definitions for each country or jurisdictions SDI or cadastre project are slightly different, but have the same underlying components.

The AMBIS and AMSIS projects from GA have shown that the cadastre and SDI are not separate entities but will be linked together. A cadastre needs access to particular spatial datasets – boundaries, legislation, resources- that would be contained in the SDI. Also, as recommended by UN-PCGIAP (2004), a marine cadastre will form a spatial data layer in a Marine SDI and therefore will need to conform to the policies, standards and technology specified within the SDI.

The Marine SDIs listed above shared many similarities. They all aim to develop a web portal that would be the access network part of the SDI and each aimed to provide access to spatial data as well as various other functions such as metadata or an on-line atlas. The datasets listed by each as fundamental are very similar, as well as the data issues that each considered causing problems for data sharing. The common issues were: data formats; reference frames, lack of metadata, lack of consistency in data; currency of data; and no common approach to data collection, maintenance and storing between stakeholders.

Each initiative stated that it would be user driven, but mentioned the difficulty in balancing the data needs of users with the data available from data providers. Also as highlighted by DFO (2001) different users have different requirements for spatial data. The other main challenges that have been highlighted from this chapter include obtaining capacity and funding for implementing common standards and technology, and obtaining the cooperation of data providers to adapt these standards, policies and technology.

Each initiative is debating the idea of extending their NSDI to include the marine environment, or to develop a marine SDI from scratch. The main difference between all these initiatives is that some include the coastal zone as part of the Marine SDI and some are only focussing on the marine environment, and have not yet considered including the coast. The overall definition for these – to develop a mechanism to different people, working in different sectors to share their spatial datasets - aims to resolve the most basic problem that is the main driver for these initiatives.

4.9 Chapter Summary

This chapter has examined the Marine SDI concept at national and international levels. It showed that Marine SDI and marine cadastre initiatives are developing in many countries, all with the aim to facilitate marine and coastal spatial information sharing to improve decision-making and management of the marine and coastal environments. The similarities and differences between these initiatives was summarised and can be compared to general spatial information and SDI activity worldwide. Many coastal countries are now examining different approaches to better manage their marine jurisdictions, often using spatial technologies or spatial data management tools. This chapter has given an overview of some of the most prominent examples of SDI or other spatial information initiatives that focus on the marine or coastal environments. This chapter has shown that while each initiative may be called a different name, they all have a common goal and also a similar goal to general SDI initiatives as outlined in Chapter 3, that is – to share spatial datasets.

This chapter has followed on from Chapter 3, in that is discusses the implementation of the marine or coastal dimension of SDI. It has examined the ‘top-down’ approach of Marine SDI development, looking at national and international scales. In order to also see the ‘bottom-up’ approach to Marine SDI the next chapter will discuss the local level, with a case study in Port Phillip Bay, Victoria, Australia.

Chapter 5: A Case Study

5.1 Introduction

Previous chapters have discussed the SDI concept and hierarchy and shown the emergence of the idea of Coastal or Marine SDI and the implementation of this idea at national and international scales. In order to examine the concept of Marine SDI completely this research aims to look at this phenomenon at state and local levels. This chapter uses a case study approach to examine spatial data use, management and sharing within the State of Victoria, in particular in the organisations and agencies responsible for management of Port Phillip Bay.

The main aims of the case study are:

- to evaluate the availability and interoperability of spatial data within Port Phillip Bay;
- to examine current use and sharing of this data; and thus
- to identify the opportunities and limitations for Marine SDI on a state or local scale.

This chapter firstly describes case study research and discussed its applicability to this thesis. It then introduces and outlines the current management and administration of the marine and coastal areas of Port Phillip Bay and the research that has taken place to respond to the objectives of this chapter. Finally the results of the case study are presented and compared to other related research to assess the reliability of this case study.

5.2 Case Study Design

In order to respond to the research objectives and in particular to identify opportunities and limitations for developing a seamless SDI that combines the marine and terrestrial components a case study approach has been adopted. This case study aims to examine Marine SDI at the other end of the SDI hierarchy, looking at the state local levels. While this research aims to develop an SDI model for both terrestrial and marine spatial data, it has been assumed that the current model (from Chapter 3,

Figure 3.1) is acceptable for land related spatial data and so only its ability to accommodate marine spatial data needs to be evaluated. For this reason the case study only examines marine spatial data sharing and usage for the case study area. Chapter 2 described marine management in general and from this chapter it can be seen that the intensity of activity and the need for decision making under pressure with conflicting uses and needs is greater in the near shore area. This area is within 3n.m. of the coastline and comes under state and local jurisdiction. Chapter 3 discussed the two different approaches to implementing SDI and described how one was more appropriate for top-down implementation, while the other worked better as a bottom-up method. As considerable research has already been conducted in the Marine SDI concept at national and international levels (shown in Chapter 4) with the top-down approach, this case study will focus on larger scale data within a state or local jurisdiction. This will examine the ideas and drivers from a bottom-up perspective.

5.2.1 Case Study Research

A case study is described by Yin (2002) as 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident'.

This thesis aimed to examine the implementation of Marine SDI and investigate this at different SDI levels, resulting in a generalised SDI model that could apply to marine, coastal and terrestrial data, as outlined in Chapter 1. Research in the form of a literature review has provided an understanding of Marine SDI development at a national and international level, however there is very little literature that examines this at a local level. As has been described earlier, at a local level SDI is more likely to be facilitated by a less formal approach with organisations forming separate partnerships and sharing data on an ad-hoc basis. Therefore using a case-study approach to examine this spatial data use and sharing will provide research into Marine SDI implementation and development at a local level.

According to Yin (2002) a case study involves five main steps:

- A proposition
- Research questions
- A unit or units of analysis

- Data collection
- Assessing reliability and validity of results

Before deciding on the location of the case study the first three steps need to be addressed. The proposition for this case study has been discussed in the research as being: to study the use and sharing of marine and coastal spatial information as part of the SDI at a local level in the SDI hierarchy. To follow on from the proposition the questions that need to be answered are:

- what spatial data is used
- who uses it and what for
- how do they obtain this data
- what standards and policies govern this data

These questions need to be asked to both data users and data producers, therefore the units of analysis to find the answers to the research questions will be the data users and data providers involved in managing this case study location.

Evans and Gruba (2002) describe a case study as 'an investigation that builds theory', where a representative group is examined that provides research that could be generalised for a population. Clearly the ability to draw conclusions from the case study relies on the appropriate choice of location or group, in response to the case studies proposition, research questions and unit of analysis. This research found an appropriate area to be Port Phillip Bay, Victoria as is outlined in the next section.

5.2.2 Case Study location

Port Phillip Bay (PPB) is located in South Central Victoria, Australia, with the capital of Victoria, Melbourne, situated most of the way around its coastline (see Figure 5.1).

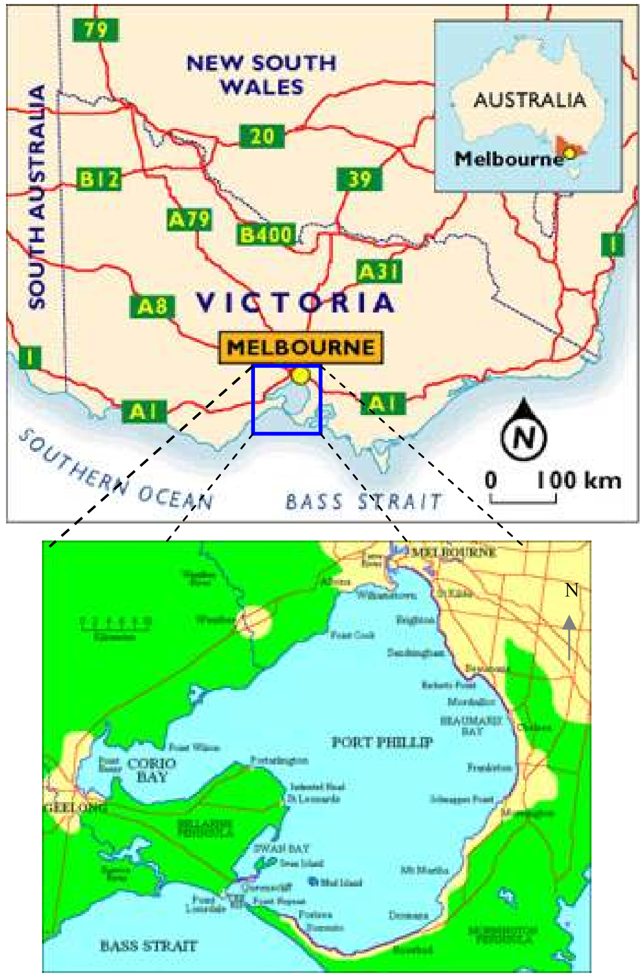


Figure 5.1: Port Phillip Bay, located in Victoria, Australia

It was originally intended to pick a local area and while local in SDI terms refers to a local government area, in the marine environment this jurisdictional area does not exist. The other consideration is that the States maritime jurisdiction extends to 3 nautical miles and also includes nearly enclosed bays, harbours or other waterways. In order to get an appropriate case study that combined the state and local governments an area such as this was used. It is more of a local/ state level SDI as the state government is responsible for below low water mark and the local government for landward from this mark. This is a smaller scale area comparatively to the State's marine jurisdiction and an area that has a defined management framework.

This area was also chosen because it represents a heavily used and heavily populated coastal and marine environment within Australia. Many different activities take place within the bay, for example: shipping, fishing, aquaculture, conservation, recreation and tourism. Economically this is an important area for Victoria as the Port of Melbourne is one of the largest ports in Australia and it is estimated that tourism from PPB contributes approximately $140 million a year to the Victorian economy (Atkinson 2005). The capital city of Victoria, Melbourne, is located at the top of the bay and it is heavily populated around the perimeter as shown by the brown area on the map in Figure 5.1. Some of the current issues in managing PPB are considered to be: pollution and marine pests prevention, managing conflict and competition for space, and a proposal from the Port of Melbourne Corporation to deepen the shipping channels within the bay.

PPB is managed by state and local governments. Local governments have jurisdiction above low water mark, however in some municipal councils jurisdiction is extended seawards to 600m from low water mark to include jetties, marinas, breakwaters and other coastal infrastructure. State government is responsible for the area offshore from low water mark; however governance of the area is also controlled by legislation from higher levels as shown in Figure 5.2.

