Stewardship of Coastal Waters – The Information Systems Perspective

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ABSTRACT

In response to the need for increasing levels of information addressing state and sustainability of the marine environment to support local, regional and national policy the concept of *Marine Stewardship* has in recent years started to take on an important new meaning and dimension. At present although *Marine Stewardship* has a country by country interpretation there is common emphasis on importance of the spatial data domain and a growing recognition that governance, interoperability and information services are key underpinning features. This paper looks at *Marine Stewardship* from the spatial data perspective and examines some of the issues that govern development of marine decision-support services that would incorporate SAR.

Keywords: Marine stewardship, governance, interoperability, decision-support, spatial information.

1 INTRODUCTION

"It is agreed among experts and interested parties that the administration of rights to marine and coastal spaces requires the management of legal and spatial information to these spaces." This quote, taken from the Sutherland and Nichol paper "The Marine Cadastre: Legal and Spatial Data Contribution to Economic, Environmental and Social Development, presented at the 8th GSDI conference in 2005 [25], sets the scene for *Marine Stewardship* today and brings into effect three of the key Chapter 40 (Information for Decision Making) recommendations of Agenda 21 from the 1992 UN Rio Conference [28].

*"**Improvement of methods of data assessment and analysis***

40.9. Relevant international organizations should develop practical recommendations for coordinated, harmonized collection and assessment of data at the national and international levels. National and international data and information centres should set up continuous and accurate data-collection systems and make use of geographic information systems, expert systems, models and a variety of other techniques for the assessment and analysis of data. These steps will be particularly relevant, as large quantities of data from satellite sources will need to be processed in the future. Developed countries and international organizations, as well as the private sector, should cooperate, in particular with developing countries, upon request, to facilitate their acquiring these technologies and this knowhow.

Production of information usable for decision-making

40.22. Countries and international organizations should review and strengthen information systems and services in sectors related to sustainable development, at the local, provincial, national and international levels. Special emphasis should be placed on the transformation of existing information into forms more useful for decision-making and on targeting information at different user groups. Mechanisms should be strengthened or established for transforming scientific and socio-economic assessments into information suitable for both planning and public information. Electronic and non-electronic formats should be used.

Establishment of standards and methods for handling information

40.23. Governments should consider supporting the efforts of governmental as well as non-governmental organizations to develop mechanisms for efficient and harmonized exchange of information at the local, national, provincial and international levels, including revision and establishment of data, access and dissemination formats, and communication interfaces".

Stewardship is a term being used increasingly by resource industries, government agencies, and community activists to describe their philosophy of resource use. In the context of the marine environment the term addresses both coastal and seaward territories and represents recognition of the diversity, complexity and sensitivity of the physical, ecological and biological environment and the need to impose governance at spatial scales to enable its management and ensure its sustainability. The term has an inherent complexity by virtue of the fact that we have to embrace the transition from an essentially 2D domain at the coastline to a full 3D domain seaward with associated increase in data diversity and stakeholder interests. The governance issues are nicely illustrated in the Figure 1 diagram below from Sutherland's 2005 paper [25].

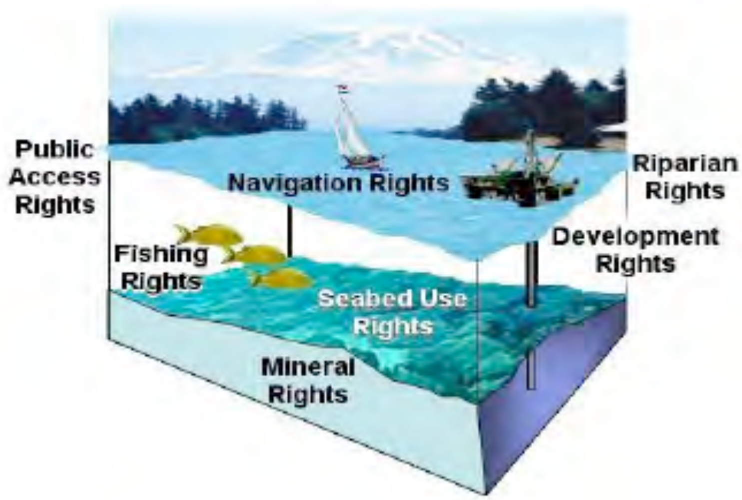

Figure 1. 3D marine parcel illustrating stakeholders rights [25].

There are overlaps of jurisdiction, administration, and ownership between government and regional or local bodies that are primarily land based and those that are marine based such as ports, navigation, coastguard and fisheries. One consequence is that data describing these domains and information about stakeholder interests may not only be fragmented but also inconsistent, incompatible and incomplete. It is this realisation and the need for data conformity that motivated the International Federation of Surveyors FIG to bring together its Commissions for Hydrography and Land to address the problem under Working Group 4.3. The FIG publication No. 36 "Administering Marine Spaces" issued September 2006 is a testament to their insight and progress.

An enabling mechanism for marine stewardship and one which incorporates many basic principles is *Integrated Coastal Zone Management* or ICZM. The earliest significant ICZM efforts were adopted in Europe and USA in the 1970's out of concern for the quality of coastal and marine environments. These efforts prompted the US Coastal Zone Management Act in 1972, the 1973 Council of Europe Resolution on the protection of coastal areas (including the promotion of integrated coastal planning), and the 1981 European Coastal Charter. Another substantive milestone was the World Coast Conference of 1993 [30] which was a direct follow-on to the 1992 Rio Conference [28]. Although ICZM is perceived to have a well defined structure and methodology content its adoption at regional and national scale over the past 10 years suggests that we are only now just beginning to get to grips with the real issues involved.

In Europe, a European ICZM strategy document was tabled in September 2000 and adopted in 2002 [9], but it is only now, in the wake of the *European Commissions Demonstration Programme* on ICZM, and feedback from EU member States [10, 11] that a more cohesive vision of the enabling mechanism is forming; by way of the new "European Marine Strategy" document [11] currently out for consultation. The UK has followed a similar path, with the government strategy on marine stewardship and conservation published in May 2002 [5]; a major review of progress "An Integrated Assessment of the State of UK Seas" published early in 2006 [6], and a new national "Marine Bill" pending [7]. An underlying feature that sits at the core of European marine stewardship evolution is a focus on *geospatial information* and its key role in enabling the information systems infrastructure needed for effective stewardship [11, 22]. The cooperative IOC&IGU programme Oceans 21 [22] also aims to focus on the emerging and converging GI-related technologies as important tools to aid in ICM. The concepts of *marine spaces, marine areas* and *marine area management* are introduced [6, 18] but without the degree of insight and structure reflected in FIG 36 document [23, 25] or the new NOAA handbook on marine managed spaces [21]. This serves to illustrate a common characterisation of *marine stewardship* across different nations but a more variable approach to addressing it within the context of different national science and political frameworks that are in place [3, 7, 11, 17, 21, 29]. For example, although the role of geospatial information and its importance in a growing Europe was prophetically set out in the 1999 document "European Spatial Development Perspective" [8] and has led directly to the INSPIRE (the Infrastructure for Spatial Information in Europe) Directive being adopted to enable a European SDI *spatial data infrastructure,* Europe is still some way behind the Canadian *Geo-Connections Programme* or the Australia-New Zealand *Spatial Information Council Programme*.

GMES the *Global Monitoring of Environment and Security* initiative, launched in 1999 jointly by the European space Agency ESA and the European Union EU, has contributed significantly to redefine *marine stewardship*, in the European sense, more into the geospatial context proposed by Sutherland and alike thinkers [20, 23, 24, 25, 26]. The GMES services development model, geared at providing operational services, provides a good starting point to explore the modern information service demands placed on *marine stewardship* and how they might be met. The GMES philosophy addresses the provision of end user information services through integration of measurement, modelling and prediction within a geospatial systems environment. This matches well with the *marine cadastre* vision being proposed today [20, 25] as the model illustrated in Figure 2 diagram below.