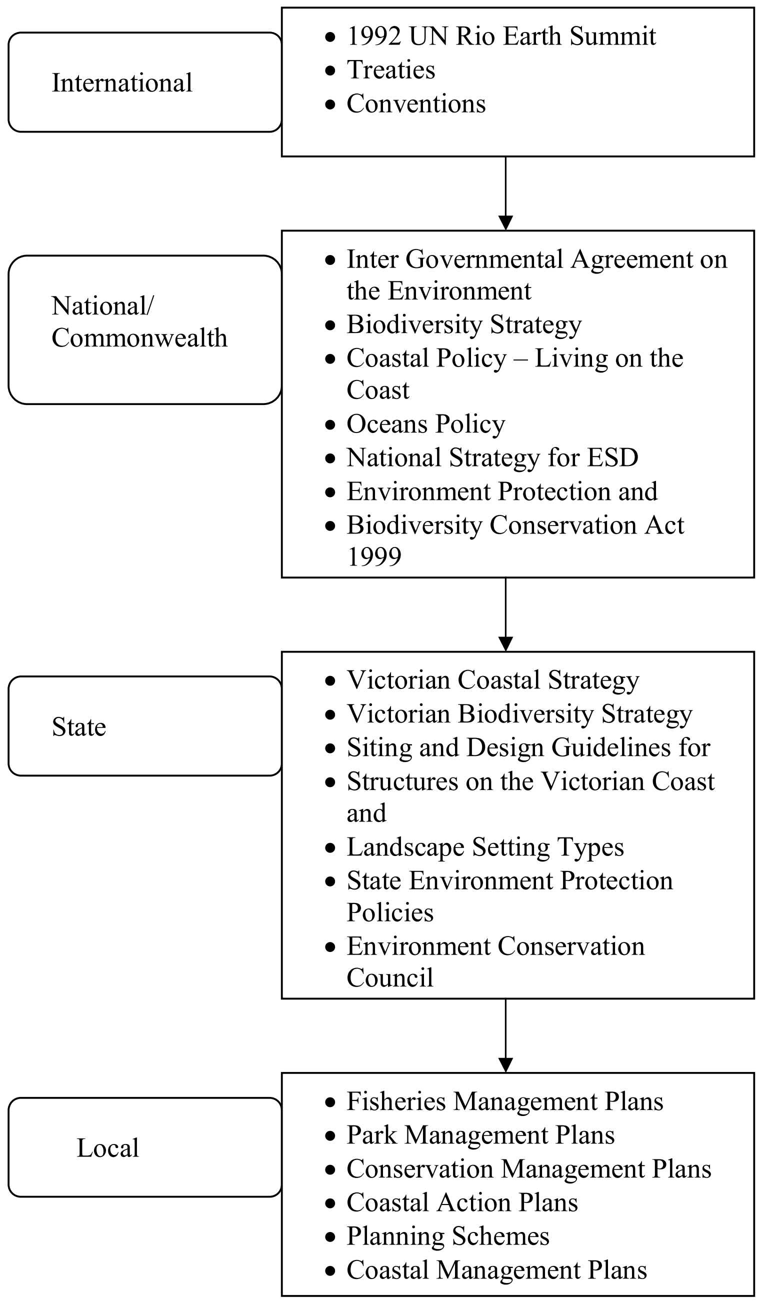


Figure 5.2 Port Phillip Bay's legislative governance framework (ABM 2000)

5.2.3 Port Phillip Bay Case Study

This case study relies on knowledge of who is responsible for managing PPB, and collecting all available spatial data from these organisations for PPB. Table 5.1 shows the organisations and their particular responsibilities.

Government Agency	Activities that are regulated
DSE	Use and development of coastal crown land Protection of rare and threatened flora and fauna
DPI	Aquaculture Commercial fishing Mineral exploration and exploitation Dredging and spoil disposal
EPA	Licensing of waste disposal Water quality Oil pollution
Marine Board of Victoria	Marine navigation and recreational boating activities Marine Safety
Parks Victoria	Port works and facilities Recreational use of waters
Port of Melbourne Corporation	Management and operation of Port of Melbourne Management and operation of shipping channels
Aboriginal Affairs Victoria	Aboriginal Heritage
Heritage Victoria	Shipwrecks and marine heritage
Municipal Councils	Planning and building approvals Waste Disposal Local regulations and by-laws affecting use and development of coastal foreshore

Table 5.1 Main Stakeholders in the Case Study Area
(adapted from ABM 2000)

This case study aimed to complete the assessment of the potential for a seamless SDI through examining Marine SDI as a state/ local level. The objectives of the case study were:

- To identify to current use, management and sharing of spatial data about Port Phillip Bay from the perspective of the people involved in managing this area;
- To evaluate the availability and interoperability of spatial data about Port Phillip Bay through collecting all available data, and generating different spatial products;
- To identify the main limitations and opportunities in use, access and sharing of spatial information about Port Phillip Bay; and
- To examine the private sector perspective in accessing and using spatial data, particularly when reporting on a critical environment, economic and social issue, in this case the development of an Environmental Effects Statement.

In order to respond to these objectives the case study involved four parts. These were:

1) Obtaining available data about PPB and examining/ analysing this data;
2) Interviewing relevant stakeholders of PPB about sharing and use of spatial data;
3) Examining from a private sector perspective through the channel deepening EES the availability and accessibility of spatial data for this area; and
4) Validating the results with previous research from the ARC marine cadastre research project.

5.3 Case Study Part 1 – Obtaining Marine and Coastal Spatial Data

A search was conducted to establish the available datasets for the marine and coastal areas of PPB. This involved searching various data directories and Internet portals throughout Victoria and Australia, as well as asking potential custodians directly. This was done to provide an audit of all data for the case study area. These datasets were then analysed to assess their availability – looking at issues such as access methods, metadata and interoperability. Through this audit the opportunity for stakeholders of PPB to find and use data about this area could be identified.

5.3.1 Accessibility of PPB Data

The main impediment to obtaining data was that there are some general datasets available, but there is limited data that is specifically related to PPB. When planners, managers and decision-makers need data for a particular area it will generally be collected once off, used and then rarely used again. This project-based data is not available for re-use by someone else. Table 5.2 outlines the results of the data survey, showing the datasets that were found and those that could be used for this research. It also gives the custodian, the availability of metadata and the method of accessing the data.

ACCESSIBILITY			
Dataset	**Custodian**	**Access**	**Metadata**
Marine National Parks	ParksVictoria	contact custodian	Yes - ANZLIC guidelines
Coastline	DSE	Through Land Channel	Yes
Coastline	DPI	contact custodian	No
Depth and Parcel data	PoMC	contact custodian	No
Melbourne and surrounds	GA	downloaded from internet	Yes
AMBIS	GA	downloaded from internet	Yes
Not used			
Aerial photography	DOI	Land Channel	Yes
bathymetry/topography	GA	downloaded from ga.gov.au	Yes

Table 5.2 Accessibility of datasets for PPB

This table shows that there were quite a few datasets available that had information about PPB, and that only two of these datasets counld not be used because of interoperability issues discussed later. This table also shows metadata as an important part of assessing the availability of spatial data. Some of the datasets did not come with metadata and this makes it very difficult to use the data. For example, the Melbourne and surrounds data was downloaded from GA's website but did not come with metadata or any other kind of data descriptions. The different layers that were available were only listed as numbers and the user would need to guess what this data actually showed. Other aspects of the data such as the scale, reference frame and accuracy are critical in using the data, and need to be documented in the metadata. These aspects were used as part of this audit to assess the interoperability of the data.

5.3.2 Interoperability of PPB Data

Interoperability of the different datasets obtained was critical as several datasets could not be used because of interoperability issues. For this audit the characteristics of the data that were used to assess the interoperability were: format, licensing, pricing, scale and reference frame. Table 5.3 shows the results for the datasets for PPB.

INTEROPERABILITY					
Dataset	**Format**	**Licence**	**Pricing**	**Scale**	**Reference**
Marine National Parks	ArcView shapefile	No	Free	Unknown	GDA '94
Coastline	ArcView shapefile	Yes	Free - agreement with Melbourne Uni	Unknown	GDA '95
Coastline	ArcView shapefile	No	Free	1:250,000	GDA '96
Depth and Parcel data	ArcView shapefile	No	Free	None/ unknown	None
Melbourne and surrounds	ArcView shapefile	Yes	Free	1:250,000	GDA '94
AMBIS	ArcView shapefile	Yes	Free	1:150,000	GDA '94
Not used					
Aerial photography	image	Yes	Free – agreement with Melbourne Uni	1:15,000	
bathymetry/topography	ASCII or ER mapper	Yes	Free	1:13,000,000	WGS84

Table 5.3 Interoperability of Datasets for PPB

Table 5.3 shows that the datasets that were used could be obtained or converted to ArcView shapefiles to be used with ArcGIS. The aerial photograph could not be used because the file size was too big, and the bathymetry/ topography dataset was not able to be converted in an ArcView shapefile. Another issue with the bathymetry/ topography was that the scale was so small that it would not have integrated well with the other datasets. Most datasets came with a license, except those that were obtained directly from the custodian. All datasets were obtained free of charge, although normally the DSE data from land channel would have a nominal fee (the University of Melbourne has an agreement with the DSE and students can use the data free of charge through the University of Melbourne data library). Pricing and licensing indirectly affect the interoperability of the data as they are often important components for the data producers. They allow data producers to freely share their data without concern of misuse or worry about liability of a wrong decision made with their data. They also provide a nominal payment for the use of the data, supporting the ability of the data producer to conform to the recommended standards and policies. Licensing and pricing information therefore makes the data more available and more likely to be interoperable.

The other datasets that were obtained but could not be mapped were from the Port of Melbourne Corporation. This data was not mapped with a reference frame and so could not be integrated with the other data. It also did not come with metadata, and so while it was easily available through the Port of Melbourne Corporation, it was not interoperable and could not be used.

5.3.3 Data Audit Results

The total data that was available is shown overleaf in Figure 5.3. This map shows the difference in data availability for the on and offshore components of the area. While there are many different data layers available for the terrestrial part of this area, there was only a couple of datasets that contained information on the marine or coastal components.

There were some discrepancies in these datasets, mainly in the coastal area. The two coastline datasets that were available and the data from GA that also showed the coastline, are slightly different; this is shown in Figure 5.4 on page77. However, Table 5.2 shows that one of the coastlines had a scale of 1:250,000, this dataset also has a positional accuracy of +/- 100-1000m and for the other the scale is unknown. The biggest difference at any point along the coast between the different coastlines was 1.3 km, and given the small scale and large positional uncertainty of one dataset, and that the scale and accuracy of the others is unknown it is impossible to tell whether there is in fact any significant difference between the two, and thus which is the ‘true’ coastline.