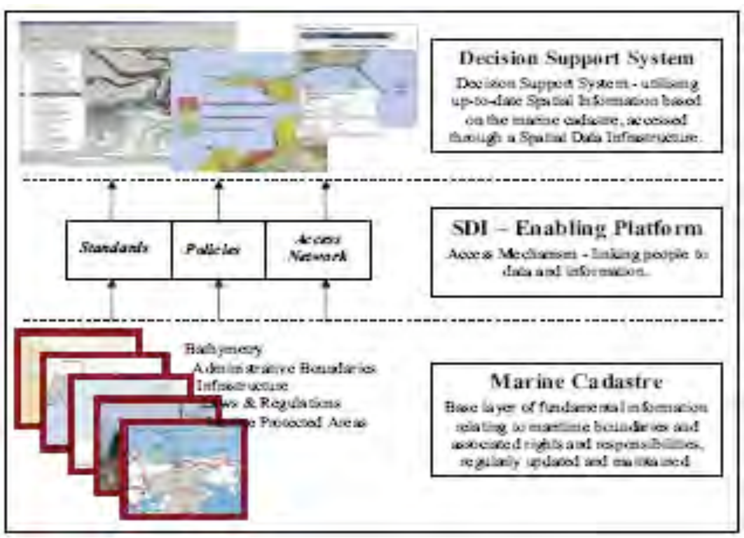

Figure 2. Underlying infrastructure for marine space administration [23].

Several important features of the above model are not sufficiently highlighted namely; the knowledge creation core that integrates data with interpretation to build added value and, the information delivery mechanism which requires adoption of web services to disseminate and visualise the information. In both, the role of standards and interoperability are crucial issues that fall squarely into the SDI domain. The trend towards open standards has opened a Pandora's box of problems and challenges for marine data scientists and the realisation of full scale operational decision-support systems has highlighted barriers and bottlenecks in data communication, visualisation and security. The ability to draw together digital data, forecasts and other information from disparate locations and centralise the complex process of knowledge generation for multi community access through a web services portal presents a major advance towards realising the true meaning of *marine stewardship*. Considerable progress has been achieved in recent years in developing marine information services architecture and demonstrating service applications.

In this short overview paper I will focus on the sector of information services that require input of ocean behaviour modelling such as oil and chemical spill response and search and rescue decision-support and I will endeavour to place these in the context of a *marine stewardship* framework and highlight the role of Earth observation SAR in the broader context of key components of an information services architecture that reflects the evolution of marine stewardship technology today.

2 STAKEHOLDERS AND INFORMATION NEEDS

What is a *stakeholder*? In the context of the marine environment it can be anybody but in the context of *marine stewardship* we can narrow the field to the following categories; ownership, administration, jurisdiction, compliance and enforcement. In other words; entities responsible for some aspect of governance or management of some small or large part of a marine space lying somewhere between the coastline and distant offshore waters. The scope of this definition is illustrated in Figure 3 which shows the various extents of legal jurisdiction over marine waters in Europe.

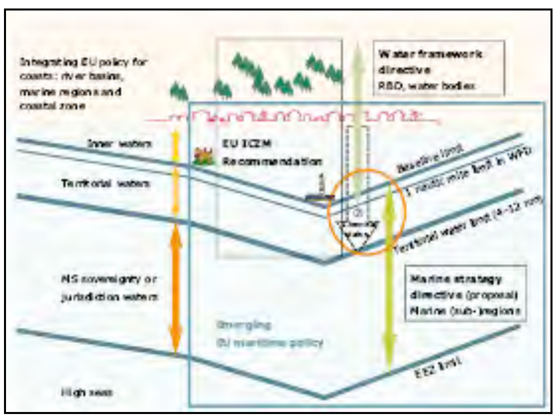

Figure 3. Legal jurisdictions in coastal waters [12].

The potential conflicts in interests and overlapping jurisdiction is illustrated in Figure 4.

In order to provide these entities with the necessary information to support their governance role, which can range from issuing dredging or gravel extraction licenses to permissions for fishing or laying sea bed pipelines, it is necessary to have some sort of marine spatial plan or decision-support system [13, 14, 20] overlying a marine cadastre [20, 25]. The key characteristics of these systems are that they target specific stakeholder information needs and are used to integrate policies across different sectors of activity which may span international, national, regional and local levels.

2.1 Information Needs

From developmental studies of operational marine information systems involving Earth observations [13, 14, 15, 20] Graff and Tyler have shown that marine information needs can be conveniently partitioned into *three generic domains;* surveillance/monitoring, management & planning, and emergency response. These domains define both stakeholder and information content and share key features that characterise their EO data requirements and decision-support mechanism.