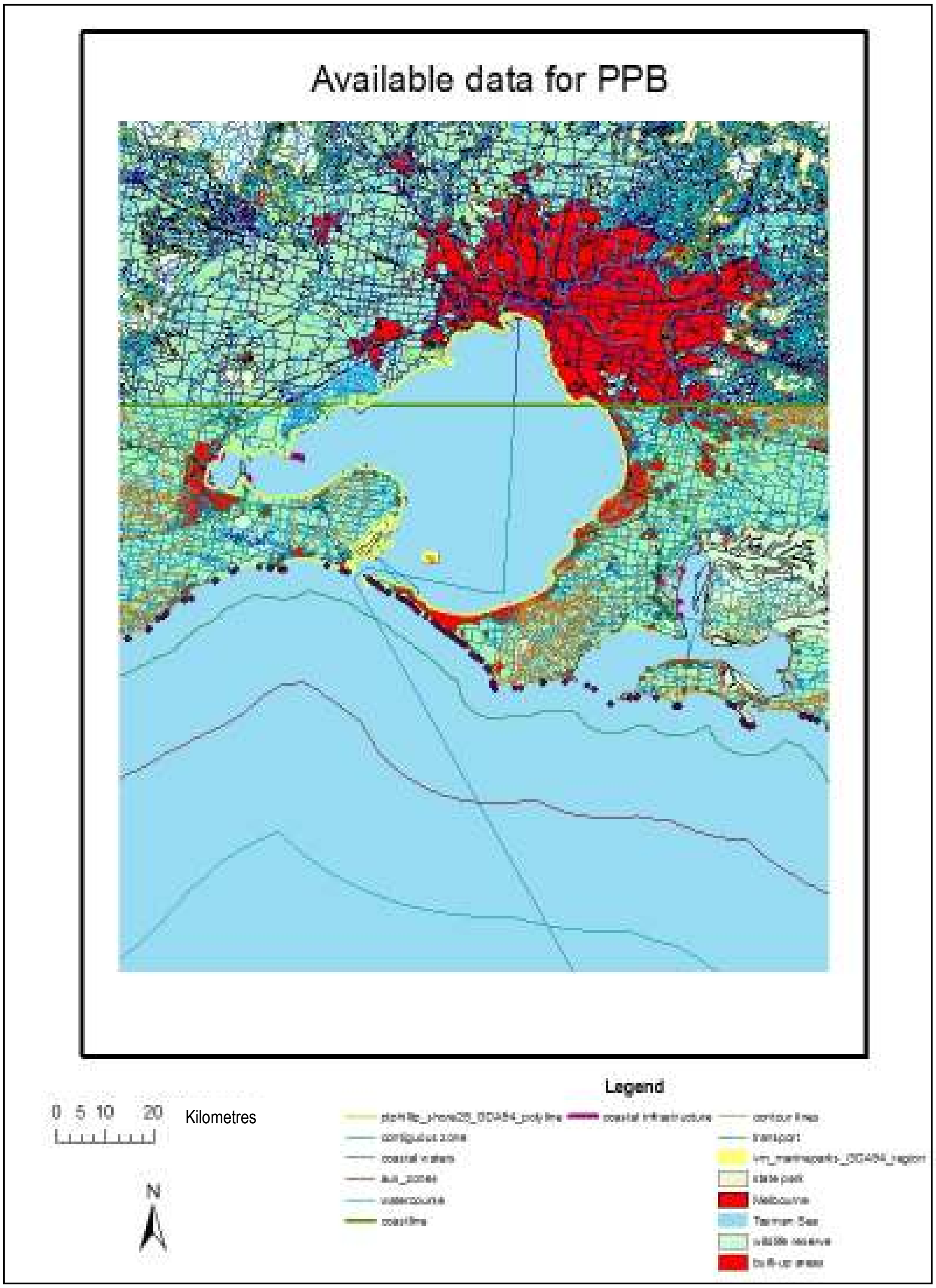


Figure 5.3: Available Data for PPB Case Study Area

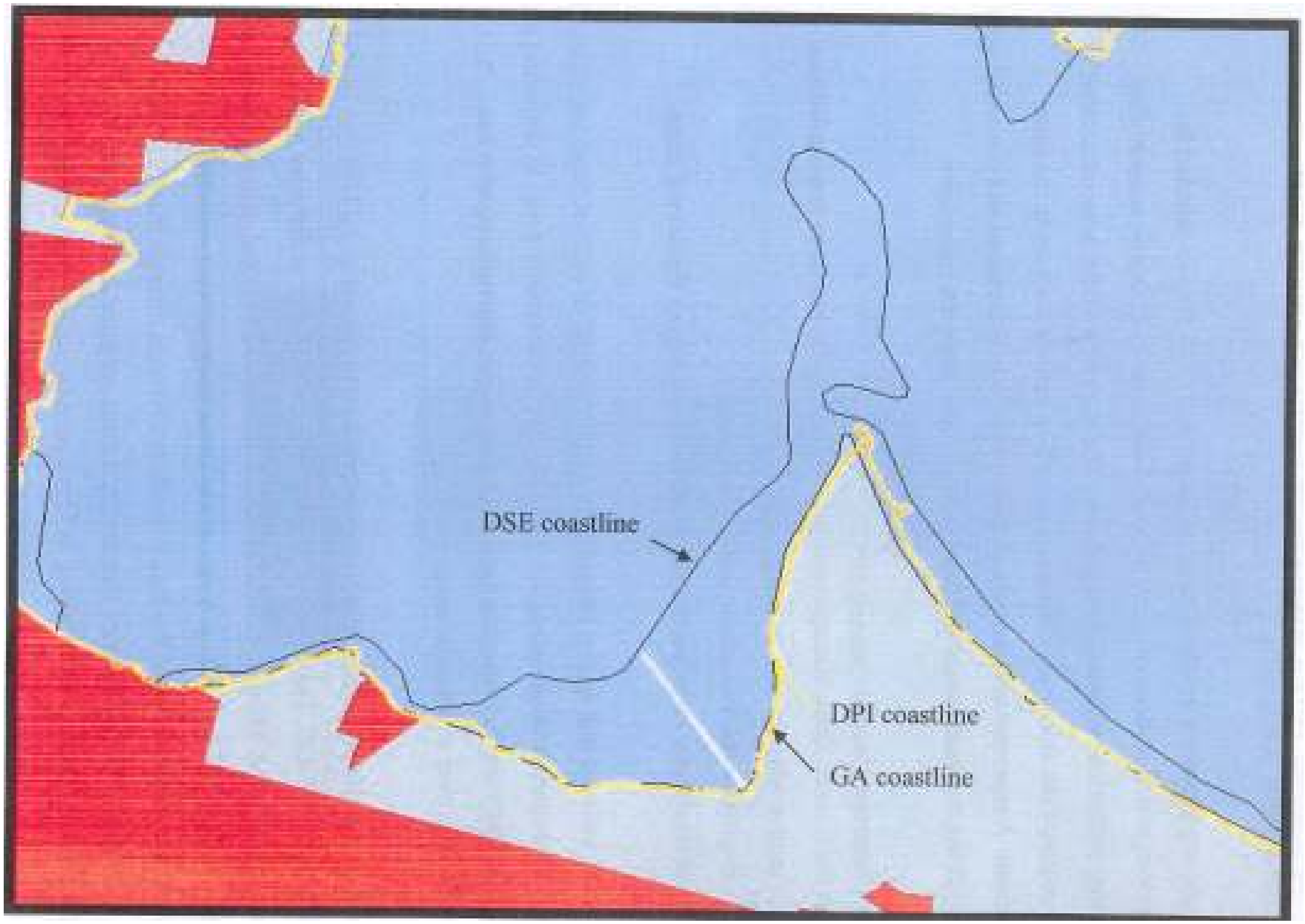


Figure 5.4 Coastline Differences in PPB case study data

This section has shown the importance of not only making spatial data available, but of also having common standards and policies to make the data interoperable. The next section of this chapter examines these same issues from the point of view of stakeholders in PPB.

5.4 Case Study Part 2 – Interviews with Port Phillip Bay Management Authorities

Several organisations involved in management of PPB were selected for interview, with questions concerning spatial data use, availability, accessibility, sharing, collection, standards and policies. The interviews were semi-structured as they required the ability for discussion as well as getting answers to the same questions. A representative sample of these interviews is included and discussed here, highlighting common issues and answers that arose from the interviews.

5.4.1 Victorian Coastal Council (VCC)

Under the Coastal Zone Management Act 1995 the VCC has three responsibilities,

1. to give advise to the minister
2. to prepare the Victorian coastal strategy
3. to coordinate other parties responsible for managing the coastal zone

The VCC believes that spatial information is fundamental in each of these activities. It is used to prepare strategic plans, to resolve issues in the coastal zone, in preparing the coastal strategy, and in managing agencies, for example determining who has responsibility over a particular area.

Spatial data is therefore used in a project-by-project basis, and is not kept and rarely collected by the VCC. The main spatial datasets that are used in different projects are shown in Table 5.4. Most of this data is more terrestrial or coastal than marine except for bathymetry. As the VCC is a part of the DSE most of the data it needs it available through the DSE's internal data collection. If data is needed that the DSE does not have then the VCC may try and find it from another organisation, or would hire a private contractor to collect it.

When accessing data from another organisation the VCC generally would ask different data custodians if they had the required datasets. Often there are problems with sharing data, these are shown in Table 5.4 and cause the problem of poor interoperability with another organisations data.

When data is collected for a particular project it must comply with the policies and standards that are set from within the DSE. However this rarely occurs and only on a project-based approach and so it is unlikely that this data would be made available for public use. Table 5.4 describes the VCCs issues with spatial data use and sharing.

Data Used	Access Network	Standards/ Policies	Sharing	Issues
Cadastre Property information Rivers Roads Topography Bathymetry Land use mapping Sites of significance Population Planning schemes	DSE internal data library or collected for a project	Set within DSE, ie at an organisational level	Don't share data with other organisations directly, but indirectly through DSE data library	Different technologies Different data formats Compatibility Data currency

Table 5.4: Spatial Data at the Victorian Coastal Council

5.4.2 Port of Melbourne Corporation (PoMC)

PoMC has jurisdiction over 500ha of land and a 1 million ha area of port waters. Within this area it is responsible for monitoring and maintaining channel depth, piers, cruise shipping, general port operations, navigation controls, asset management, land surveying, environmental planning and property.

Currently spatial information is used by many of the sectors within the organisations, for example finance, asset register, engineering projects, planning, corporate property, channel deepening, navigational, harbour control, ship movement, hydrographic surveying, marketing and environmental. In a recent company review the importance of spatial information for PoMC was highlighted and currently there is organisation research into developing more effective and efficient ways to use spatial information. Most of the spatial data PoMC uses, they capture for themselves because they want such large scale data about a specific area that is often not available else where. Table 5.5 shows the datasets that are used by PoMC.

This data is shared with Heritage Victoria, DSE, the Department of Primary Industries (DPI) and the tenets of the area. Metadata is not collected for this data, but there is an in-house description of the data. Generally an organisation that is looking for data will contact PoMC, and if they have the data that is desired it will be emailed through to the other organisation. There is no licence for other organisations wanting to use the data, and no pricing or other policies to restrict who uses the data. PoMc just requires that they get back a copy of the data if the other organisation intends on updating or adding anything to it. If PoMC wanted to access another organisations data they would just get in contact with that organisation directly.

Data is collected frequently as PoMc needs up-to-date information. The data is collected to defined internal standards. PoMC believes that data sharing between different organisations could be improved, but it is not a priority and therefore money and other resources would be unlikely to be used to improve this. Current problems they sometimes find when sharing data are to do with compatibility of different datasets and technologies that different organisations use which causes a lack of interoperability (Table 5.5).

Data Used	Access Network	Standards/ Policies	Sharing	Issues
Rail Titles Reserves Cadastre Roads Wharfs Land use Land values Imagery Emergency zones Channel outlines Retaining walls Pipelines Navigational aids Historical features	Mostly collected by PoMC and use some VICMAP data	Internal PoMC surveying standards for reference frame, precision and accuracy. No metadata	Share data with Heritage Victora, the DSE, DPI and with their tenants. This is done through direct custodian contact	Need large scale data No resources for improving data sharing Compatibility of technology and data

Table 5.5: Spatial Data at the Port of Melbourne Corporation

5.4.3 Bayside City Council

Bayside City Council is a local government of Melbourne that is responsible for part of the coastline. It is responsible for administering several rights, restrictions and responsibilities over the coastal zone up to the low water mark, and in some areas out to 600m where there is a pier or marina. It also plans and manages the foreshore for the area that it has jurisdiction over.

Bayside City Council uses spatial information through its digital cadastral database (DCDB), a GIS that contains all the council's relevant spatial information. This is mainly used for mapping and information purposes and has limited spatial analysis use. The datasets stored in the DCDB are shown in Table 5.6. These are mainly land-related, however coastal assets are also recorded. The council also has aerial photography from the last 3 decades, which is used to trace environmental changes.