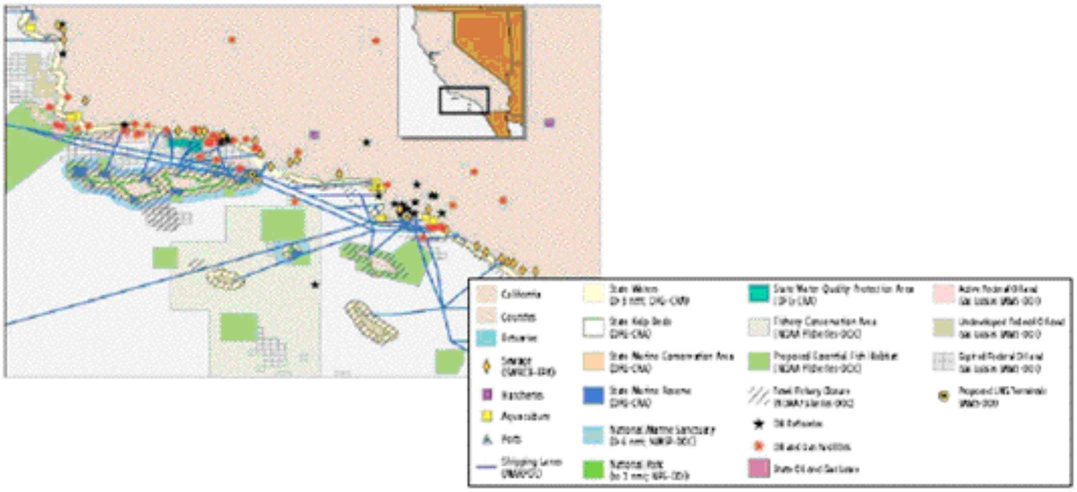

Figure 4. Fragmentation of management for human uses of marine areas in Southern California [4]

Surveillance/monitoring: This covers all aspects of remote surveillance, satellite, airborne and in situ, for long term and short term information. The most significant feature of this application domain is its continuous demand for data and as a data feed to the other two application domains. It is also characterised as having stringent requirements for the data delivery chain between satellite and end user.

Management and Planning: This covers a wide range of activities ranging from engineering design, through to production of charts. A key characteristic is that the applications do not usually have an urgency associated with them. Planning and design can take months to years. In this application domain the spatial requirements for data are at regional and national scales. Another key characteristic is the requirement for climactic and statistical summary data needed for regulatory reporting on state of the environment.

Emergency Response: This is the most stringent application domain from a data ingest and information delivery point of view. The domain addresses oil and chemical spills, search and rescue, flood warning, fires, explosions, natural hazards and humanitarian response. In all applications, the timeliness of information delivery is critical.

Table 1 below highlights the main characteristics of the three stakeholder-information domains.

Table 1. Characterisation of the three generic application domains.

Feature	Emergency Response	Management and Planning	Surveillance / Monitoring
Application	Oil Spill Response Chemical Spill Response Search and Rescue Algae bloom response Flood warning	Collecting metocean data Coastal sensitivity/land use mapping Oil spill contingency planning Coastal engineering design Flood sensitivity mapping	Algae bloom detection Effluent discharge surveillance Oil/chemical spill surveillance Coastal flooding Port operations
Timeliness of implementation of data	As near to real time as possible	Long time-scales of implementation are acceptable	Less timeliness than for emergency response is acceptable
Spatial Resolution Need (approximate)	~ 100m	100 – 10000m	1000m sufficient
Temporal Resolution Need (approximate)	2 - 48hrs update	days	Whenever data is available
Regularity of need	Un-predictable	One off – updated periodically	Continuous/systematic
Time period of interest	Nowcast / Forecast	Hindcast / Forecast	Nowcast
Scale of Interest	Local to incident	Regional, National and International	Local to regional

2.2 Oil Spill Response

A high profile example for illustration is the need for spatial information system to enforce compliance against oil spills under the global MARPOL 73/78 Convention. In Europe, which has 13 designated Large Marine Ecosystems and 4 regional seas protected by Convention, the problem of oil spill pollution is severe as shown in Figure 5 and there are information requirements that go across all three stakeholder domains.