The spatial data the Bayside City Council uses is mainly collected by private contractors by from the council for a specific project or purpose. Data is rarely shared, although has been with Parks Victoria, as there is a National Park within the council's area and with Melbourne Water a public water corporation. The main problem that Bayside finds with this is that data is collected at one instance and so only provides a snapshot at a certain time; it is not updated regularly and loses value quickly.

Standards are set from the Vicmap datasets as Bayside uses Vicmap cadastre as the base layer for all the other datasets. These standards come from the DSE. Some data is acquired from other organisations, such as DSE and Bayside would generally contact the data custodian directly. They believe also that data sharing could be improved, but state that this is not a priority in managing a local government area with limited funding and manpower, there are other bigger concerns. These issues are summarised in Table 5.6.

Data Used	Access Network	Standards/ Policies	Sharing	Issues
Cadastre Roads Pedestrian and bike paths Fences Vegetation Buildings Lights Coastal infrastructure	Use Vicmap data Also get data from DSE and collected internally using contractors	No defined standards or policies	Rarely	Updating data Limited funding and resources for improving spatial data use and collection

Table 5.6: Spatial Data at Bayside City Council

5.4.4 Marine Safety Victoria

Marine Safety Victoria (MSV) is the regulator of all Victorian waterways. MSV is a division of the Department of Infrastructure (DOI). MSV uses spatial information in auditing the usage of waterways, to track the position and movement of assets and also as a tool that can assist in other aspects of waterway management. The spatial datasets that are useful for these activities are shown in Table 5.7. The navaid and signage data and the boating safety program data are collected by MSV and the rest are sourced from other organisations. MSV has found increasing uses for this spatial information and because of this it is becoming more important in day-to-day business activities.

The datasets are stored on an internal DOI network and the licenses are held by the DOI. Within MSV data is obtained in either MAPINFO or ArcGIS format off the network. The MSV data is collected from field activities using ESRI technology and GPS. There are currently no best practise data collection standards or policies and this is an issue that MSV is hoping to resolve in the future. They hope to make the data more reliable through validation. Often the MSV data is collected by private contractors, so is collected using their desired standards, format, scale, reference frame and this information is recorded in metadata that is generally kept for all datasets.

Most of the data that MSV collects is for internal use only, however some data is made available to waterway managers. All the data that MSV currently needs is available through the DOI intranet, but as the use of spatial information becomes more important and they would like more spatial data, they would consider using other methods to obtain data. The current problems that MSV has with using and obtaining spatial data are shown in Table 5.7: They would be more open to using web-portals on on-line access networks if they could answer some of these problems.

Data Used	Access Network	Standards/ Policies	Sharing	Issues
Cadastre Hydro Melways Roads Aerial photography Navaid and signage Audit data Boating safety program	Through DOI at an organisational level	No defined standards or policies	Rarely	Expense Hardware issues Connectivity Appending data in databases Keeping spatial data current

Table 5.7: Spatial Data at Marine Safety Victoria

5.5.5 Heritage Victoria (HV)

Heritage Victoria is a part of the DSE. It is responsible for managing and maintaining underwater heritage such as shipwrecks, piers and jetties. This involves managing access to these sites, recording the positions of these heritage sites and making sure they are protected. There are approximately 700 shipwrecks in Victoria, but these are not all within protected zones. Spatial information is essential for HV. It is used to locate the shipwrecks or other underwater heritage and then map them in relation to other resources or potential hazards. The spatial datasets that HV uses are shown in Table 5.8. Most of this information is collected by HV, but some datasets are available through DSE. This causes some problems as data is not always collected by the same people and there is a mix of consistency relating to formats and references frames. Also often the people have little spatial understanding and do not take these issues into consideration.

The data that HV collects is sometimes shared with other organisations such as PoMC. This occurs on an informal and ad-hoc approach and the datasets are usually just emailed across. HV believes that better access and sharing of data could be achieved by a more formalised approach, this would allow many different organisations to share their datasets. HV finds that they need policies, mostly concerning privacy as often the information they are dealing with is sensitive, as well as standards to govern the use of their data. As most of their data comes from the DSE they use the DSE spatial data standards and policies. Often they do not have metadata for their datsaets as they are collected and developed for in-house use and HV does not see the importance of metadata for this kind of usage. However as HV collects most of their own data they find using and obtaining relevant spatial data relatively easy. Table 5.8 describes the use and sharing of spatial data at HV.

Data Used	Access Network	Standards/ Policies	Sharing	Issues
Aircraft and ship wrecks Underwater heritage Maritime infrastructure Melways Hydrography Boundaries Satellite imagery	Through DSE and collected internally	DSE standards and policies No metadata Privacy policies	Sometimes with PoMC	Inconsistent formats and reference frames

Table 5.8: Spatial Data at Heritage Victoria

5.5.6 Department of Primary Industries (DPI)

The DPI is responsible for managing the primary industries in Victoria and promoting sustainable use and development. In the marine environment the DPI is responsible for the overall governance of the fishing and aquaculture industries and regulating the offshore minerals and petroleum industries. As a part of this the Marine Discovery Centre within the DPI is developing an Australian Oil Spill Response Atlas (OSRA). OSRA aims to have nationally consistent datasets that are interoperable through adopting the common standards, metadata formats and data dictionaries that can be used to respond to an oil spill

This builds upon a previous initiative from the DPI to develop a Coastal Resources Atlas for Victoria. The atlas was to be part of a National initiative where each state developed its own coastal resource atlas and they were combined to form one for the whole country. However this caused many problems at the National level as each State developed its atlas separately using different standards and data formats, the data was not interoperable, and there were inconsistencies between borders. In order to avoid these problems OSRA is not being developed separately by each state, but as a national initiative. It has set Australian Marine Safety Authority standards to be adopted for the data within the Atlas.

The spatial datasets contained in OSRA was both collected specifically for the project and obtained from the DPI or from other custodians. The data was found through Land Victoria's online access network – Land Channel/ Geospatial data library, or by contacting an organisation directly. The main problem that the marine discovery centre found when collecting data was the lack of consistency in coverage over the whole nation. Not all datasets are complete and some areas are more used and hence have more data collected for them than other areas. Most of the data that was available was from around the coastline with less data as the distance increased from the coastline. The other difficulty in collecting data was that some data is readily available, but other data is much more difficult to collect. For example fishing catch data has privacy restrictions under the Fisheries Act 1995 and so is only available with a filter and is difficult to obtain and rarely comes with metadata. As the data comes from many different organisations the data formats, standards, metadata were not consistent and in order to be incorporated into OSRA the different datasets needed considerable processing after being obtained.

The Marine Discovery Centre has some of their data available through Land Channel, but access to OSRA is only for agencies that have a role in oil spill response. The marine discovery centre has some trouble making all its data available for anyone to use due to time and other resource constraints. At the moment not all data has metadata or is catalogued and there is no budget within DPI to make this happen, or for further data maintenance, updating or conforming to certain standards, as this is not seen as important. Spatial data at the Marine Discovery Centre is usually collected for a specific project and is collected at standards that are the best for that project. It is unlikely that there would be resources within a project to then make the data available to the general public. This data may also be sensitive and the people involved in the project may be unwilling to share it with anyone. Data that is collected for a project is also likely to be a one-off collection that will not be updated and will only be accurate for a certain time-frame. The same data will not be collected again unless another project requires it.

The marine discovery centre finds that the difficulty with accessing data is that there is not one central authority or database that they can be sure will contain all the available spatial data, and therefore it is easier to directly to the data custodian. This means that data will come from many different organisations and as data management and maintenance are expensive and not mandated there will be a range of accuracies, standards, completeness and consistencies with the different spatial datasets. The

other main problem that the Marine Discovery Centre finds with using and sharing spatial data is that often the people collecting the data are marine biologists or geologists and have limited spatial understanding, such as the need for consistent standards or reference frames. Despite this the Marine Discovery Centre does not have too much trouble finding and using spatial data and has been able to develop the OSRA to AMSA standards with a nationally consistent approach.
These issues are summarised in Table 5.9.

Data Used	Access Network	Standards/ Policies	Sharing	Issues
Roads Coastline Environmental species Logistic data Marine attributes Other data within DPI collected on a project based approach	DSE Geospatial Library Direct from custodians	Australian Marine Safety Authority standards for OSRA Standards based on project needs for other data No metadata	OSRA available for those working in oil spill response Other DPI data rarely shared	Inconsistent coverage No budget for making data available anf compliant with other standards No one location where all data is stored

Table 5.9: Spatial Data at the Department of Primary Industries

5.5.7 Parks Victoria (PV)

PV is responsible for 13 marine national parks, 11 marine sanctuaries and is the custodian of the recreational management of Port Phillip Bay. PV defines it activities under 6 performance areas, these are: caring for the environment, managing wildfire, protecting cultural heritage, enhancing visitor experience and managing natural resources. Spatial information and PVs GIS system underpin many of these activities including fines, mapping natural resources, monitoring pests, mapping vegetation areas, built infrastructure, planning and management. Some of the datasets that are commonly used are shown in Table 5.10. These base layers are usually obtained from the DSE with the rest of PVs data collected internally. PV finds it needs to capture most of its data as it requires large scale data that is not available elsewhere. PV describes having access and use of this spatial information as critical. However at the moment most of the data that PV has is land-related, very little is about the marine or coastal environments. PV is currently involved in a biogeographic and regional assessment of the marine environment and has so far found that data availability is one of the biggest problems. Even the most fundamental data like bathymetry does not exist in the scale that they need.

As most of PVs data is collected internally it is generally collected in an informal and ad-hoc approach. They don't find standards, or metadata to be necessary, although sometimes the ANZLIC standards are used. The level consistency and the use of standards for collection generally depend on who is collecting the data. Many people have a limited spatial understanding and would not understand the point of using data collection standards. The GIS department of PV believe that first people need to understand and appreciate the benefit of being able to share data with others before standards will become more common place.

PV is part of the DSE and is involved in spatial data sharing within this organisation although they rarely share data outside of this. There is a liability statement attached to their data that states the quality of the data, but they have not looked into other issues such as pricing or sensitivity. PV probably would share their data more, however they believe that the effort of complying with standards and policies that are set by someone, is not worth the reward for them. These issues are summarised in Table 5.10.

Data Used	**Access Network**	**Standards/ Policies**	**Sharing**	**Issues**
Park boundaries Topography Roads Vegetation Other project data	Through DSE and collected internally	Sometimes use ANZLIC or DSE standards Often no standards or policies	Within DSE	Unwilling to make data compliant with set standards and policies Poor spatial understanding Lack of availability of projects

Table 5.10: Spatial Data at Parks Victoria

5.5 Case Study Part 3 – The Private Sector Perspective

Thus far the case study has considered the public sector in determining the use and management of spatial information that relates to PPB, as they public sector is mainly responsible for management and administration of these areas. However the private sector can also be users and providers of spatial information, especially in response to a particular need or business activity. Therefore the perspective of the private sector is examined in this section through a proposed project in PPB.

This project involves deepening some of the shipping channels in PPB to allow larger ships through to the Port of Melbourne. Figure 5.5 shows the shipping lanes in PPB as the yellow and pink lines. The pink lines are where deepening of the channels is required.

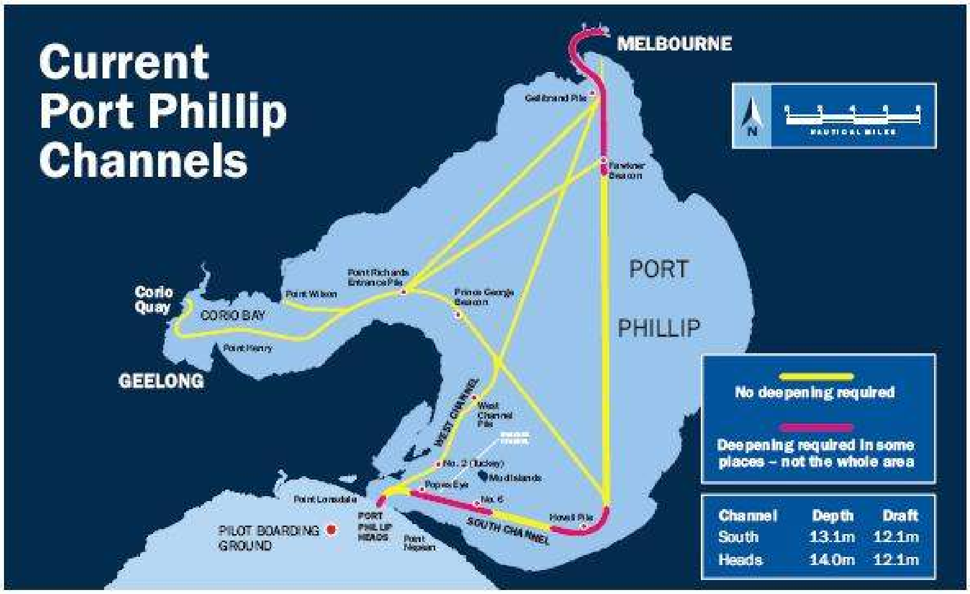


Figure 5.5 Channel Deepening in PPB (PoMC 2004)

Before this can go ahead, the Port of Melbourne Corporation was required to produce an Environmental Impact Statement (EIS) to assess the effect the channel dredging operation would have on the environment. The EIS addressed issues such as noise pollution, sediment, dumped material, pollution from buried heavy metals, underwater heritage, marine ecology and animals. Private contractors were hired to undertake each section of this EIS. This section examines the need for spatial data within the investigation into the impact on Port Phillip Bay, and the use and availability of spatial data for these contractors.

Spatial data was required to develop the EIS for most of the different areas. Common datasets that were required were bathymetry, tides, waves, salinity, and currents. This data was generally required on a local level scale, and almost all of the private consultants stated that they had to collect this data themselves (Lawson and Treloar 2004), or use data that they had previously collected for another project. Sometimes data was sourced from another organisation, and this mainly occurred with contact directly with the particular data custodian (Mustoe 2003).

Problems that many of these consultants listed in using and obtaining information were often to do with general lack of availability of spatial data that related to PPB, the channel deepening area and coverage of the available spatial data. An example of this difficulty was shown in the analysis of the effect of the channel deepening on marine animals. Data was needed on current catch numbers, fish species and numbers and this data related to locations within PPB, however much of this information is considered sensitive as fisheries do not want it made public (David Ball pers. comm. 22/03/2005). Therefore it was not available to be used for the EIS and decisions had to be made and risks calculated on less useful data (Meryck and Associates Pty Ltd 2004).

The other dataset that most organisations required was the spatial extent of legislation and policies. Figure 5.3 shows the different laws, conventions and policies that can affect PPB, but these do not all apply to the entire bay. For example the RAMSAR convention for the protection of wetlands only applies to the specified wetlands areas, of which there are several in the coastal areas of PPB. There are also several marine state and national parks that have a different set of rights, restrictions and responsibilities attached to them compared to the rest of PPB. Consultants often listed this information as important for undertaking the EIS because the different rights and interests could alter the level of a particular environmental risk or effect (Rhodes 2003).

Another part of assessing the channel deepening project was assessing the social and economic effects of the proposal. These projects also required access to different datasets in order to undertake an assessment. Similar problems as listed earlier were an issue such as availability and completeness of datasets. (Gillespie et al 2000) estimates that between 50% and 80% of the cost of producing an EIS come from finding and collecting relevant data. It can be seen from this particular EIS for the PPB channel deepening proposal that obtaining useful and useable data can affect the decision-making process in an EIS and thus the outcome of the project.

5.6 Case Study Part 4 – Other Related Research

Within the marine cadastre research group in the Department of Geomatics, there has been several attempts to assess user needs and current marine spatial data use and access. These mainly focussed on this area in terms of developing a marine cadastre, however the questions were similar and the audience, while on a national scale, was made up of many of the same kind of organisations (government departments and agencies responsible for managing some part of Australia's maritime jurisdiction). This research can provide a measure of reliability and validation to the case study in this thesis. As mentioned in section 5.2.1 an important part of case study research is obtaining some estimation of the reliability and validity of the results (Yin 2003).

5.6.1 Questionnaire

Though the marine cadastre research group website a national questionnaire was made available on-line in September 2002. Emails were sent to 260 people or organisations that were stakeholders in the marine environment. The questionnaire had 110 responses (Forse and Collier 2003). These people came from marine administration, defence, research, environmental and conservation, and commercial industry. Most of the people came from government organisations, particularly state and territory government departments and agencies.

While this questionnaire wasn't directed at local/ state government level, most of the response came from state and territory government agencies and departments, which is similar to the target audience from the PPB case study and as it is at a national scale there were responses from all around Australia, which can be used to verify the reliability of the PPB case study.

The people who responded to the survey were nearly all users of spatial information and most of there were also suppliers and producers. Similarly to the PPB case study 94% of respondents regarded spatial information as essential or important to their business activities. The spatial data that these respondents used was similar: marine parks and other boundaries, sea floor vegetation and ecological information, the coastline and bathymetry. The respondents also regarded legislation and fishing data as important datasets. This data was mostly used to make maps and charts, or for management, scientific and environmental purposes.

The most important aspects of spatial information were listed as being: that the information was current, that metadata was recorded and that data was three-dimensional. The areas that respondents thought could be improved were: access to more information, having more current and accurate data, and more metadata recorded for data. The same impediments to accessing data were given as in the PPB study of finding data and the cost of obtaining it. However despite these problems most users were fairly happy with the spatial data that they have at the moment.

5.6.2 Industry Consultation

As a follow-up to the questionnaire several organisations were chosen for an interview that discussed in more detail accessing spatial data and how data was used in the particular stakeholders business activities. Organisations were selected from state governments around Australia involved in managing, exploration, exploitation and conservation of Australia's marine environment.

From Queensland the Department of Transportations Maritime Safety section, the Environment Protection Authority, and Natural Resources, Mine and Energy were consulted. Within Victoria, a division of Land Victoria (now known as Spatial Information Infrastructure Group) and Parks Victoria were involved, and at a National level the organisations were GeoScience Australia, and the Australian Hydrographic Office. As this consultation was conducted with the aim of understanding the data requirements for a marine cadastre, the answers were slightly different than in the PPB study, but show some similar trends.

The interviews showed many of the same issues that have been discussed throughout this chapter. All organisations interviewed described the need for access to a variety of spatial datasets in their business activities. Some of the common datasets were: topography and bathymetry, national parks, ecological boundaries, and the coastline. They mostly also stressed the need for spatial descriptions of legislation and the various boundaries that exist in the marine and coastal environments. Many organisations relied on sharing data between different agencies and required that this data be interoperable. However some mentioned that currently there is a lack of industry support for defining set spatial data standards and requiring organisations to record metadata. Conforming to pre-defined standards and policies is also not supported within agencies responsible for managing the marine environment.

One of the biggest problems found with sharing marine spatial information was the lack of interoperability of different datasets from different custodians. The biggest impediment to interoperability was that not all organisations used the same data format, and so their data could not be integrated with other data. The other problems were the differences in scales, quality and coverage of spatial data and the lack or poor quality of metadata. The ability to use another's data often relied on that data coming with comprehensive metadata and this was not always available (Binns and Fraser 2004). An issue that was brought up in these interviews that was not mentioned in other parts of this case study was the need for interoperability across the land-sea interface. Many of these organisations are responsible for managing not only marine and coastal areas, but also terrestrial areas, and activities (ie tourism, oil and gas mining) that may cover all of these environments. These organisations stressed the need for data that could cover all of these areas, or datasets that were able to be integrated from all areas.

The ideas for solving these problems that came out of these interviews were more focussed on cooperation and collaboration between the different organisations, than technical solution. There is still limited understanding of the usefulness of spatial data, and the need for using common standards, metadata and data sharing to improve some of the problems described above. Many respondents believed that the opportunity to develop better data sharing practises and better access to spatial data came from support through a lead agency in this area and the development of partnerships between different organisations that promoted and facilitated data sharing. The general consensus was that the technology is available to provide sharing and interoperability of marine and coastal spatial datasets, but the institutional understanding and willingness is still not.

5.7 Case Study Common Limitations or Opportunities

Overall these results have shown some of the limitations and opportunities for the development of a Marine and Coastal SDI, or an SDI that can accommodate data from terrestrial as well as marine and coastal environments. This will be further summarised and discussed in the next chapter. The final part of case study research is validating the research and then generalising the results into a theory. As described above the results of the PPB case study can be compared to the previous research conducted by the marine cadastre research group within the Department of Geomatics, University of Melbourne in order to test the reliability of the case study.. The questionnaire and industry consultation provided some similar research with a national scale that had some similarities, as well as some differences. Many of the differences between the case study as the previous research came form the differences in the aims of the two. The Port Phillip Bay case study focused on spatial data use, management and sharing, while the questionnaire and industry consultation were examining the possibility of an Australian marine cadastre and discussing spatial data within this context. The results of this chapter show that while the stakeholders in PPB all wanted better access and sharing of spatial data, there are some common problems that are faced by each of them. The problems are limiting the development of a Marine or Coastal SDI will be summarised and compared with the research at a national and international scale in the next chapter.

5.8 Chapter Summary

This chapter described the case study that was undertaken within this research project. The aim of the case study was to describe and examine the use, management and sharing of spatial data at the lower end of the SDI hierarchy – the state and local levels. This was undertaken through a case study of Port Phillip Bay in Victoria, Australia through several different components and verified with previous research from the marine cadastre research group in the Department of Geomatics, at the University of Melbourne. The case study research can be compared to the research from Chapter 4 into the emergence of Marine SDI at national and international levels, and more general SDI research and the ASDI from Chapter 3.

The case study showed that spatial data is an integral business component for the many organisations that manage PPB. Spatial data is used in many different activities from maintaining heritage sites to harbour control and marketing. While all organisations are collecting their own data and using their own standards and sharing policies, there is some coordination within the organisations that are a part of the DSE. Many organisations also stated that there was improved use and appreciation of common standards internally and that they are beginning to examine other opportunities for obtaining spatial data other than collecting it themselves. Overall this chapter shows that there is a lot of duplication in collecting spatial data in PPB and that the stakeholders in this area are becoming more open to the idea of sharing spatial data within a common framework.

Chapter 6 discusses these comparisons and generalises the results of the research, particularly focussing on the case study aspect, and assesses the ability for a theory to be formed and the applicability of this theory outside of the case study location.