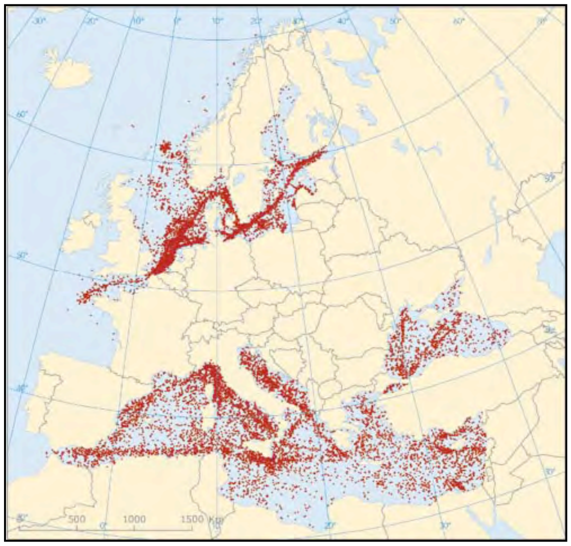

Figure 5. European oil spills 2000-2004 [12].

The stakeholders which involve regional, national and international bodies with overlapping jurisdiction can be categorised in a hierarchical form as shown in Figure 6. They cover the three domains discussed above namely; surveillance, management and emergency response.

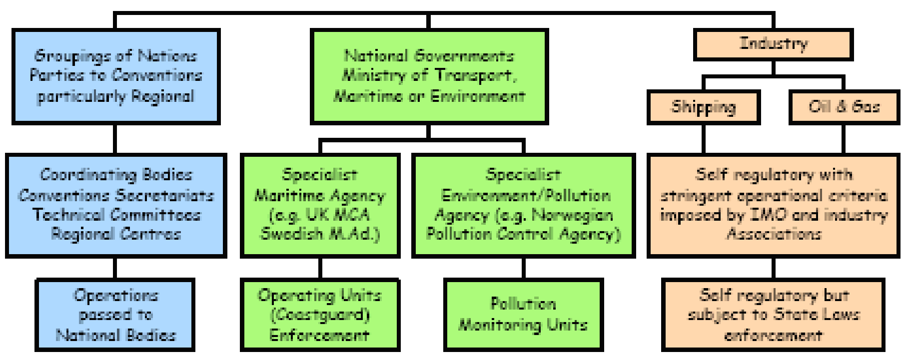

Figure 6. Oil spill enforcement stakeholder categories [15].

Enforcement requires national capacity in detection, legislation and prosecution and regional collaboration is essential to ensure political will and policy structure. The North Sea community is well advanced under the Bonn Agreement and a new enabling framework is being put in place by the new European Marine safety Agency EMSA.

For oil spill enforcement the stakeholder or end user requirements are well understood and have been well defined in recent studies [15, 27] as shown in Table 2.

Table 2. End user requirements for oil spill enforcement under MARPOL 73/78 [15]

Template – Oil Spill Control: End Users Requirements	
1.	Continuously monitor territorial waters
2.	Detect potential pollution events
3.	Confirm pollution event
4.	Identify nature of pollutant
5.	Identify potential candidate culprit(s)
6.	Evidence to confirm candidate culprit (s)
7.	Build legal case
8.	Prosecute
9.	Community based information sharing
10.	Build knowledge of the environment
11.	Minimise cost burden of information

Three important requirements are identified (shaded item numbers 9, 10, and 11) which are also implicit in the context of Treaty or Convention compliance driven user information needs, where the users are State public authorities and self-regulatory industry bodies. More specifically, their justification [15] is;

- **Community based information sharing:** within a Treaty agreement structure involving users from within and across different State boundaries it is desirable and feasible to ensure an information sharing system
- **Build knowledge of the environment:** any system accumulating data through monitoring of the marine environment should use these data to also create knowledge about the health of the environment
- **Minimise cost burden of information:** any public community based information system incorporating a *shared cost principle* must ensure that the burden of shared cost is minimised

It can be seen that oil spill information needs cut across all three stakeholder domains which imposes significant demands and challenges on the design of appropriate operational decision-support systems.

3 INFORMATION DELIVERY

Information delivery mechanisms that incorporate any form of EO especially SAR have to take the form suggested in Figure 2 where EO is simply another data layer in the marine cadastre. In the case of oil spill information systems [27] the Figure 2 model can be represented as shown in Figure 7.

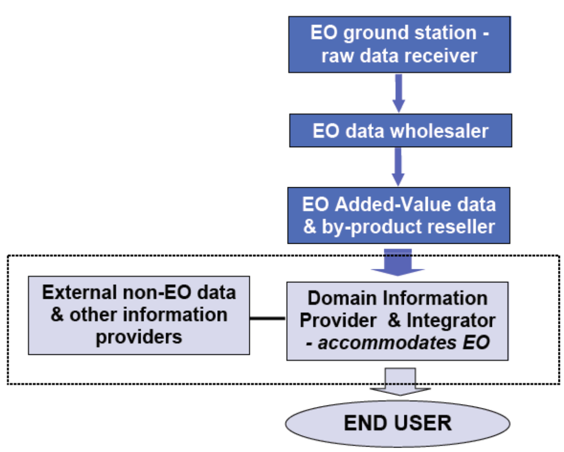

Figure 7. Marine information system delivery chain integrating EO.

The essential component is the decision support content, shown within the wire frame in Figure 7, which integrates a complex diversity of data to produce information that is specific to the end user needs. In the case of oil spill policing the full set of information demands within a delivery chain designed to address the *Requirements Template* in Table 2 are illustrated in the form of an information needs analysis Figure 8 that shows data demands, data flow paths and data exchange interfaces [27].

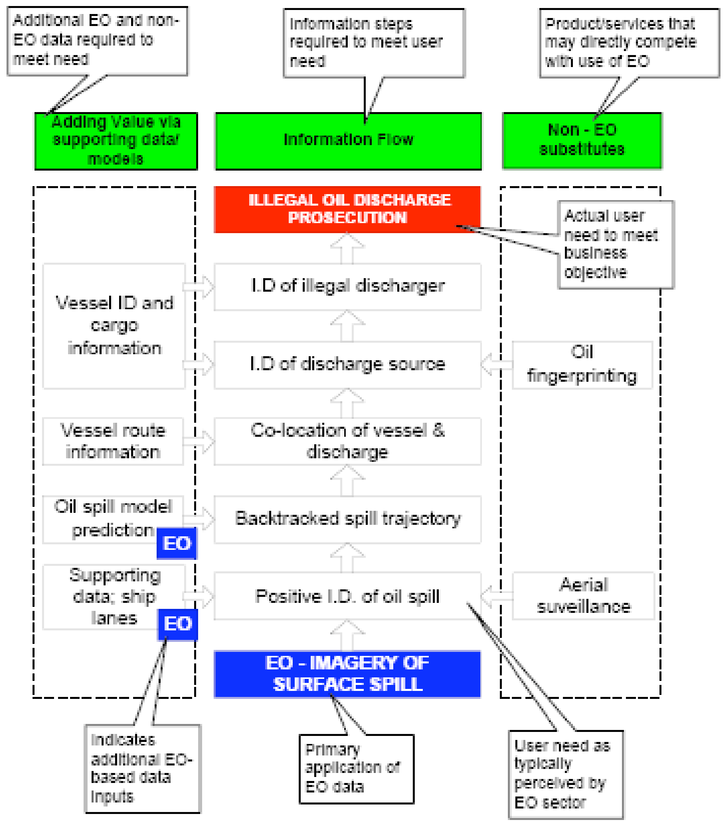

Figure 8. Oil spill policing information needs analysis illustrating main features [27].

Even although Figure 8 shows only the main information needs and data exchange pathways it is sufficient to illustrate the complex data demands and data dependencies that exist and which will feature in any similar data driven marine information service. Some important common data use features are;

- Seabed and coastal environment feature maps
- Electronic nautical charts
- Operational weather and ocean forecasts & hindcasts
- AIS data for ship identification
- Visualising data and dissemination over the internet

In all cases it is fair to say that there are currently no governing standards that apply to ensure a common approach to marine data access and information service architectures.