Chapter 6: Results and Discussion

6.1 Introduction

The last two chapters have examined the Marine SDI concept and discussed marine and coastal spatial data sharing and use at local, state, national and global scales. Both chapters also noted that these initiatives were developing separately from land related SDI. Chapter 2 stated the importance of an integrated approach to managing the on and off shore environments and the need for a country to manage its whole jurisdiction. This was reflected in the ICZM management initiative, as well as in planning policies such as Australia's Oceans Policy. It also noted that people in both the land and marine environments will need access to marine, coastal and terrestrial spatial data, and will need this data to be interoperable and integrateable.

This chapter examines the difference between national level Marine SDI initiatives, and the results from the case study in comparison to the ASDI to assess the current limitations and opportunities for developing a 'seamless' SDI. It begins by discussing the ability for the results of this research to be developed into a general theory. The key issues are then summarised and the results presented and discussed. This chapter uses the SDI components from Figure 3.1 to present and organise the results.

6.2 Developing a General Theory

The previous two chapters have shown that there are both similarities and differences when looking at national and international scale Marine SDI development and when focusing on state and local level. This chapter examines the similarities to provide a general example of the main opportunities and limitations for developing a seamless SDI to provide access to spatial data from the land, coast and oceans. However as was described in Chapter 5, a case study area was used for the state and local level marine SDI research, and hence the results come from only one specific area. This causes some problems as the results may only apply to that case study area. Part four of the case study was undertaken to provide a way to show that these results could also be applicable outside of the case study area of Port Phillip Bay.

Effort was taken to choose a case study location that gave many different possible uses and issues, and represented the complex and often conflicting marine management system within Australia. Most of Australia's capital cities are located on the coastline or on a watercourse that flows to the coast and three-quarters of Australia's population live within 50km of the coast. Given the length of the coastline and the small size of the population a large part of the coastline of Australia is dissimilar to PPB. With this in mind, this research examined the spatial data needs of the managers, planners and users of the marine and coastal areas, not the specific activities that take place, in a more general way as this will be similar around Australia even as the number and size of activities is not. It was also considered that PPB would be a good case study area as, in theory, it should have some of the best managed marine and coastal spatial data in Australia. It is unlikely that spatial data management would be better in other parts of the Australian coastline that are less populated and less managed. Therefore PPB can be labelled as a 'best-case' representative area.

6.3 Summary of Research Results

6.3.1 Comparison at National/Global levels

Each country or jurisdictional level at the National and International level identified a similar problem in their effort to improve management of their maritime jurisdictions, which was the need for improved methods of sharing and accessing spatial data. The most common theme that came from the research into trying to solve this problem was to develop of an internet portal that provides any potential user with access to metadata and/or spatial data. Each of these portals aims to be a 'single-source' for marine and coastal data, however even within different countries they are developing separately. For example within Australia there is AMBIS and AMSIS, the NOO Oceans Portal, and the marine cadastre project, as well as the ASDI, although many of these initiatives aim to tie in with the ASDI. Another commonality is that most aim to be user driven and have undertaken some kind of survey to establish user needs, often coming up with similar results. The fundamental datasets listed by each initiative were also similar, with the most common being: boundaries, water quality, protected areas, planning information, tenure, bathymetry, infrastructure and oceanography.

The main issues that each initiative highlighted were also common. Some of the major problems mentioned were a lack of institutional willingness to share data and a lack of common standards and policies that are applicable for the marine environment. This has lead to poor interoperability between different organisations datasets with disparate data formats, reference frames and metadata. In resolving these issues at the national level most initiatives were adopting a process-based approach - that is working on better communication channels to link users with available spatial data. At the global level a more product-based approach has been used, responding to the problem of limited data at this scale. GOOS is aiming first to obtain different datasets, and then establish the access networks.

6.3.2 Marine SDI Issues at State and Local Levels

The case study research combined with the industry consultation and questionnaire that had been previously conducted showed that marine and coastal spatial data is used by many different organisations and sectors. All organisations reviewed described spatial data as important for their business activities and most mentioned that a lot of time and resources was spent on data collection. Spatial data is shared between some organisations, and within departments. The common datasets that were used are: transport, parcels, reserves, cadastral drawings, wharfs, land use, land values, imagery, emergency zones, utilities, channels, pipelines, navigation aids, and historical features. This data comes from both the land and marine environments. The PPB case study showed that often the data that could be considered ‘fundamental’ such as bathymetry and water currents had to be collected because it wasn’t available.

This research showed the same main problem with data sharing from the data user perspective (similar to those mentioned in the higher SDI levels) including a lack of interoperability from different data formats, reference frames and metadata, caused by institutional unwillingness and lack of ability to adopt common data standards and policies. Users mentioned that finding out what data is available was hard because there is no one organisation or authority that holds all spatial data, therefore users would generally just contact the possible data custodian directly. This has resulted from the lack of a formalised approach to data collection, maintenance and sharing in the marine and coastal environments and many users believed that improvements could be made if there was a formal, common approach.

From the provider perspective making data available is difficult because data is usually collected for a particular project, and is rarely made available for other organisations to use, as this would involve adapting the data to required standards and policies. Spatial data sharing initiatives have evolved in response to specific drivers, for example the oils spill response atlas that provides spatial information for any organisation involved in oil spill response.

At the lower level some organisations are beginning to adopt standards and policies regarding their spatial data, but are still unwilling and would not grasp the full use of open and nationally set standards. It seems a more product-based approach is being used, with many organisations establishing framework datasets and slowly increasing awareness of common nationally set standards to improve interoperability. The use, understanding and appreciation of data standards and data sharing is growing slowly (D. Henderson per comm. 12/04/05). While now data sharing occurs more on an ad-hoc approach than through formal mechanisms, it can be seen that this is slowly changing.

6.4 Comparison of Marine SDI Issues with ASDI

The common issues that have been identified from the research into Marine SDI and marine spatial data use and sharing can now be compared to the ASDI concept and components. The main aim of the ASDI is for (ANZLIC 1999, p. 2):

'all users to have easy efficient and equitable access to fundamental spatial data where technology, data formats, institutional arrangements, location, costs and conditions do not inhibit its use'.

From the results of the research and case study it is clear that the ASDI has the same underlying concept as all of the Marine SDI initiatives. The main difference between the ASDI and a Marine SDI will be in the different components that make-up the SDI, 'people, data, standards, access networks and policies' (Figure 3.1). The differences within each of the components are discussed in this section.

Data

The SDI cookbook (2004) describes the importance of framework or fundamental data, as has been shown through this research, many organisations will spend most of their budget collecting the fundamental data and have no resources left to collect the application or project data. This has also been shown through this research, as much of the data that is considered fundamental in the marine and coastal environment is not available and most of the stakeholders were collecting it themselves. At the same time it is highly likely that many other organisations either have or are collecting the same data. There is clearly an opportunity to share these resources through developing common, available fundamental datasets. Fundamental datasets exist in most SDI initiatives, but are generally related to the land environment. Table 6.1 shows an example from the SDI for the State of Victoria, Australia, of the datasets that are considered fundamental in the land environment and some of the common datasets from the Marine SDI initiatives at international, national and state levels for the marine environment. It also shows the spatial description of the marine datasets as an example of the way that marine data can be spatially portrayed.

Land	Marine
geodetic framework	bathymetry,
property	water currents
address	wind directions
transport	natural resources
topography	spatial extent of legislation
administration	protected areas
hydrology	biodiversity
imagery	political boundaries

Table 6.1: Fundamental datasets in the land and marine environments

Table 6.2 shows that the datasets that could be considered fundamental in the marine environment are significantly different from those for the land. A suggestion to accommodate marine datasets in the current list of fundamental datasets is to extend them out into the marine environment. For example in the USA NSDI bathymetry is a sub-layer of the elevation fundamental dataset (Bartlett et al 2004). This may be possible for some datasets; however it is likely there will be some that will be regarded as fundamental only in the marine environment (ie salinity, waves, water quality), and these would need to be developed separately.

Another important consideration that was often mentioned in this research was interoperability, as data sharing problems often occur as a lack of interoperability. (Smith and Kealy 2003). Most organisations discussed in this research described the importance of interoperable data. The differences in the marine and terrestrial environments in fundamental datasets, data collection and technology used in these environments will make interoperability between marine and terrestrial spatial data a big challenge.

Standards

Standards in the ASDI specify regulations for data access, content, and exchange (ANZLIC 2002). Standards are used to ensure interoperability and integratability of different datasets. ANZLIC also promotes the use of international and open standards. The International Standards Organisation Technical Committee 211 (ISO TC/211) has recently developed a set of 40 Geographic Information related standards most of which are focussed on terrestrial spatial data. In the marine environment the International Hydrographic Organisation (IHO) in conjunction with the International Hydrographic Bureau have developed a transfer standard for digital hydrographic data (S-57) and are examining other standards for marine data. These standards, however, are not at the same level of completeness as the ISO TC/211 standards. The main issue is that if different standards need to be developed for marine spatial data exchange this will limit the interoperability between marine and terrestrial spatial data. It also creates confusion in the coastal zone as to which standard should be applied.

Another initiative that aims for interoperability between datasets from different custodians is the development of Extensible Markup Language (XML). XML is an exchange data format that is used on the Internet and has been described as ‘the building blocks that house data’ (Keely 2004). There are several projects around the world examining the creation of a marine specific XML. The International Oceans Commission (IOC) has established a Marine XML consortium, which is looking at developing an international standard form of Marine XML. Standardisation at an international level is required for interoperability on a global and regional level, otherwise Marine XML will become 'just another data format' (Ronai et al 2002). The main benefit of using XML is that it provides a common format to store data, and so allows data to be exchanged easily between providers, value adders, and users. Marine XML is being developed and used by the Australian Oceanographic Data Centre to encode their marine data for storage and exchange (Ronai et al 2002).

Policies

Policies are influenced by international best practice in spatial data management and exchange. The current ASDI policies cover access, data custodianship, conformity, quality, content, industry engagement, avoidance of duplication and sensitivity (ANZLIC 2003). In applying these policies for terrestrial spatial data to the marine and coastal environments it is likely there will be differences in terms of data quality, data access and privacy. Data quality depends on collection, completeness, currency, reliability etc. and due to the complexity of the marine environment and the different technologies used for data collection, may be more difficult to achieve at the same level as terrestrial data. Fixed line data transfer supports data access onshore. In the marine environment there is the need for wireless data transfer capability for people accessing or uploading data offshore. Privacy over spatial data in the marine environment is a concern with many countries reluctant to share spatial information relating to their marine jurisdictions and as such there may need to be different privacy policies for offshore data (Bartlett et al 2004).

Access Networks

Access networks usually comprise data warehouses, data portals, one-stop shops, on-line atlases or similar. For these access networks to support interoperable and coordinated data they must comply with the standards and policies specified by the SDI. An issue highlighted in the '*Policies*' section is the ability of someone offshore being able to access data. For example bathymetry for navigation, the rights and restrictions attached to a particular location, or sea surface temperatures or currents in a search and rescue operation. The technology that allows data transfer and access onshore, will not be appropriate for use offshore, and so alternatives, such as wireless data transfer will be needed.