4 MARINE SPATIAL DATA INFRASTRUCTURE - THE STUMBLING BLOCK

In the terrestrial domain, the need to share and integrate geographic data for more efficient resource information management has been recognised for over a decade [2, 8, 17] and has led to development of spatial data infrastructures (SDI) at all space scales. In the case of coastal and maritime the pace of evolution since UN Agenda 21 [28] in 1992 and the World Coast conference in 1993 [30] has been very much slower with much trumpeting about national marine spatial strategies [3, 5, 6, 7, 9, 11, 22, 29] and data driven policies but no great progress in adopting a strategy to develop a unified marine SDI infrastructure. To date most of the focus has been placed on marine data formats and exchange standards with considerable progress under the IOC umbrella engaging marine data centres world wide but we are no closer to having ubiquitous facilities for access to these data. As for national Hydrographic Agencies, Ocean Forecasting Authorities, Space Data Centres and Environment Agencies, who all hold data that is important to a marine cadastre vision , we are still a long way from bringing all players to the same table.

This disparity nicely illustrated in the Table 1 from [2] which is reproduced shown below.

Table 1. Coastal SDI components appearing in various national, regional and global SDIs

SDI Component	USA	UK	Canada	INSPIRE-WFD	Asia-Pacific SDI	GlobalMap Project
bathymetry	yes	yes	yes	yes	maybe	maybe
shoreline	yes	yes	yes	yes	yes	yes
marine cadastre	yes	maybe	yes	no	yes	maybe
coastal imagery	maybe	maybe	maybe	yes	no	no
marine navigation	maybe	yes	yes	maybe	no	maybe
tidal benchmarks	maybe	yes	maybe	yes	no	no
benthic habitats	maybe	no	maybe	yes-WFD	no	no

Figure 8. Disparity in SDI coastal components across different national SDIs. Table 1 in [2]

Nebert [19] in his recent September 2006 seminar series in Australia has clearly highlighted the key issues and barriers that have to be addressed which include; data access services, common catalogues, common acquisition capabilities and business driven applications. Above all is the need for greater recognition of the importance of common standards governing marine data and interfaces and the need for greater communication in this area to ensure connectivity across all interested parties and players involved. The two diagrams below are intended to help capture the key themes.

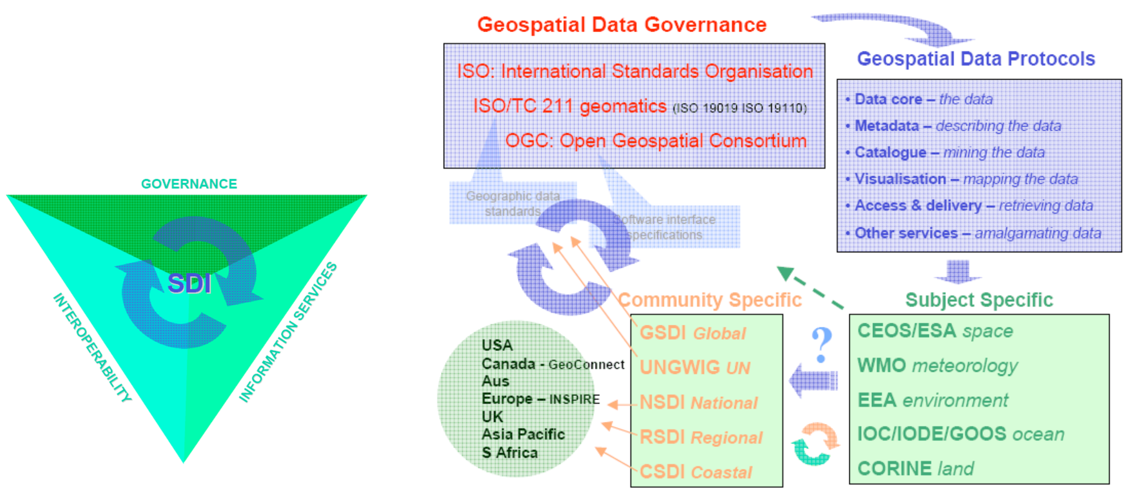

Figure 9. Schematics designed to capture importance and relevance of SDI marine theme today.

It is enormously heartening to see the contribution of major new thinkers such as Sutherland [24, 25, 26, 27] and Ng'ang'a [20] who are acting through both Global SDI Association and the International federation of Surveyors FIG to bring a new dimension into the development of marine SDI. Equally, the recent establishment in June 2006 of an SDI Unit in the European Joint Research Centre JRC will help to focus and accelerate technological effort to accommodate compliance with the content of the diagrams above.

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