People and Partnerships

This component is one of the most important components of SDI. The people in SDI are the data providers, value-adders and data users. In the marine environment these people will come from private industries such as shipping, defence, aquaculture and conservation, as well as from government at local, state and national levels. There will already be some degree of spatial data management that is occurring within these groups, even if only within or between organisations. It is important that this is recognised and can be built upon for the SDI to be relevant to those who will use it. This data management will also need to be integrated with the standards and policies that are set at global, regional and national levels. Both Binns (2004) and ANZLIC (2003) have reported that a barrier to SDI development and Marine SDI development is 'immature institutional arrangements' and the reluctance of many organisations to share their data. Therefore a challenge in developing a Marine SDI will be in encouraging cooperation and creating a culture for spatial data sharing between the institutions involved in marine and coastal spatial data collection and use (Rajabifard and Williamson 2003). Underlying these issues is the need for an institutional framework that will support Marine SDI development, and impose responsibility for organising and building the SDI.

The key to success in SDI initiatives is partnerships within and between organisations involved in marine administration and spatial information. Multiple reports internationally have highlighted the need for better coordination and integration between and within levels of government to improve coastal zone management (Hudson and Smith 2002, Middle 2004). Partnerships drive the development of SDI, allowing people to work together to achieve their respective goals. In the marine environment it is likely that there are existing partnerships between or within organisations, without these being developed and built upon a comprehensive Marine or Coastal SDI will never be realised (DOI MMS 2004).

6.5 Expanding the SDI model

Described above are the main differences between land and marine spatial data and SDI within each SDI component. These can be used to expand the current SDI model (introduced in Figure 3.1) so that it will accommodate the access and sharing of marine and coastal spatial data as well as terrestrial spatial data. The previous discussion highlighted some common impediments in using, accessing and sharing marine spatial data, which have been summarised below as common limitations. Also highlighted were some common areas that could be built upon to aid in the creation of a Marine or seamless SDI and these have been described as opportunities. These key limitations and opportunities within each SDI component will be used to create a seamless SDI model.

People

The main impediment to data sharing and developing a Marine SDI for the people component came from a lack of institutional willingness and ability to conform to national or state level set standards and policies in order to make their data available to others. The causes for this problem were lack of resources, and limited spatial awareness.

One of the most important issues highlighted in all of the research, that may help to resolve this problem was the need for a lead organisation or a champion to set out the access network, standards and policies and to encourage implementation of the common framework. While this does exist in Australia it is mostly focused on terrestrial spatial data and the difference between marine and terrestrial SDIs can be seen as partly a result. Promoting spatial data, sharing and using common standards and a single access network may help to counteract some of the unwillingness that exists, and encourage greater cooperation and collaboration in the marine sector. Another opportunity in Marine SDI is through improved vertical communication between the different SDI levels – global, national and state. At each level there are different ideas coming from the different people involved and while some coordination is apparent, such as the desire for use of ANZLIC and OGC or ISO standards, the initiatives are developing separately. Communication between the different levels can help coordinate these initiatives better and this is particularly important in the marine environment, as state and federal governments have variable rights, restrictions and responsibilities over this area and different activities and boundaries can cross these borders.

These common limitations and opportunities are summarised in Figure 6.1. Within this figure an opportunity describes an area that can be used or built upon to help create a seamless SDI, while a limitation is a problem or hindrance that will need to be overcome.

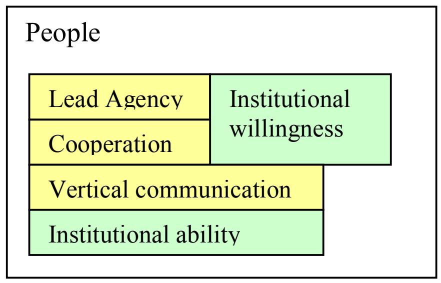


Figure 6.1: Extending the people component
(Denotes opportunities, denotes limitations)

Standards

Standards already exist that apply to terrestrial spatial data, hence the main opportunity in developing a seamless SDI is in the creation of interoperability standards that will allow a user to integrate data from any environment. Interoperability standards and metadata are being developed around the world that aim to improve the ability to exchange and access marine spatial data, for example Marine XML (Merati et al 2005). XML is also being developed to apply to many other areas such as legal XML and Land XML. There is clearly an opportunity to use and build on this research to develop interoperability between marine, coastal and terrestrial data.

The main limitation to interoperable data is in the different data formats, scales, reference frames and lack of common standards that are used today. Many of the standards and technology already exists, but needs to be embraced by users. Research showed that many organisations had a growing appreciation of the need for common standards and were beginning to implement greater use of standards, but also that a lot of data is collected for particular projects and this data is collected on an ad-hoc approach without the use of formal standards, or with standards more appropriate for the particular project. These limitations and opportunities are shown in Figure 6.2.

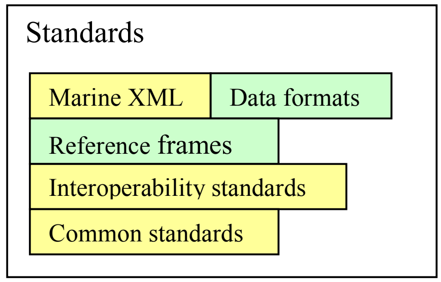


Figure 6.2: Extending the standards component
(☐ Denotes opportunities, ☐denotes limitations)

Policies

The main limitation in using the same policies for on and offshore data are policies that cover sensitivity and quality, as described earlier. There is an opportunity however to first establish and promote policies that relate to data sharing, use of common standards and avoidance of duplication. A lot of data collection is duplicated in the marine environment, and once these policies are established they can then be built upon. If all stakeholders in the marine and coastal environments have a policy for avoiding duplication of spatial datasets, they may be more likely to examine different ways to share and re-use data in order to comply with this policy. This is also true of a 'promote data sharing' policy that would promote the idea of data sharing and encourage organisations to first examine different opportunities for accessing spatial data before collecting it themselves.

The main policies that exist in the current SDI model that will hinder the development of a seamless SDI relate to sensitivity, quality and pricing. As mentioned earlier, many data producers are reluctant to allow their data to be shared and while this is also true with the current SDI and the reason for these policies, it seems to be intensified with marine and coastal data. Therefore while the current fundamental datasets that relate to the land environment are often provided to anyone who wishes to use them, and at minimal cost, this may be more difficult to achieve with marine and coastal data. Figure 6.4 displays these common limitations and opportunities.

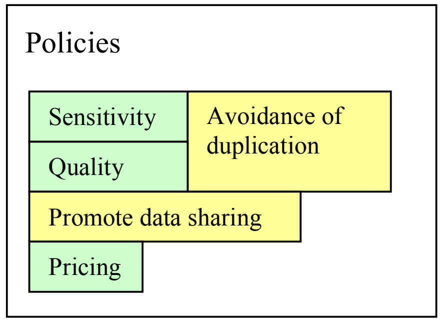


Figure 6.3: Extending the policies component
(Denotes opportunities, denotes limitations)

Access networks

As described earlier there are many different access networks under development that aim to provide access to marine and/or coastal spatial data. This limits the availability of data as it is spread over so many portals it can be hard to find. An opportunity therefore is to promote one common portal for all data to be made available through. This would mean that potential data users only need to visit on web-site or Internet portal to discover all the possible data that is available. At international and National levels and within the Marine Cadastre questionnaire that ability for one-stop shopping was regarded as important for easy access to spatial data. Chapter 5 showed that some marine related datasets are available through the ASDD, therefore within Australia common use of the ASDD could be promoted to marine and coastal spatial data producers to help provide one common access network.

Another area that would provide the opportunity for better access to marine spatial data would be wireless data access, which has been described earlier in this chapter as a useful addition to a Marine SDI, as many potential users may be offshore.

The main limitation for accessing marine and coastal spatial data is the lack of metadata for these datasets. Little or poor quality metadata makes it difficult for a potential user to assess the accessibility and applicability of the dataset. An issue that was highlighted at all Marine SDI levels was the lack of metadata for many datasets and this was found in the data audit in the PB case study and caused some datasets to not be able to be used. Accurate and complete metadata will be needed in order to include marine and coastal spatial data within an extended SDI.

These limitations and opportunities are summarised in Figure 6.4.

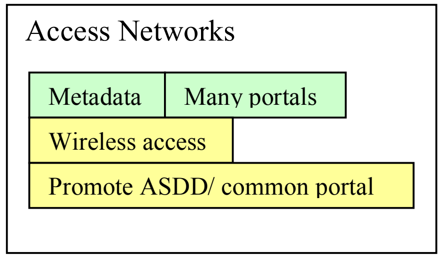


Figure 6.4: Extending the access component
(Denotes opportunities, denotes limitations)

Data

The main limitations in the data section are the lack of available data and the interoperability problems already described. There is an opportunity for improving both these problems through the creation of fundamental marine datasets. These will be different for marine, coastal and terrestrial environments, but if common standards are used could be interoperable. Fundamental datasets will allow potential data users to access base data with known standards that they can use for their own purpose. This will also encourage data users to adopt these common standards, so that their data is interoperable with the fundamental datasets. The other benefit of fundamental datasets is that resources can be pooled to create and maintain them, so that many agencies are creating the one dataset, instead of many agencies making duplications of one dataset. This should lead to better quality fundamental datasets.

Another opportunity lies in the development of a Marine Cadastre as one of the fundamental datasets using the common standards, policies and made available through a common access network. As the Marine Cadastre shows all the different boundaries in the marine environment and their associated rights, restrictions and responsibilities it will be an important data layer for many people involved in managing the marine environment. Using these fundamental datasets and a Marine Cadastre could be the stepping stones to a functional Marine SDI. These opportunities and limitations are shown in Figure 6.5.

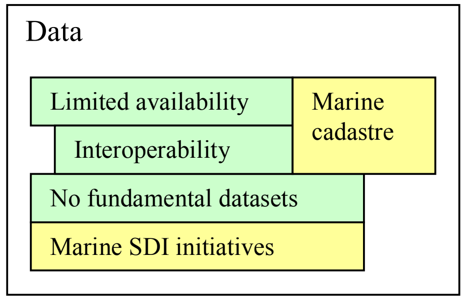


Figure 6.5: Extending the data component
(Denotes opportunities, denotes limitations)

6.6 The expanded model

This research has developed a set of opportunities and limitation in extending the SDI model to create a seamless SDI model, based mainly on the ASDI. These separate sets of opportunities and limitations can be put together to describe the full extended model (see Figure 6.6, overleaf)

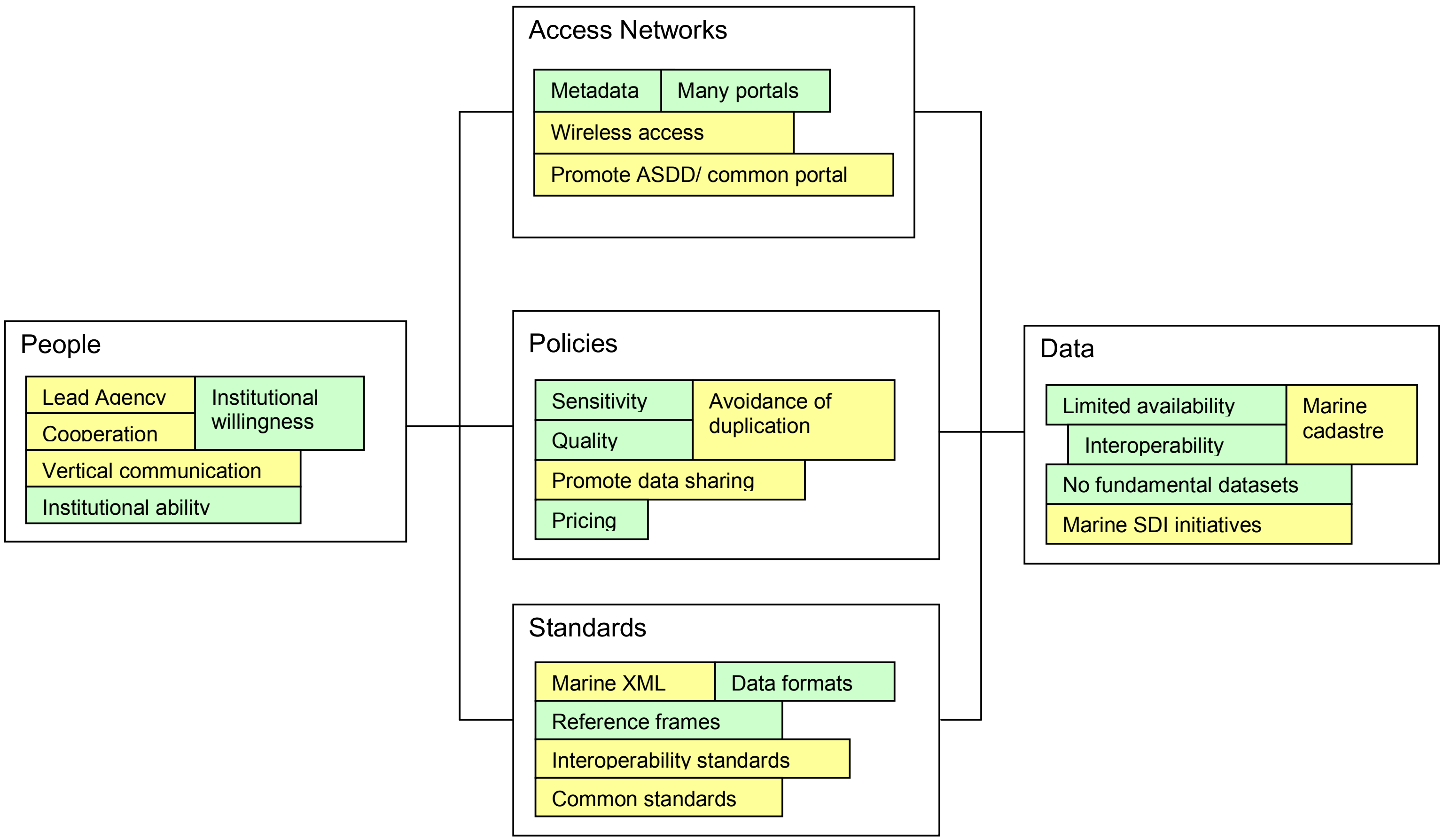


Figure 6.6 The extended SDI model

(Denotes opportunities, denotes limitations)

Figure 6.6 shows that while there are some SDI components that already exist in the marine environment, these need to be coordinated and built upon to develop a fully functional SDI. It also shows that the same model can be used to develop a seamless SDI, but that within each component there are some areas that will cause problems and some that will provide opportunities. For example within the access networks component of the seamless SDI model a limitation is shown to be the many different marine data portals that are developing, this will hinder the development of a seamless SDI as potential data users will have to go to a different access network for their terrestrial and marine datasets, and it does not provide an access network for coastal data. Also the development of many different access networks for marine spatial data will not help to improve availability of this data as potential users will still have to conduct considerable searches through all the different access networks before they find their data. A solution to this is by promoting the inclusion of these different marine access networks on the ASDD, providing one place that all potential data users can search for data from marine, coastal and terrestrial environments.

However the limitations in the people component show that many organisations believe they lack the ability and/ or are unwilling to conform to national and state level set standards and policies and to share their data through a common access network. These beliefs will hinder the development of a seamless SDI through limiting the availability of data from some organisations. One opportunity that may be able to convince data producers to conform to set standards and policies is the development of a Marine Cadastre as a fundamental dataset in a Marine SDI. A Marine Cadastre will be an important dataset for all stakeholders in the marine environment. If it is developed in accordance with current SDI standards and policies and made available through a common access network, for example the ASDD, as the first fundamental dataset for the marine environment, many of these stakeholders will want to use it and will be influenced by these standards and policies. This will be particularly true as other fundamental datasets are developed and made available, encouraging stakeholders to conform their own data, so that it can be integrated with the fundamental datasets.

Figure 6.6 shows all of limitations and opportunities that have been discussed throughout this chapter. This model can be used as a guide to aid in the development and implementation of a seamless SDI, as it is highlights impediments and opportunities for improvement within each component.

6.7 Chapter Summary

This chapter analysed the results of the research and discussed the potential for extending the ASDI out to the marine environment, within the context of both the higher SDI levels and the local and state SDI levels. While the research was based on a case study of a small part of Australia, the results can be applied in a general sense and the outcome was an extended model for the whole country. The model involved a list of the limitations and opportunities found within each component of the SDI model described in Chapter 3. The final chapter of this thesis will discuss the conclusions that can be drawn from this work and outline potential future areas of research.

Chapter 7: Conclusion

7.1 Introduction

This chapter outlines the major findings of this research in terms of the problem statement and objectives described in Chapter 1. This research investigated the possibility of developing a seamless SDI. That is one that could provide a framework for access and sharing of marine and coastal spatial data from the land, coastal and marine environments. In order to achieve the objectives from Chapter 1, SDI development in Australia through the ASDI was examined, as well as international and national level Marine SDI initiatives. To complete the Marine SDI research a case study of a state/local level marine management areas was chosen and the marine spatial data use, management and sharing within the area examined. This provided a bottom-up view of the development of Marine SDI and also gave the perspective from the main stakeholders in the marine and coastal environment, as most activity occurs within 3n.m. of the coastline. The previous chapter discussed the results of the research. This chapter summarises these results and discusses the conclusions and future research areas.

7.2 Research Summary

Chapter 2 set the context for this research by establishing the need for better management and administration of marine and coastal areas. The development of marine management, the idea of more integrated and holistic management, and the application of these ideas within the management of Australia's Marine Jurisdiction were also discussed. Lastly Chapter 2 introduced the idea that better access to spatial information would support better management of the marine environment.

Chapter 3 introduced spatial data infrastructure and the SDI concept, nature and hierarchy. It described the two different views of SDI development and some of the implementation issues that can result from these different approaches. It also gave a practical example of the ASDI, as a national level SDI and demonstrated the implementation of an SDI. Finally this chapter discussed the focus of current SDIs on land –related datasets and the potential for these SDIs to expand into the marine environment.

Chapter 4 examined the emergence of national and international level Marine SDI initiatives and evaluated their similarities, common issues and opportunities. Many countries with a considerable maritime jurisdiction are investigating different ideas and methods for better management and spatial data sharing within these areas. This chapter discussed each of these and looked at some collaborative initiatives at regional and global levels. This chapter showed that the idea for a Marine SDI is emerging in many countries, but that often it is considered separate form the National SDI which has focussed on mainly on land-related data.

Chapter 5 described the case study approach and its applicability to this research. The case study consisted of four parts, three of which involved the case study location Port Phillip Bay and establishing availability, accessibility, use and sharing of spatial data for this area. The last part validated the results using previous research as a comparison. This chapter described the availability and interoperability of spatial data for the case study area through a spatial data audit and from the perspective of many of the stakeholders. From Chapter 5 the availability and sharing of marine spatial data at a local or state level can be assessed.

Chapter 6 discussed the results of the research and outlined the possibility of extending the SDI model (using the ASDI) to include the marine and coastal environments. Chapter 6 used the previous two chapters to describe the similarities and differences in Marine SDI at international and local levels. It also discussed the difference between the ASDI and the development of the Marine SDI, examining the different SDI components. From the research an extended SDI model outlining the current opportunities and limitations involved with developing a 'seamless' SDI (Figure 6.6) was created. This model can be used to guide the development and implementation of a seamless SDI as it describes the opportunities to be built upon and the areas which will provide difficulty.

7.3 Major Outcomes

The current SDI model can be extended to include the marine and coastal environments. The SDI concept, nature and components are as applicable to the marine environment as the terrestrial environment, however within these components there are some limitations that are specific to the marine environment. Some of the main problems are:

- no lead agency or champion
- inconsistent data formats, scales, reference frames, and standards
- little or no metadata and ambiguous metadata
- institutional inability or unwillingness to adopt common standards and policies, and to share data through common access network.

There are also many opportunities that can be used to continue to development of Marine SDI, and to coordinate the terrestrial and marine components. Some of these are:

- the development of fundamental datasets for the marine environment,
- most of the technology is available, for example the development of Marine XML and Land XML,
- spatial technology is being used in the marine environment, such as GIS, GPS, aerial photography, data standards,
- slowly a better understanding of spatial technology, and a need for standards is growing,
- there are a lot more collaborative events at national and international level that focus on marine spatial data and information; and
- there are several organisations that are taking a lead role in SDI, and even in Marine SDI

Therefore this research concludes that the ASDI could be extended to also include the marine environment, and this is already occurring in many different ways, however these are currently occurring separately and often in an ad-hoc manner. A more integrated national approach to Marine SDI can be brought about, however it needs to start simply, through establishing the fundamental datasets that are required by many organisations and which are currently not available. Once these are established, the use of common standards can be promoted, as well as the adoption of national level policies and use of the ASDD. It is important that these initiatives are promoted at all levels and vertical communication between jurisdictions is encouraged because in the marine and coastal environments resources and activities cross jurisdictional boundaries.

While this is more of a product-based approach in developing the fundamental datasets, it will perhaps move to become a more process based approach once datasets are established and developing a communication channel will be critical in enabling the success of an Australia Marine SDI.

7.4 Future Research

Through this research some areas for future research have been identified. These are:

- Develop design guidelines for seamless SDI

  This research has shown some of the common problems that occur in using and sharing marine and coastal spatial information and also some of the opportunities that could enable the SDI model to include the marine and coastal environments. This could be extended to create guidelines or criteria that provide a more detailed description of how this could be done.

- Further establish the role of spatial data and SDI in marine and coastal management

  The role of SDI in marine administration has been defined in this thesis, however it is still unclear to the people involved in management and administration of the marine and coastal areas. Its use is more established in land administration, where the concept for SDI was first established. A better understanding of the potential for sharing spatial data would enable the creation of a Marine or seamless SDI

- Development of a marine cadastre as a fundamental dataset for Australia based on the Marine SDI guidelines

  One of the fundamental datasets that most organisations stated as necessary for their business activities was boundaries and/ or administration areas. A marine cadastre would therefore be an integral part of a Marine SDI. As a basis for testing the Marine SDI guidelines, a marine cadastre could be built following these guidelines. This would also form a base layer for a future Marine SDI. Figure 6.l showed some potential marine fundamental datasets and described the differences between these and land-related datasets. There is an opportunity for more research in this area, particularly relating to the spatial description of these datasets.

The need to improve the management and administration of the World's coast and oceans in terms of sustainable development is now internationally recognised. There are many different initiatives developing that aim to do this through improving availability of marine and coastal spatial data. In order to support an integrated and holistic approach to managing the environment this thesis has proposed an extended SDI model that can facilitate seamless access to marine, coastal and terrestrial spatial data.

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